Scientific Conference of Young Researchers 2017

17th Scientific Conference of Young Researchers

May 16th, 2017
Herľany, Slovakia

Proceedings from Conference

Faculty of Electrical Engineering and Informatics
Technical University of Košice

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Foreword

Dear Colleagues,

SCYR (Scientific Conference of Young Researchers) is a scientific event focused on exchange of information among young scientists from Faculty of Electrical Engineering and Informatics at Technical University of Košice – series of annual events that was founded in 2000. Since 2000 the conference has been hosted by FEI TUKE with rising technical level and unique multicultural atmosphere. The Seventeenth Scientific Conference of Young Researchers (SCYR 2017), conference of graduates and young researchers, was held on 16th May 2017. The primary aims of the conference, to provide a forum for dissemination of information and scientific results relating to research and development activities at the Faculty of Electrical Engineering and Informatics, has been achieved. 95 participants mostly in doctoral categories were active in the conference.

Faculty of Electrical Engineering and Informatics has a long tradition of students participating in skilled labor where they have to apply their theoretical knowledge. SCYR is an opportunity for doctoral and graduating students to use this event to train their scientific knowledge exchange. Nevertheless, the original goal is still to represent a forum for the exchange of information between young scientists from academic communities on topics related to their experimental and theoretical works in the very wide spread field of a wide spectrum of scientific disciplines like informatics sciences and computer networks, cybernetics and intelligent systems, electrical and electric power engineering and electronics.

17th Scientific Conference of Young Researchers at Faculty of Electrical Engineering and Informatics Technical University of Košice (SCYR 2017) was organized in a beautiful village Herľany. The Conference was opened in the name of dean prof. Ing. Liberios Vokorokos, PhD. by the vicedean of faculty, prof. Ing. Alena Pietriková, CSc. In her introductory address she noted the importance of the Conference as a forum for exchange of information and a medium for broadening the scientific horizons of its participants and stressed the scientific and practical value of investigations being carried out by young researchers.

Traditionally, the program includes two parallel sessions:

- Electrical & Electronics Engineering
- Information Technologies

with 95 technical papers dealing with research results obtained mainly in university environment. This day was filled with a lot of interesting scientific discussions among the junior researchers and graduate students, and the representatives of the Faculty of Electrical Engineering and Informatics. This Scientific Network included various research problems and education, communication between young scientists and students, between students and professors. Conference was also a platform for student exchange and a potential starting point for scientific cooperation. The results presented in papers demonstrated that the investigations being conducted by young scientists are making a valuable contribution to the fulfillment of the tasks set for science and technology at Faculty of Electrical Engineering and Informatics at Technical University of Košice.

We want to thank all participants for contributing to these proceedings with their high quality manuscripts. We hope that the conference constitutes a platform for a continual dialogue among young scientists.

It is our pleasure and honor to express our gratitude to our sponsors and to all friends, colleagues and committee members who contributed with their ideas, discussions, and sedulous hard work to the success of this event. We also want to thank our session chairs for their cooperation and dedication throughout the whole conference.

Finally, we want to thank all the attendees of the conference for fruitful discussions and a pleasant stay in our event.

Liberios VOKOROKOS
Dean of FEI TUKE

May 16th 2017, Herľany

Contents

A Decentralised IoT Integration Platform

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***Abstract*—The IoT integration platforms represent a new trend toward the interoperability in IoT. While a centralised architecture with the whole logic in the cloud can be relatively straightforward and simple, a decentralised architecture with the distributed logic can bring up many benefits. This paper presents an architecture design for a decentralised IoT integration platform.**

***Keywords*—Decentralised Architecture, Internet of Things, IoT Integration Scenario, IoT Platform.**

I. Introduction

The Internet of Things (IoT) is a highly discussed paradigm based on connecting everyday 'Things' to the Internet. Although the term IoT was first coined by Kevin Ashton in 1999, who used it for a global network of objects connected to Radio Frequency Identification (RFID) in a supply chain [1], the IoT paradigm has become immensely popular and thus has spread to many other areas as well. Nowadays, the application areas of IoT are so diverse that there is no one unified, broadly accepted definition. Nevertheless, IEEE IoT Initiative [2] recently collected and analysed different IoT definitions in order to identify the common core features and help to clarify the whole concept of IoT.

The heterogeneity of IoT creates challenges not only for the theoretical definitions but also for the practical implementations. IoT is based on the interconnection of different devices from different environments. However, this diversity brings up many interoperability issues, especially when dealing with low-powered devices communicating via constrained networks. To overcome this challenge, there is a demand for IoT integration platforms.

The aim of the IoT integration platform is to establish the needed interoperability and to define a way how to efficiently manage IoT devices and process the acquired data. By developing IoT integration platforms, we would be able to shift from application specific implementations to general, use-case agnostic solutions, where the exact functionalities would just be a question of final configuration. The potential of the IoT platform is tremendous due to a number of benefits it can offer. Consequently, Gartner's 2016 Hype Cycle [3] has revealed the IoT platform as an emerging technology with very high expectations and 2-5 years to mainstream adoption.

This paper focuses on the analysis of IoT integration scenarios and the direct comparison between centralised and decentralised architectures, which is described in Section II. The main contribution of this paper comes from the architecture diagrams that present the decentralised IoT integration platform with the computing at the edge. The defined architecture is in Section III. Finally, Section IV. provides the conclusion and future work.

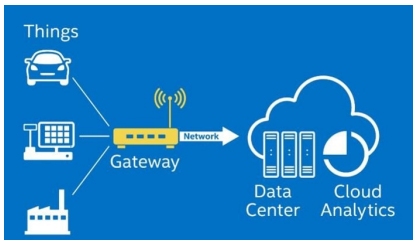

Fig. 1: Typical IoT Integration Scenario.

II. IoT integration scenarios

IoT platforms aim to interconnect devices and process the acquired data in a meaningful way so that we would be able to get the desired output. However, different use-cases may have different requirements on the resources, use different technologies to deal with their constraints, and produce different results. To meet all these use-case specific needs, an IoT platform has to be based on the versatile and efficient architecture.

The typical IoT integration scenario is depicted in Fig. 1. Devices from the environment are connected to the cloud, either directly or via a gateway, but all logic for control and management is on the cloud [4]. This approach represents a centralised architecture.

A better approach, however, may be to shift a part of the logic from the cloud to the edge. The execution of tasks at earlier stages, for example at a gateway or even at devices themselves, greatly reduces unnecessary network traffic and offers a more transparent management. Such an integration scenario is based on a decentralised architecture.

The decentralised architecture is more complex, due to the distribution of data processing and decision making, but the gained benefits from the more efficient solution can override the initial effort spent on designing the IoT integration platform with the cloud computing at the edge. The decision when to choose which architecture is explained in TABLE I.

III. Architecture design for decentralised IoT networks

We discussed the idea of decentralised architecture for IoT networks in the previous section. This section provides an

TABLE I: Selection of the right architecture

	Centralised architecture	**Decentralised architecture**
Number of devices	low	high
Sending rates	low	high
Connectivity	reliable, high network throughput	unreliable, constrained networks
Resources	abundance of cloud resources	need for the efficient use of cloud resources
Response rate	seconds	real-time

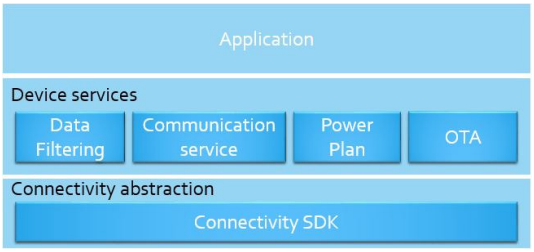

Fig. 2: End device diagram.

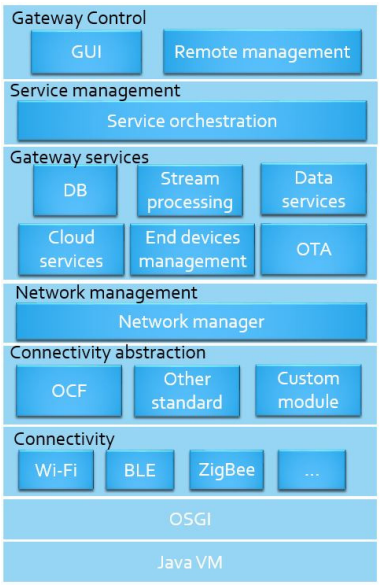

Fig. 3: IoT gateway diagram.

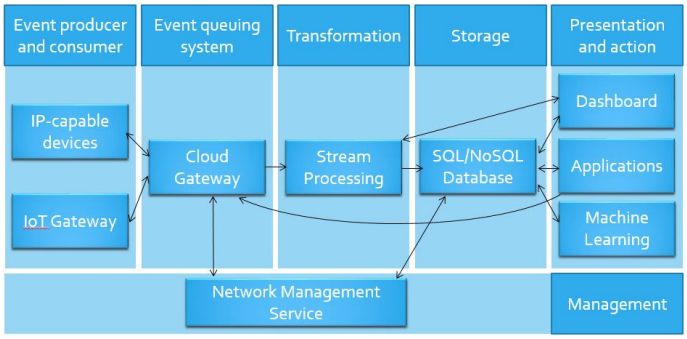

Fig. 4: Cloud diagram.

architecture design for the implementation. Our aim was to address the diversity of IoT and solve the interoperability issues, and therefore, the presented decentralised IoT integration platform is loosely coupled, scalable, and highly modular. Moreover, our architecture design is multi-network based and completely event-driven, which makes it an ideal approach for constrained environments. We present separate diagrams for the end-device (Fig. 2), gateway (Fig. 3), and cloud (Fig. 4).

The end-device diagram (Fig. 2) is relatively straightforward, consisting of 3 layers. The connectivity abstraction is meant to hide the used underlying network technology and provide access to services of a device regardless of the specific implementation. The concrete application is running in the top layer, nevertheless, the architecture enables to communicate with the device in a standardised way.

The gateway diagram (Fig. 3) is more complex. The multi-network approach is achieved by implementing the connectivity abstraction and network management layers. The service management layer is responsible for all gateway services, including stream processing, which brings computing to the edge. The gateway can be controlled either from the graphical user interface (GUI) or remotely via application user interface (API).

The cloud diagram (Fig. 4) is a generalised description of currently offered services and basically provides an understanding how to manage IoT networks in the cloud. The main interest should be aimed at IoT network management service, which is responsible for the management of all gateways and end devices connected to the cloud. Due to their standardised APIs, it is possible to control the whole network from one place.

IV. Conclusion

In conclusion, IoT integration platforms can be described as a new big trend toward the interoperability in IoT. While a centralised architecture is simple to deploy and manage, a decentralised architecture can reduce the network traffic and provide cleaner results. This paper presented the decentralised integration architecture design suitable for IoT networks. The main contribution was in the provided architecture diagrams that depicted the concrete layers and modules of the platform.

Our future work will be focused specifically on the stream processing module within a gateway. The objective is to take advantage of the edge computing and monitor an IoT platform in runtime to efficiently utilise available resources based on the expectations. Therefore, we identify 3 areas for further research – monitoring an IoT platform in runtime by using measurement concepts, ensuring the fulfilment of the desired output quality, and optimising the utilisation of resources based on the expectations defined by specific applications.

Acknowledgment

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A parallel connection of the DC/DC converters and the current-sharing methods

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***Abstract*—The paper is focused on the investigation of possibilities of the parallel connection of DC/DC converters as a power supplies. In the first part can be find verification of parallel connection without engagement any special arrangements. The verification shows issues of parallel connecting of converters. The further chapters contain theoretical overview of methods for parallelization of power stages, specifically converters.**

***Keywords*—DC/DC converter, current-sharing, controller, current-programming**

I. Introduction

Nowadays switch-mode power supplies are very popular thanks to their high effectivity, small size, low weight and relatively low cost. The essential part of each switch-mode power supply is a DC/DC converter. There are several types of DC/DC converters, but my research is primarily aimed at non isolated converters without transformer and their parallel co-working.

Parallel connection of more converters brings some advantages, e.g. higher possible overall output power, smaller and less expensive components of individual converters, power redundancy and fault tolerance. On the other hand parallel connection of converters brings also a number of issues and difficulties. Elemental requirement for the proper functioning of the whole system is, that individual converters have to share load current equally and stably. In other words, each of the converters should have the same output current. Therefore there have been proposed and developed several so-called *current-sharing methods* [1]-[4].

Next chapter will describe my own measurements of simple parallel connection of two DC/DC converters without using any of the current-sharing methods. Purpose of that is to point out issues and attributes of the parallel connection realized without any special arrangement. Further chapters are focused on principled description of major current-sharing methods.

II. Measurements of parallel connected DC/DC converters

The first step in my research was to find out how parallel connected converters would work without any special precautions. Hence I conducted a number of measurements of DC/DC converters connected in parallel. The verification was realized with two different types of integrated switching voltage regulators, specifically L4960 and LM2574N. I measured output volt-ampere characteristic according to changing output load. The whole circuit was implemented on breadboard. The workplace with connected system can be seen at the figure bellow.

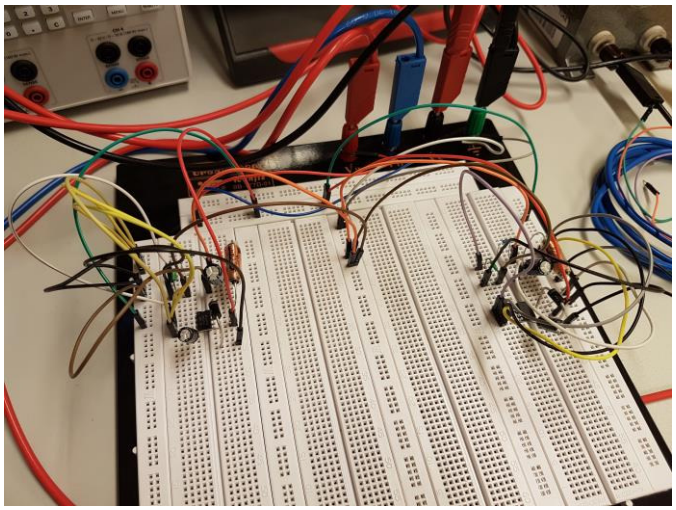

Fig. 1. Two DC/DC converters connected in parallel on the breadboard. Both converters contain switching voltage regulators LM2574N, diode, inductor, capacitors and resistors. As a load there is used adjusting resistor.

Volt-ampere characteristics of converters connected in parallel are at figures bellow for both types of switching voltage regulators.

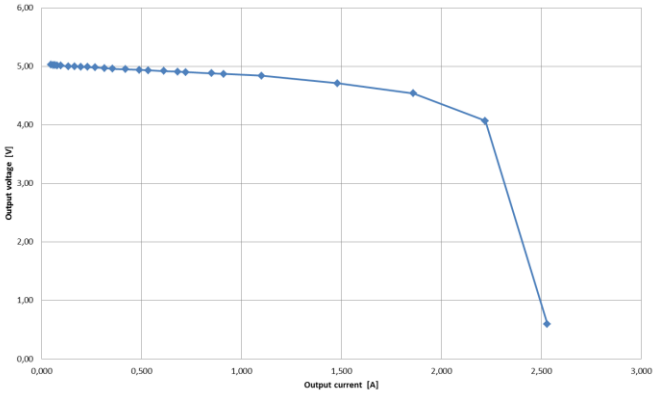

Fig. 2. Volt-ampere characteristic of parallel connected converters with LM2574N.

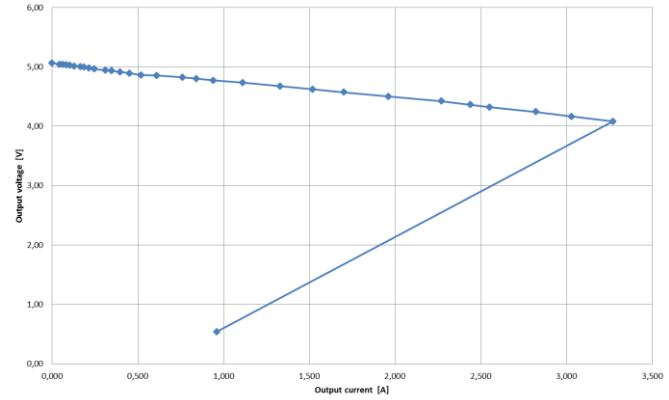

Fig. 3. Volt-ampere characteristic of parallel connected converters with L4960.

Regulator LM2574N is rated at 0,5A of output current while required output voltage is 5V. Two LM2574N in parallel should theoretically have output current 1A. As can be seen at the Fig. 2 output voltage is relatively stable until 1A. Converters reach even higher output current, but output voltage is continually decreasing and approximately at 2,5A there is a rapid fall of the output voltage. Consequently switching regulators LM2574N have proved as a good option in my configuration of parallel connection. However for L4960 rated at 2,5A there have emerged issues in a parallel layout. Two L4960 in parallel should give us theoretically 5A output current, but as can be seen at the Fig. 3, maximum output current is approximately 3,2A with severely decreasing output voltage. The reason of that is hidden behind the fact that even same types of regulators are never totally identical. One of them is dominant and supplies more power to the load. As a result this dominant regulator is more thermally stressed and it leads to fault. High thermal stress of the one of the converters was observed while measuring. Whereas one of the coolers of the voltage regulators was cold other was hot. So a majority of the reached output current 3,2A was supplied only by one of the two converters. A circuit for current protection, which is included in the integrated switching regulator, then turned off this dominant converter, because it exceeded its maximum allowed output current.

It follows that more power regulators L4960 cannot be connected in parallel without any special treatments. Parallel connection of power stages is always problematic and the most common issue is described and illustrated above on the L4960 example. Therefore there are some current-sharing methods, which are described in the following chapters.

III. Droop Current-Sharing Methods

Current-sharing methods can be classified in two groups, in the first group are droop methods and in the second are active current-sharing methods. This chapter is dedicated to the droop methods [1].

A droop method can be defined as one in which the output voltage droops as the load current is increased. In general can be said that better the voltage regulation means worse current-sharing ability. This is reason why the conventional power supplies are not good in current-sharing, because they are designed as good voltage sources. One of the main properties of the droop methods is that there are no interconnections between individual converters. Every converter is regulating its own output current, so when every converter is set to same value, output current should be the same for all the converters connected in parallel. It has advantage in simplicity but droop methods are not as robust as their active current-sharing counterparts [1].

A. *Using converters with inherent droop feature*

The simplest way how to design system with parallel connected converters, is to use such converters which naturally satisfy principles of droop methods. Therefore connection of these converters does not require any special precautions. Converters working in discontinuous inductor current mode, the series resonant converters are good examples [1], [4].

B. *Voltage droop due to series resistor*

Principle of this method is based on initial adjustment of output resistance for each converter individually in order to achieve the same output current in each of the converters. This adjustment is carried out by a resistor connected in series with the load. The resistance value of this series resistor is usually tens of mΩ. Disadvantage of this method is high power dissipation in the series resistor. Therefore this method is suitable only for low power applications [1], [5], [6].

C. *Voltage droop via output current feedback*

In this method is sensed output current from converter. Voltage signal from the current sensor is added up with the output voltage feedback [5]. Sum of these two signals is then compared with reference signal and resulting signal is used for controlling converter. When reference signal is equal for each converter, then will be ensured proper current-sharing. Block diagram for this method is depicted at the figure below [1].

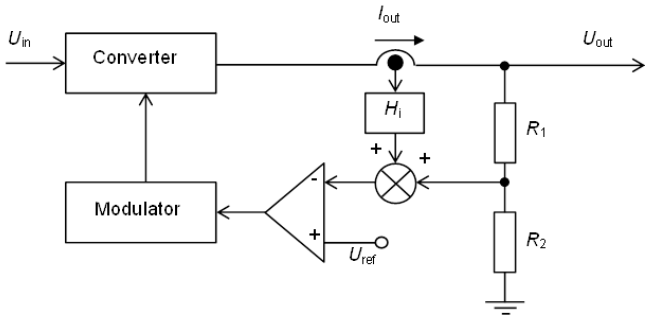

Fig. 4. Block diagram of voltage droop via current feedback method.

Output voltage U_{out} can be expressed as:

$$U_{out} = U_{initial} - I_{out} \cdot R_{droop} \quad (1)$$

Where R_{droop} is equivalent series resistor and is equal to:

$$R_{droop} = H_i \frac{(R_1 + R_2)}{R_2} \quad (2)$$

Voltage $U_{initial}$ represents equivalent initial output voltage and is equal to:

$$U_{initial} = U_{ref} \cdot \frac{(R_1 + R_2)}{R_2} \quad (3)$$

D. *Current mode with low DC gain*

This method uses a voltage feedback. It means that voltage from the output is compared with reference signal. As a result we get voltage error signal. Subsequently, value of output current is deducted from this error signal. The resulting signal is used for controlling converter. At the figure below is depicted block diagram of this method [1].

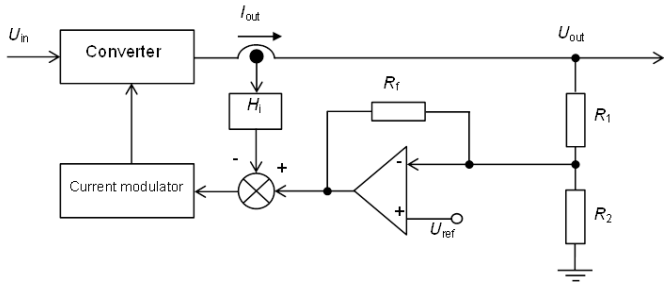

Fig. 5. Block diagram of current mode with low DC gain method.

Output voltage U_{out} can be expressed as:

$$U_{out} = U_{initial} - I_{out} \cdot \frac{R_1}{R_f} \cdot H_i \tag{4}$$

Where value H_i represents the gain of the current sense circuit. Voltage $U_{initial}$ represents equivalent initial output voltage and is equal to:

$$U_{initial} = U_{ref} \cdot \left(1 + \frac{R_1}{R_2} + \frac{R_1}{R_f}\right) \tag{5}$$

IV. ACTIVE CURRENT-SHARING METHODS

In comparison to droop methods are active current-sharing methods more complex, more difficult to design and more expensive. On the other hand they provide more control and they are more reliable. They contain one superior feedback loop for precise regulation of each converter. The purpose of this loop is to communicate with each converter in order to find out error in current-sharing and according to that regulate control circuits of each converter [1].

Methods of active current-sharing consist of two essential parts. The first part is regulation structure and the second is current-programming scheme. In this chapter will be described three basic regulation structures and one general current-programing scheme.

A. *Regulation structure – Inner regulation loop*

In this structure there is one common reference voltage U_{ref}, one common voltage feedback and also one common compensator $G(s)$ [1].

Signal from the common voltage feedback is comparing with reference voltage and the resulting signal is flowing to the error voltage compensator. Block $G(s)$ represents transfer function of this compensator. Output from the compensator is added up with signals from current-programing circuit. The signals from current-programing circuits are individual for each converter. A result of this sum is control signal for specific converter. Block diagram for this method is depicted at the figure below.

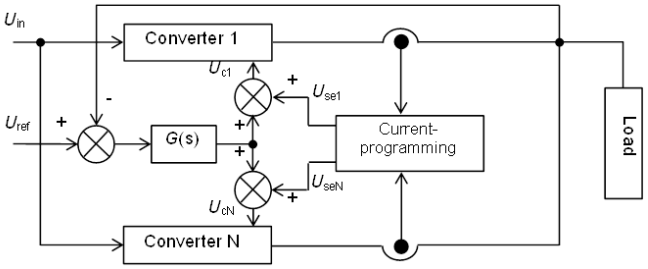

Fig. 6. Block diagram of inner regulation loop.

The advantages of this structure are stable current-sharing and precise output voltage regulation. The disadvantages are poor fault-tolerance and degradation of the modularity of the system [1].

B. *Regulation structure – Outer regulation loop*

The key feature of this structure is that the each converter has its own independent voltage feedback, reference signal and voltage error compensator. At the figure below is depicted block diagram of this structure [1].

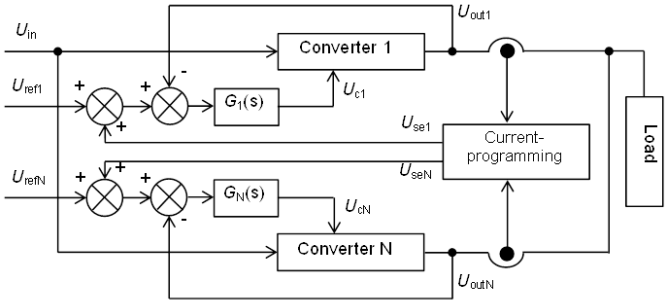

Fig. 7. Block diagram of outer regulation loop.

The control signals from current-programming circuit are added up with reference voltage. From the result of this sum is then deducted feedback voltage. The resulting control signal is flowing to the converter through the compensator.

The advantages of this structure are good modularity, flexibility in system configuration and excellent fault-tolerance. The disadvantages are limited voltage feedback gain and that the system can be unstable in transient [7].

C. *Regulation structure – External controller*

Another alternative structure is to use external controller [8]. This controller controls output voltage and also ensures current-sharing. So the external controller senses output voltage and current of each converter and according to that sends individual control signals to each of the converters [9]. Block diagram of this structure is depicted at the figure below.

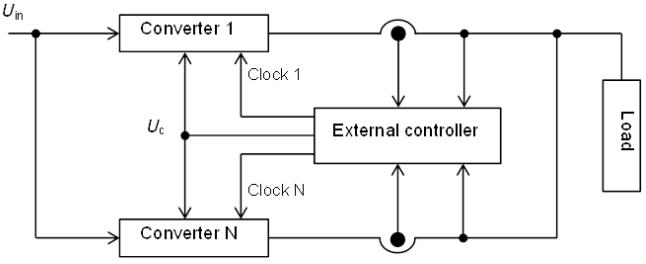

Fig. 8. Block diagram of regulation structure with external controller.

The advantages of regulation structure with external controller are [1]:

1. External controller can also synchronize timing of individual converters – it leads to the significant decrease of output voltage ripple.
2. Good current-sharing ability.
3. Good output voltage control.
4. Easy to implement failure monitoring.
5. Possibility to use existing supervision system.

The disadvantages of external controller are [1]:

1. Many interconnections between controller and converters.
2. Degradation of modularity.
3. Decreasing of reliability because of many interconnections and complicated control.

D. Current-programming scheme

The current-programming circuit is vital part of the active current-sharing methods. This circuit needs to communicate with each converter in order to get current-sharing error information then can send corresponding control signals. At the figure below is block diagram of general current-programming scheme [1].

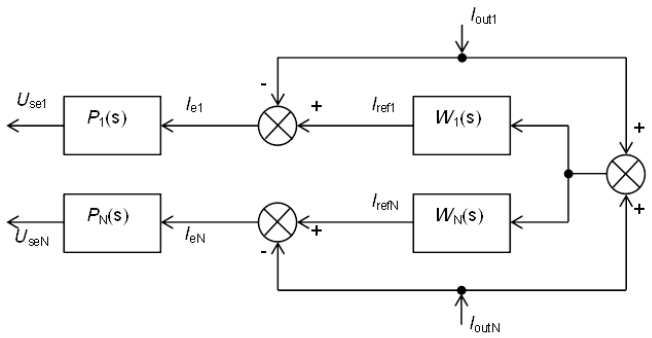

Fig. 9. Block diagram of general current-programming scheme.

The sensed output currents from each converter are added up. The summed current is then flowing to the *W*(s) blocks. *W*(s) blocks represent weighting functions. At the output of these blocks we have reference current signals, which are in proportion to the desired current-sharing ratios. These reference currents are compared with individual output currents. The resulting difference represents current-sharing errors, which are flowing to the *P*(s) blocks. *P*(s) blocks represent transient functions of adjusting amplifiers. At their output we have control voltages for controlling individual converters. These control voltages are the output of current-programming circuit.

There are several specific current-programming schemes, which can be separated into two groups [1]:

1. *Average current-programing methods* – reference current is proportional to the average value of the output currents of all converters.
2. *Master-Slave current-programming methods* – reference current is proportional to the value of the output current of the converter, which has Master function.

V. Conclusion

The measurements and verification which I realized at the beginning of my research were important for understanding of difficulties and issues, which come from parallel connection of more DC/DC converters. These measurements also well served as illustration of importance of using one of the current-sharing methods.

Theoretical overview of methods for parallel connection of power stages is another essential step in the research. In the theoretical overview is described just a basic principle of each method. In the next step of research, the experimental approach is needed for better understanding of these methods. The use of computer simulation is appropriate for this task. The verification of all methods can reveal best solution and also brings better state of knowledge needed for own proposals for improvements.

Acknowledgment

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Active Circuits for Electrically Short M-sequence Radiators

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***Abstract*—This article shortly summarizes basic principles of electrically short radiators for non-sinusoidal waveforms and current-state development in their active transmit and receive circuits. The research is aimed at exploiting those principles in a novel concept of ultra wideband (UWB) ground-penetrating radar based on M-sequence.**

***Keywords*—electrically short radiators, M-sequence, active antenna, large-current radiator**

I. Introduction

Antenna is an inevitable part of each device transmitting or receiving electromagnetic waves. In the early beginning of radio communication, all antennas were electrically small, as Marconi in 1908 recognized that long wavelengths were needed for long-distance transmission [1]. Although size of almost all electronic components has been reduced by several decades in the last century, antennas became and still remain proportional to the operational wavelength.

UWB radars typically operate in microwave range, which allows design of efficient antennas with dimensions of few centimeters. In that case, the requirement for compact antenna which may be integrated within a handheld UWB radar device manipulated by a single operator can be satisfied by conventional solutions, one such UWB antenna is designed e.g. in [2]. On the other hand, a problem is encountered when we try to design the antenna for a GPR (ground penetrating radar), which has to operate in lower frequencies (from tens to several hundreds of Megahertz) due to attenuation of higher frequencies in the soil. In this case, full-sized antenna dimensions achieve several meters, making such antenna expensive and inappropriate for a handheld device.

Although multiple principles for efficient shortening of antennas for narrowband transmission were published and are widely used, radiation of M-sequence signals requires different attitude. The M-sequence is a non-sinusoidal signal and requires not only wide frequency band, but also impulse response without significant ringing. That is why conventional narrowband principles cannot be used and radiators with simple non-resonant physical structure should be exploited. To match these radiators to a feeding line, active circuits are necessary.

This article offers a state-of-the-art overview about electrically-short radiators for non-sinusoidal waveforms and active circuits which are suitable for operation with them.

II. Electrically Short Radiators for Non-Sinusoidal Waveforms

In a paper published in 1947, Harold Wheeler defined an electrically small antenna as an antenna that could be enclosed within a radian sphere [3]. The radian sphere was a sphere of radius equal to $\lambda/2\pi$, where λ is the wavelength [1]. For further description we will consider two types of electrically short antennas – the short dipole and its variation called large current radiator (LCR). These two antennas were chosen because of their simplicity and non-resonant structure suitable for radiating non-sinusoidal waveforms.

A. Short dipole

The short dipole is one of the simplest antennas. It consists of two conducting arms of length L fed in the center of the dipole. The arms are short compared to the wavelength, usually $L/\lambda < 0{,}1$. Arms may be of various shapes to achieve better wideband properties. The short dipole has typically high input impedance consisting of very low radiation resistance and high capacitive reactance. The radiation resistance is typically less than 10 Ω and grows quadratically with the dipole length. Omitting the antenna losses and low radiation resistance, the dipole can be modeled by a capacitor C_d loading the transmitter. If considered as a receiving antenna, we can imagine the short dipole as an AC voltage source with series capacitance. The open-circuit voltage V_0 on the short dipole is given by

$$V_0 = E \cdot L_{eff} \tag{1}$$

where L_{eff} is the effective length of the dipole and E the magnitude of electric field intensity tangent to the dipole [4]. Equivalent circuit diagram of the short dipole as a receiving antenna loaded by the amplifier input impedance is shown in fig. 1b.

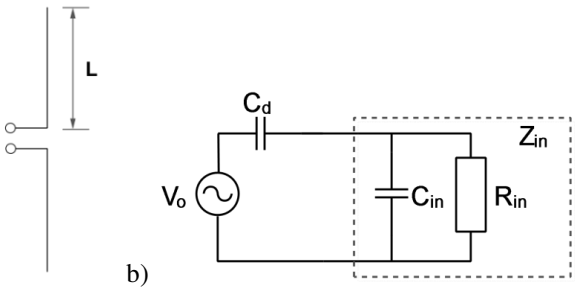

Fig. 1 a) short dipole construction; b) equivalent circuit of the short dipole loaded by the amplifier input impedance Z_{in}

Equation (1) shows that the amplitude of the voltage induced in the unloaded short dipole is independent on frequency. From this point of view, the most important property of the active circuit designed for receiving active antenna is its input impedance which loads the dipole. Its importance may be deduced from fig. 1b.

The voltage source V_0 and capacitor C_d form the short dipole equivalent circuit. Input impedance of the amplifier Z_{in} connected directly to the feed point of the dipole is modeled as a parallel combination of resistance R_{in} and capacity C_{in}. It is obvious that although the input capacity of the amplifier forms with C_d a frequency-independent AC voltage divider, the input resistance R_{in} creates a high-pass filter attenuating the received signal at low frequencies. Therefore, we can conclude that with the proper design of the active element for the short dipole antenna, it is possible to obtain a flat frequency response over a wide band of frequencies even if the antenna dimensions are much smaller compared to the wavelength.

B. Large current radiator

When Prof. Henning F. Harmuth suggested using non-sinusoidal waves for radar and radio communication [5], he quite logically raised the problem of a special radiator for propagating ultra-wideband (UWB) pulse electromagnetic fields, and he suggested using "large current radiators" (LCRs) [6], [7].

The LCR differs from well-known classical electric dipoles and magnetic loop radiators. Its principal diagram is shown in figure 2c. Considering the substantial differences, it is suggested to designate the LCRs as a special class of electromagnetic radiators. Distinct from the loop antenna, the LCR radiates in a more effective dipole mode like the Hertzian electric dipole. However, in contrast to the electric dipole, the LCR has low resistance permitting the excitation with a large current at a low driving voltage like the magnetic dipole, which increases the radiation efficiency. Thus, based on Harmuth's reasoning, the LCR should make an effective radiator [8].

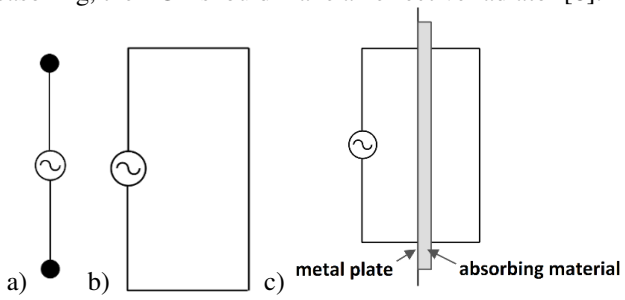

Fig. 2 Derivation of LCR principles. a) Hertzian dipole, b) short-circuited Hertzian dipole, c) LCR setup

The large current radiator is derived from the Hertzian dipole as described in fig. 2. Let us consider the Hertzian dipole, i.e. a very short dipole with capacitive terminations on both ends (fig. 2a). The Hertzian dipole is fed by alternating current which flows through dipole arms into the capacitive terminations while radiating electromagnetic waves proportional to the first time derivative of the current. In practice, it is difficult to realize such antenna efficiently because of extremely high voltage or capacitance necessary to excite sufficient current in the dipole. This may be overcome by simply interconnecting the ends of the dipole arms by a conductor (fig. 2b). The charge carried by the current does not have to be stored in the terminations anymore, but has a free path in the loop.

Nevertheless, the current of the same magnitude but the direction opposite to the dipole current flows through the conductor which connects the dipole ends. This return current radiates electromagnetic waves with opposite direction of electric field vector. Radiated fields interfere and result in a weak radiation proportional to the second derivative of the dipole current [9]. The cancellation of the electromagnetic fields may be avoided by a plate made of absorbing material inserted between the dipole and return conductors to separate their half-spaces on cost of absorbing a part of radiated energy. Work [9] describes using a metal plate covered with material with permeability around 10 and sufficient ohmic loss as the most convenient solution. Propagation around the plate has to be avoided as well.

III. ACTIVE CIRCUITS FOR ELECTRICALLY SHORT ANTENNAS

An electrically small antenna tends to be weakly coupled to the radiation field, which means that the ratio of the energy stored on the antenna to the energy radiated per cycle is large. In terms of impedance, this characteristic means that the reactive component of the antenna radiation impedance is always much larger than the resistive component. It is difficult to match such an impedance to a desired optimum impedance over a broad range of frequencies. For a receiving antenna, the desired optimum impedance is one that minimizes the noise figure of the receiver; for a transmitting antenna, it is one that permits the radiation of maximum power [10]. Moreover, in case of UWB systems, impedance connected to the antenna should ensure extremely wide bandwidth.

This difficult impedance-matching situation is aggravated if a cable is used to connect the antenna to the receiver or transmitter. The addition of a cable generally results in increased dissipative losses and non-radiative energy storage in the system, and usually decreases the bandwidth. It was recognized that eliminating the cable and incorporating a transmitter or receiver amplifier directly into the antenna should improve the antenna performance [10]. Therefore, active antenna concept is suitable to satisfy antenna requirements in UWB systems using low frequencies and short radiators.

For driving the above mentioned electrically short antennas, several active circuits have been designed. In the next subsections we will concentrate on those suitable for UWB operation with non-sinusoidal waveforms. Although intensive research on current pulse generators has been done [8][11][12], those generators not capable of operating with an M-sequence signal will be omitted from further considerations.

A. LCR driving circuits

Switches with Bipolar Transistors

The driver with bipolar switches shown in fig. 3 is from the U.S. Patent 5 365 240, by Harmuth [13]. Both Harmuth and Mohamed have experimentally tested such a pulse generator as an LCR driving circuit [14].

As shown in fig. 3, when a positive pulse feeds the terminal In1 and a negative pulse feeds the terminal In2, the transistors VT2 and VT3 will conduct and a current will flow from the terminal +U via R4 and VT3, the radiating antenna, and VT2 and R3 to ground. The problem starts because the radiating antenna not only radiates but also produces a near field or inductive field; so the radiator acts like an inductor and stores magnetic energy. When the current stops in the transistors, the magnetic energy (stored near the radiator when current flowed through it) returns by means of special diodes D3 and D6 back to the power

source. Similar processes occur when the transistors VT1 and VT4 conduct and the antenna produces the opposite polarity impulse. Thus, the stored energy (the energy that does not radiate) does not dissipate but returns back to the power supply and gives the antenna a high efficiency [8]. Similar circuits in CMOS technology have been developed for low-power impulse UWB radars [15].

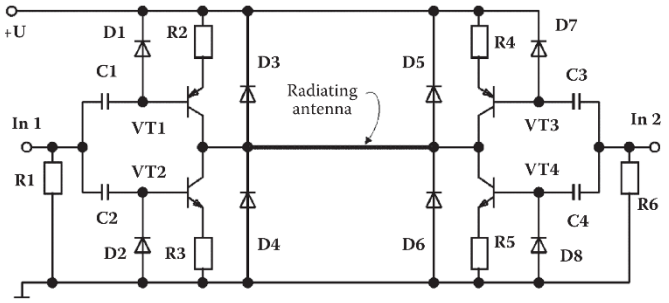

Fig. 3 Switch with bipolar transistors in bridge configuration

FET and GaAs FET Switches

Because field-effect transistors (FETs) do not store charges, they satisfy a necessary requirement for fast current switching and a way to develop power current pulse generators for LCRs [16]. The supply voltage and power consumption of power pulse generators can be reduced by using GaAs FET as switching elements. The on-state resistance of this transistor approaches 0.5 Ω, which causes a large current to flow in the radiating antenna of the LCR.

The driving circuit of the antenna shown in figure 4 represents two switches with the high-power field-effect GaAs transistors (VT3 and VT4) connected in series with the radiated antenna. By operating together, they provide balanced antenna excitation [8].

Two 51-Ω resistors R14 and R15 are connected in parallel with the transistors VT3 and VTS (between the source and drain) to fix the potential on the drains of VT3 and VT4. These resistors work together with the diode D1 to promote the decrease of the voltage overshoot at the instant of switching off VT3 and VT4. The resistor and diode attenuate oscillations occurring in the antenna after switching off VT3 and VT4. Notice how the connection of R14 and R15 increases the power consumption by 50 mA for each driver, but we have to accept this penalty [8].

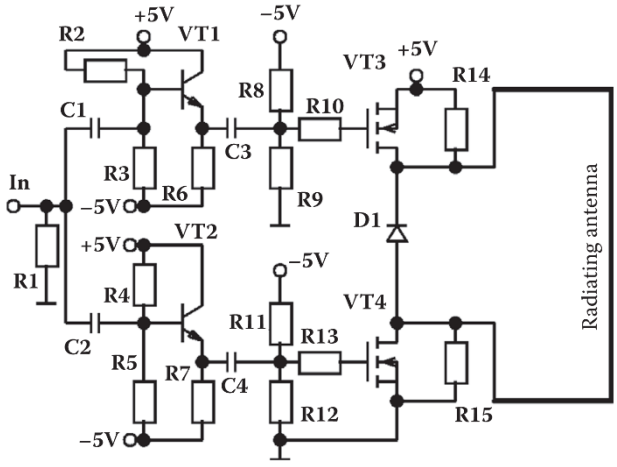

Fig. 4 Switch with GaAS FETs

Switches with logic gates

High-speed digital integrated circuits include elements that can work as switches for the LCR. Thus, relatively cheap logic gates can be used to drive the LCR. Each of their outputs can switch a given maximal current in range of tens to hundreds of milliamperes with a few volts supply voltage and about 1 ns rise time.

To achieve stronger radiation, number of radiators should be increased for increasing the total current in LCR. However, this causes problems with simultaneous switching of all drivers due to the coupling between radiators, which are loads for the integrated circuits [8].

B. *Short dipole active circuits*

Although both electrically short antennas – the short dipole and the LCR – are capable of both reception and transmission of electromagnetic waves, the LCR is mostly intended for transmitting while the short dipole is more suitable for receiving. Therefore, receiving small signal amplifiers designed as the short dipole active elements will be listed in this subsection.

As mentioned earlier, if the amplifier input impedance is high enough, it is possible to achieve efficient reception over a wide frequency range. Basically there are two active circuit concepts which allow for high input impedance:

Amplifiers with FETs

Example of one amplifier channel with high input impedance used for short dipole signals amplification was published in [17]. The half-circuit schematics is depicted in fig. 5. It uses a low-noise GaAs FET in a simple circuit structure to amplify the signal and match the impedance of the output coaxial cable at once. Using discrete transistors allows for wide range of applications in various frequency bands.

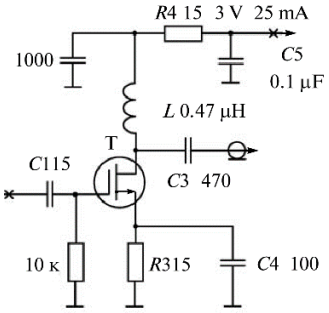

Fig. 5 Short dipole active circuit with FET

Operational and instrumentation amplifiers

Authors of [18] and [19] describe the use of instrumentation, respectively operational amplifiers. High-grade instrumentation amplifiers are available for low frequency range (up to 1 MHz), which makes them suitable especially for electric field probes and very low frequency reception among amateur-radio operators.

Fast operational amplifiers are available for frequencies up to 1 GHz. Therefore, they are suitable for wide range of applications including M-sequence radars. Example of differential amplifier with fast operational amplifiers is shown in fig. 6.

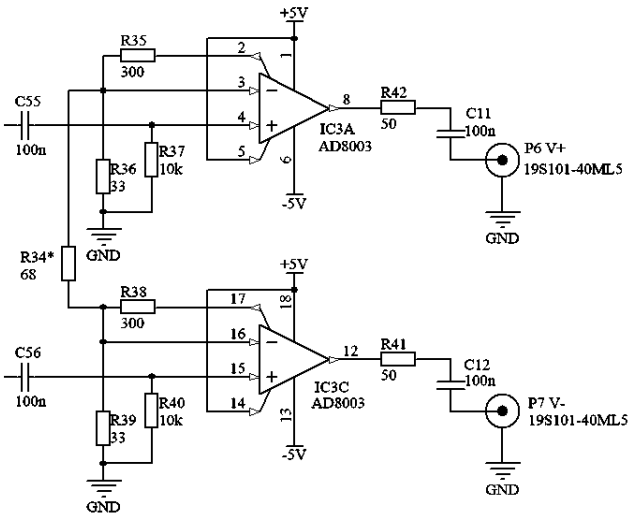

Fig. 6 Short dipole active circuit with operational amplifiers

IV. Conclusion

As shown above and proven by references, a lot of research has been done in the area of electrically short radiators for non-sinusoidal waveforms. From the 1980s pioneering times of H. F. Harmuth whose ideas have found wide acceptance in the non-sinusoidal electrodynamics area, till current research led mainly by Ukrainian scientists around G. P. Pochanin, the research has concentrated mainly on radiating short pulses. However, M-sequence radiation by these antennas and appropriate active circuits were not deeply examined till now. LCR and short dipole fed directly by a differential coaxial line is proposed by Sachs in [20] and simple active circuits are designed in [21]. The most appropriate active circuits, although designed for pulse radiation but suitable also for M-sequence signals are listed in this article according to the current literature.

At present, the LCR has limited practical applications. As we have shown, the structure and electrical properties of the LCR such as high inductance and electromagnetic coupling between the antenna elements present considerable challenges to the antenna engineer [8]. This is especially true for continuous M-sequence radiation, because there is no relaxation time between pulses to relieve the energy stored in the near magnetic field. However, with an active driver designed properly, results of previous research are promising.

Short dipoles and monopoles are widely used as electric field probes and tuned narrowband antennas for handheld communication equipment. Although their theory of operation is well known, they are not widely spread in UWB radar applications. Use of the short dipole in its basic configuration with active driver for both transmitting and receiving UWB signals is also a challenging task.

From the above mentioned facts we can conclude that electrically short active antennas may be a very valuable solution for UWB M-sequence ground-penetrating radars to minimize antennas dimensions and costs. However, intensive research is needed not only in the area of electrically short radiators themselves, but it is necessary to examine these antennas together with active circuits connected to them. Such an approach gives the antenna designer totally new view on antenna properties in terms of both time- and frequency domain characteristics.

Acknowledgment

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Advanced visual and non-visual approaches in estimating the parameters of multi-dimensional objects of real-world scene

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***Abstract*—In this paper the findings of the research on visual and non-visual estimation of real scene object, having as the focus the human body, are presented. Several approaches in the field of visual estimation from the single still image are explored, while the author proposes own approach to the estimation of parameters through the camera calibration process. The other approach, non-visual, is dealing with the proposal of own hardware experimental solution for extraction of the real-world data. The human body description format (HBDF) is proposed as a part of the overall research, bearing in mind the requirement to create standardized entry of human body visual parameters. The experimental verification proves the proposed methods valid. Synthesis of HBDF and selected approaches was carried out.**

***Keywords*—calibrated camera, camera, human body description format, non-calibrated camera, visual estimation.**

I. Introduction

Measurements of human body were carried out way before the advent of computerized machines. Having human body dimensional parameters is essential to multiple areas of industry. This data case be used, in case of computer science, for development of like-like character or skeleton model. Human body, whether in photograph or real world has various dimensional characteristics. These can be measured, in terms of digitization process, both directly or indirectly.

Indirect measurement in our case is the extraction of human body parameters from the single still image, i.e. single photograph. Several approaches will be considered and described as a part of this research. The first part of this paper is devoted to the visual-based extraction process.

Direct extraction is more straightforward, specific device is required to carry out the direct measurement process. There is no existing solution that would be directly focused on the extraction of anthropometric data. For this reason, such experimental device is proposed and experimentally verified.

The data entry and structure of data has great importance in understanding of content. Based on prior communication with standardization organizations it was found out that no format or language for description of human body parameters exist. There is, however, ISO for the measurement process of anthropometric data. This standard was considered in the research and on the most part of the proposal of HBDF is based on this ISO standard.

II. Visual Approaches in Estimating Parameters

Two cases of the visual approaches are covered, first the calibrated and later the non-calibrated camera. Each of these was experimentally verified. The primal goal is the extraction of dimensional information with focus on human body parameters, i.e. distances between specific joints visible on human body (only in utilization with HBDF). As the input to a system, in all cases, is considered only single image. However, note that calibration procedure might be possible.

A. Calibrated Camera Environment

Intrinsic or extrinsic camera parameters, or the information of the scene are known or extractable. Detection process is not the principal focus and thus was bypassed with the input requirements to a system, these are *background* of scene and *person with the background*. The detection processed can be omitted having these two input images, since the background subtraction can be deployed.

Two approaches are proposed in this research, the extraction of *angles* and related extraction of *distance*.

Extraction of angles presumes having on the input the vertical field of view of camera (VFOV). Knowing the VFOV allows to determine the other angles, specifically angle of the person in the image. Formulas for the calculation of angles were set up in the research process. Along with the information on the angles, the information of height of person from the image is relevant. Lowest point of image to human body (or bounding box surrounding the body) and height of box are required along with VFOV. One other parameter is also required – distance. Need of having exact distance from the camera resulted in proposal of methods for extraction of the distance from the image, based on calibration procedure.

Extraction of distance is following the proposed calibration procedure and includes the analogous cases having static *horizon* or *static* camera. Due to comparable methods in calibration the static *horizon* is primarily covered.

Having static horizon presumes presence of the reference horizon in the image, i.e. horizontal line p can be constructed and is parallel to the image width. The relevant input (or extracted data) from the image is the distance between the lowest point of calibration object and the horizontal line, denoted as d_h. This position from the horizontal line is of linear

nature in terms of the changing distance from the static horizon to the size of object in pixels. The calibration factor C_f that is ratio of real size of object to pixel size is introduced to enable universal utilization, since polynomial function can be extracted based on several distances from the image. Specifically, three distances furthest, middle, and closest were considered. The AruCo markers were utilized as calibration object. Having the calibration procedure with three initial images, where the distance from the static horizon is extracted, outputs the polynomial function, which is used on real images for the estimation of distance

B. Non-Calibrated Camera Environment

In case of non-calibrated camera, the information extractable from the scene is very limited and also no information on the camera parameters is known. Several approaches were considered. First, utilization of body proportions, which yielded poor results due to changes in geographical distribution of human beings and also due to changes in sex. Another approach considers utilization of vanishing line and points. This approach provides better results – in case of one vanishing point deviation of 16 mm and in case of two vanishing point 32 mm. Algorithm for the extraction using vanishing was proposed following the prior researches [1], [2].

C. Depth Camera

Depth camera was considered, even though having dynamic nature to measurement, since it introduces new dimension, i.e. depth. Moreover, it allows extraction of multiple human body parameters. In the prior researches only height of person was considered. Depth camera, while utilizing prebuild skeletal model, uses over 20 parameters to build skeletal model. Formulas for calculation of distances between these parameters were set and experimental verification was carried out.

III. Non-Visual Approach in Estimating Parameters

The principal goal of the estimation of parameters in non-visual manner includes proposal of pilot experimental hardware device. Such device is to enable extraction of real data of specific user and further enable creation of user database and provide way of structure data entry. Device is to have analogous functionalities to traditional analog anthropometric devices. The design is to enable measurements of distances between joints and provide digitized input and data storage. Based on experimental implementation and related verification, the precision of device is comparable to traditional tape meter. There are many utilizations for such device, e.g. ergonomics, tailoring, statistical data collection and also it is to be utilized in proposed HBDF that is introduced next.

IV. Human Body Description Format

Need of having format for visual description of human body parameters fills the gap in this area, as was also confirmed by the major standardization organizations (W3C, ISO, IEEE). In the current state of the research is the format only merely a concept that may in later research result as human body description language (HBDL). Two principal data inputs are presumed in this phase of research: *ISO 7250* and *tailoring* data. The specific parameters were selected, following the comparative analysis of parameters utilized in both formats.

The proposal of ISO-based measurement, being in a main focus, represents the parameters in form of weighted pseudograph, where graph V is made of set of vertices, (u,v) is the order pair, denoted as E. Each parameter is representing one vertex that may contain self-loop (v,v), which is representing the circumferences. Most of the measurements are directly measured (principally vertices), the weights of graph $w(e)$ are in majority of cases calculated based on proposed formulae.

Another way of representation is in form of 16x16 symmetric matrix. Also, compressed matrix formats were proposed due to large matrix sparsity of over 90 percent. Possibility of traversing the graph and calculating the distances is through the distance matrix, which is based on adjacency matrix. The overall proposal is storing data in form of proposed XML dialect. For this dialect, the XML scheme was created.

V. Conclusion

In the presented research, multiple approaches to estimation of human body parameters were proposed. Extraction of angles is considered as the best approach having error of up to 1% (> 20 mm). However, the most visible limitation is the need of having known distance. In case of the distance approach the estimated error is up to 1.47% (> 25 mm). Utilization of vanishing points was considered as most relevant in case of uncalibrated camera, having deviation of up to 1.5 percent (> 25 mm). In this specific case limitations are conditions of scene and need of having the reference height. Experimental verification in case of depth camera yielded error of 1% (> 17 mm) and up to 30 mm for other human body parameters. Major contribution is the proposal of human body description format (HBDF) for structure entry of visual human body parameters. Pilot experiments were carried out and prove the usability of HBDF in estimation of several parameters in the extraction of angles (I.) and also in conjunction with proposed computerized electronic device. Selected parts of research are published in [3], [4] and [5].

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An unconventional acquisition and compression method for biomedical signals

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***Abstract*— This paper is a summarisational article in the range of 2 pages, which is the summarization of my work for the past year of post gradual study. Main research task is aimed on application of the compressed sensing in acquisition of biomedical signals. Although some other interesting tasks were solved too, including improvement in the decomposition of multiexponential signals.**

***Keywords*— Compressed sensing, AIC, biomedical signals, summarization.**

I. Introduction

Compressed sensing (CS) [1] is an interesting method used to outmaneuver the need for fulfilling a Nyquist-Shanon-Kotelnikov sampling theorem while performing a signal acquisition process. This is usually done using so-called analog-to-information converters (AICs) that are able to directly convert the analog signal into some kind of compressed digital information. This information is of much lower size than the signal sampled at Nyquist rate using a conventional analog-to-digital converter (ADC) would be. When it comes to biomedical signals the main advantage of this method should be the reduction of data rate at the output of wireless health-monitoring sensors. Hence a power consumption of transmitter is reduced and the battery life of sensor is enhanced. Moreover the compression done by CS is computationally undemanding in comparison with common data compression techniques. In certain types of AICs there is even no digital computation going on. The most difficult task of this method is the signal recovery where beside the suitable recovery method usually a great computation power is needed. Recovery is done at the receiver site where the energy constraints are not critical. Finally it is necessary to mention that the CS can be applied only to so-called sparse signals.

II. Compressed sensing

Assume the input signal

$$f(t)=\sum_{n=1}^{N}\alpha_n\psi_n(t), \qquad (0)$$

here $\psi_n(t)$ are the known basis functions and α_n are the expansion coefficients. If there are only few expansion coefficients with values significantly greater than zero then we call $f(t)$ a sparse signal. Now it is possible to perform a CS on such signal, using a random modulation AIC for example.

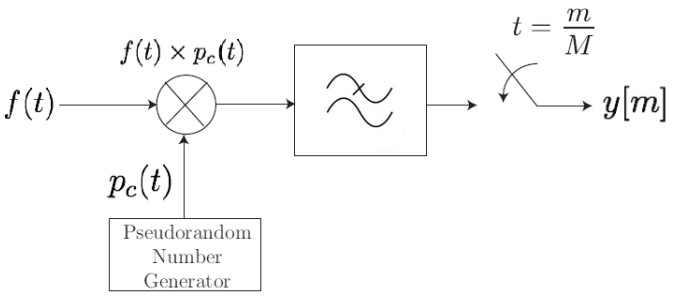

Fig. 1. A random demodulation AIC architecture

As it can be seen in fig.1 the input signal is firstly multiplied by an analog signal containing a pseudorandom sequence composed of ±1 values which should change at least at the Nyquist rate of the input signal. This procedure is going to mess up the input signal in such a way that its frequency components are going to spread in spectra. The result of multiplication is then filtered by a low-pass filter and sampled using a conventional ADC but at much lower sampling rate than the rate in which Mr. Nyquist would probably sample.

Implementation of such AIC looks very nice and simple until it comes to the recovery of input signal. Now the knowledge of sparsity domain and pseudorandom sequence is needed as well as a very good computer model of the entire real AIC used to acquire information including all the uncertainties of analog circuits. Using this model the optimization algorithm with very well defined objective function takes place to find the signal which yields the same output information as the one acquired by real AIC. The objective should be to find the minimum number of nonzero α_n coefficients including their values in sparse domain. If the output information of both real and modeled AICs is matched then the input signal was successfully recovered.

There was nothing done before with this because it is quite new and this particular implementation of the AIC was according to the literature available rarely successfully used to acquire a biomedical signal.

III. Tasks solved in previous year

A. CS of ECG signal

First approach on solving CS was to find in which transform domain is the electrocardiogram (ECG) signal sparse. Trying several wavelets we found that the optimal approach for representing an ECG is using a Symlet 3 wavelet. After a discrete wavelet transform discarding all the

coefficients with values not so much greater than zero only about 50-60 coefficients have left. These were just enough to represent ECG wave well enough so that no error in signal could be actually seen after the inverse transform by an unaided eye.

Next approach was simulating a random demodulation AIC and reconstructing acquired undersampled ECG signal in wavelet domain using differential evolution algorithm. This was absolutely not working according to the theory described in [2] and [3]. The objective function of minimizing the L_1 norm defined as a sum of α_n is not useful for wavelet domain at all. It does not work well even after several modifications which I have tried including the coefficient weighting. Fortunately I have already found some other approach of ECG reconstruction in the time domain just hoping it will work.

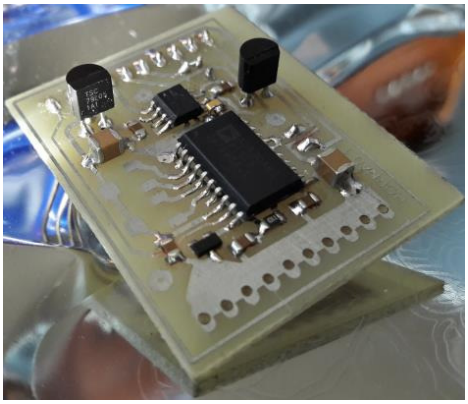

Fig. 2. The "Hornád 1" – our first experimental prototype of random demodulation AIC

Meanwhile as there is need to make some real experiments we also created a working prototype of random demodulation AIC which can be seen in fig. 2. For better recognition it was named "Hornád 1". Basically it is nothing but a modulator and a switching capacitor low pass filter. The generator of pseudorandom sequence and ADC is made using a DAQ board. If this will work properly then we are going to replace the DAQ board using some microcontroller to make it more compact.

B. Decomposition of multiexponential signals

Be it known that we have also made some improvements in the previously solved problems of multiexponential signal decomposition using a Prony-like method [4]. The main disadvantage of this method was that it was sensitive to the superimposed and quantization noise of the input signal so we simply used a digital filter to get rid of it. We proposed few types of filters: averaging, integrating and a combination of both. Surprisingly the simplest averaging filter was the best one. Using this improved method we have made analysis of dielectric absorption on real capacitors decomposing the record of their discharge current into particular exponential components. According to experiments the worst capacitor was for sure a well-known ugly brown-colored Tesla metalized paper one, so we immediately knew that our method works correctly as this was the only capacitor where even 12 exponentials were not enough to describe its discharge current.

Knowing parameters of some real capacitors in [5] there was a try to investigate whether the dielectric absorption has an influence on the integral nonlinearity of a dual-slope integrating ADC. The result was that it has a bad influence concluding that the dielectric absorption has to be taken in consideration although manufacturers of these ADCs rarely describe the recommended parameters of integrating capacitor in detail while it is the only external component.

C. Other tasks solved

One of the first things solved previous year include helping to prepare tasks and measuring stands for exercises of completely new subject named "The signal and communication interfaces" so I was very glad that some old products of my work [6] are finally going to be practically used.

Of other maintenance-mainly engineering tasks maybe I should mention the hacking of OKI C5600 laser printer in our office (now it thinks it has a brand new belt installed although it has not since the new belts are no longer in production) and repairing several devices including the Tesla BM642 universal counter from Lab III. because it worked rather as a smoke generator instead of frequency counting.

IV. WHAT IS GOING TO BE SOLVED

The main problem going to be solved is to put the CS with ECG signal into practical working condition further also using the "Hornád 1" AIC. The first thing is to try reconstructing the ECG signal in the time domain using some good mathematical model. It seems that using a model is even sparser as when wavelet transform is being used. If that would not work even after implementing some of the improvements which are planned then a major change in the implementation will take place.

ACKNOWLEDGMENT

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I would like to thank also to my colleagues Ing. Andráš and Ing. Hajduk for support while solving these CS recovery tasks which will hopefully work properly someday.

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Analysis of cognitive radio in Wi-fi networks

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***Abstract*—This paper brings the basic view of cognitive radio (CR) technology on channel selection, spectrum sensing in CR, compared with spectrum sensing in Wi-fi. Wireless devices don't use effective available spectrum. Communication between devices has a lot of free spaces (holes), where the medium is idle and it is nothing sending. There is always communication between more than just two devices at the same time, this leads to interference between them. CR should solve this problem with adaptively using not only secondary (unlicensed) frequencies, but also using primary (licence) frequencies for communication between devices. Primary frequencies can take only other devices, if there are no active communications. With this technology secondary users (SU) can communicate in the spectrum, where primary users (PU) operate. CR devices need to monitor the spectrum around device, because spectrum sensing is about to use the available spaces (holes) in frequency to send data. SU monitor the spectrum to vacate primary spectrum, if one of the PU wants to start a communication. Cognitive radio needs to adaptively with not very long delay calculate assignment channels to nodes in the network. The first group is with a proactive method, where is the constantly spectrum sense, then store all information and calculate channel assignment. The second group is a reactive method where the calculation begins only when it is requested from nodes.**

***Keywords*—available spectrum, cognitive radio, primary users, secondary users, spectrum sensing.**

I. Introduction

Every device would like to be connected to the internet at the same time, but it isn't very simple. The technology that should solve this problem is Cognitive radio (CR) [1] which will use more effectively limited available spectrum. CR is able to change parameters of the mobile antenna based on the environment around them and parameters of other devices [2]. Limited spectrum is one of the problems in CR, another and a very important one is primary and SU. PU use licensed frequency for services, which they use and they can't be interrupted by SU in any circumstances. SU monitor the spectrum around them and when they have the opportunity to use unlicensed, or licensed space in frequency, they will send data throughout it. Users don't distinguish if there is a CR transmit or PU transmit, the device can just distinguish the presence of a signal in the medium. The mobile operator pays for his own rights for some licensed frequencies, they are called license (primary) spectrum for PU. These channels in traditional (origin version) communication technology are fixed and only PU can use them. CR is about to let the SU approach these channels adaptively for sending data, but only if they observe one of the most important rules: if the PU is on a frequency, or start the process of connection to medium on that frequency, SU need to immediately vacate spectrum. SU will send data with a delay through the only available unlicensed channel.

II. Cognitive radio principle

The author in book [3] describes all important facts to understand this topic. How will device manage the available channels? Which method is used and how they communicate to obtain a channel for data sending, but at the same time, they wouldn't interfere with each other. The main problem in Wi-fi will be how devices split the available channels. Wi-fi is a very popular technology nowadays and it is also free. On the other hand, there are also PU, who are users connected to the router or AP. SU will be other devices not connected to this network. The author in article [4] describes spectrum sensing in CR through the game theory.

CR technology is present not only in Wi-fi networks, but also in ad hoc networks. Ad hoc or opportunistic network works on the principle where every device is equal to each other. The network doesn't have a router or Access Point in this topology, as it is in a typical network with a router and wireless stations. Network topology with no AP makes stations equal to no master device, so every device needs to sense spectrum (frequency) around itself and to decide when and how it will choose the right channel, without limiting others by it's choice. Ad hoc networks are working in places where are no infrastructure (disaster places), in cities or in the university campus, where students can send data only through mobile stations, no AP as a master device. Devices are equal, so they can sense neighbours only in their Wi-fi range. Communication is delayed. Data routing is possible with multiple different paths, so in different time will receive same data [5]. Ad hoc with CR will help to improve not only the changing channel, but it will also more efficiently distribute the available spectrum for sending data. [6]

A. Spectrum sensing in CR

The first thing in general what device needs to do when it wants to start communication with another wireless device is a spectrum sensing around it. Sensing is detected not only on the transmitter side, but also on receiver side so basically on every device in the network. Equally important is the management of the spectrum functionality that sets parameters such as available frequency for communications, information about local availability [7]. Transmitter (non-cooperative) detection is usually used as a detector for spectrum sensing in CR, based on weak received PU signal from the local user observation.

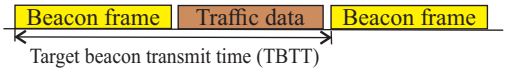

Fig. 1. Beacon frame period of transmit

The first type of detector is Matched filter detection. This type of detection is optimal for static Gaussian noise, because it maximises the received signal-to-noise ratio. The advantage of it is highly processed of gain due to the coherence. On the other hand, the detector needs to know some data about PU signal characteristics (a type of modulation, pulse shape, packet format).

The second group is energy detection, where threshold λ is used. This value decides if there is a signal in the spectrum or not. Adjustment of this value is not very easy. It is influenced by the distance, interference around device, environment noise. It is suitable for unknown signals, because only noise power is noted.

The third group is cyclostationary feature detection which uses characteristics of the signal (wave carrier, pulse trains, hopping sequence) that appears in some periods. Detection is based on the analysing function of spectral correlation.

B. Spectrum sensing in Wi-fi

Wi-fi exists with AP (router), it manages all important information also predicts and tries to avoid collision where devices are communicating. Next one is networked with no AP so every device is equal. Spectrum sensing in Wi-fi technology is shown on Fig. 2. and it has two main groups based on used method, how the device will obtain important information:

1) Passive sensing
2) Active sensing

Passive sensing is the listening beacon from AP in IEEE 802.11 standards. This method uses zero energy, while scanning the medium. Scanning channel goes across all available channels in Europe from 1 to 13. The device sets channel frequency and remains on this channel frequency for certain time (listen time). During the listen time Beacon frame is transmitted from AP in periods to save energy detailed frame. The period between transmitting beacon is called Target beacon transmit time (TBTT) shown in Fig. 1. The channel medium isn't idle between two beacon frame transmits. Free space is used to send data to a device which has already the successful connection, until the next beacon frame will be transmitted. As the device can move the beacon needs to transmit periodically. When the device will go too far from actual AP, the handoff will connect this device to another AP with stronger signal strength. During a time when the beacon frame is transmitted as a broadcast, all devices in this channel will receive this frame. If a device wants to obtain this frame needed to listen during this period. The beacon is transmitted in the periods so the device awakes only in a time slots, when this frame will be transmitted [8], [9].

Active sensing: this type needs to use energy to transmit probe request frame. The device sets up the frequency of the channel in the same way as it is done in passive sensing. This will go step by step through the last one. Station sets up the channel frequency, then transmits the request to the environment. If there is an AP on this channel frequency, it has to obtain this request and immediately send back a probe response. Probe response contains information about the

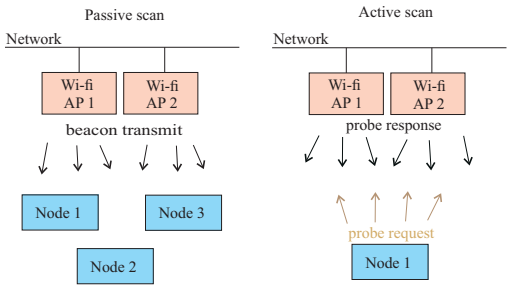

Fig. 2. Spectrum sensing in Wi-fi first one only listen frame, transmit from the device. Active is about the process of transmitting and receiving frames between devices.

station. This response will be transmitted if AP is present in the actual sensing channel. The connection process between the two devices will progress with authentication and association. After these processes will be successful in every step, they can start sending actual data.

Sensing is not only about which of these methods to choose, but also about time intervals, especially in wireless networks, where is no database about the network as it is in wired. Wireless networks need to predict, if the other devices are transmitting data and trying to avoid a collision in communication. Time slots are used to help to prevent it.

C. Time intervals in sensing spectrum

The frame can be send randomly in time by the different station, but in that case, there will be the burst of frames, which can't be recognised in the receive station. Intervals are used to make the order of sending data across the environments through unlicensed space especially in wireless networks. Sending frames one by one isn't the only reason to use intervals, another one is information about the time that the station needs to stay in current mode. These intervals are divided based on the duration length. Each interval consists of time slots. The author of article [10] describes each of these slots. The frame information is used in signalling data in the connection process between two devices.

1) PHY determines: the short interframe space (SIFS),
2) PHY determines: the slot time,
3) the priority interframe space (PIFS),
4) the distributed interframe space (DIFS),
5) the extended interframe space (EIFS).

Duration of SIFS interval is the shortest, it is used between RTS/CTS frames or between CTS and data sending. The authors [11] describes an RTS/CTS method which particularly solves the problems about the collision, but in a network with multiple nodes and data, sending is not enough due to several signals transmits. This time interval avoids the corruption of one type of frame with another different frame (sending data or acknowledge – ACK). Free space between frames provides better receiving quality on the receiver side. Slot time is the next interval, slightly longer in time. Next one is PIFS, its duration consists of SIFS duration with one another time slot. DIFS duration consists of SIFS duration plus two-time slots. It is applied when the station decides to start the sensing the medium. After this waiting time, there is a random backoff time interval to prevent collision between sending the frames. The longest interval is EIFS. It doesn't have a fixed value of the intervals. The EIFS is applied only if there is an erroneous transmission of frames. Duration each of these intervals is

based on which type of modulation method is used to access the medium. Some of them are FHSS (Frequency Hopping Spread Spectrum), OFDM (Orthogonal Frequency Division Multiplexing), DSSS (Direct Sequence Spread Spectrum).

Random backoff interval generates random numbers of time slots which the station needs to wait until the start of the next sensing on the medium. This time is different in each generating so if there are more stations they don't have the same time when they want to sense the medium for activity. When we take look at the area 500 m x 500 m, there isn't a problem if two devices sensing the same channel frequency if their distances are far enough from their Wi-fi range.

III. Procedure of channel selection with Cognitive radio in Wi-fi

Nodes start the process of scanning wireless spectrum, after finishing the process and obtaining all available APs in the range they start the process of sending signalling data to selected APs. This operation includes the exchange of signalling requests and the response frames between node and AP. After that the last step in process of connection is established, there is no need to select the channel, because data are sent only through the same channel all the time. This is connection in Wi-fi with AP. On the other hand CR will change channels to make use the free spaces in the spectrum. Channel selection is closely related to the media access method. Wi-fi uses the distributed coordination function (DCF) in CSMA, and point coordination function (PCF). When a device needs to make a poll request to access to the medium, it will make this request and send it to the AP or device which will accept or deny this demand. Both of these methods have benefits and disadvantages, but if we want to use only the benefits of them, we have to use the hybrid coordination function (HCF). The detailed description of time intervals in the previous paragraphs explains that main function of them are preventing interference or unreadable frames on both sides of communications. Sending signals from the device is based on different types of antennas (omnidirectional, beamforming).

A. Approach in Wi-fi

Networks with constantly changing parameters, topology and range between specific two nodes based on their movement need to have a channel selection algorithm with not very long duration of calculating, because if nodes move and change their location the information will not be current in node status. There exist two main groups of approach which should solve the problem that occurs:

1) reactive,
2) proactive.

The reactive approach starts to work only when a problem occurs. This method is not very effective comparing to the time needed to calculate the necessary solution, because this method starts finding solutions only when there is a request to do it. The first step that method will do is to sense and store important information about the network. After that starts an algorithm to solve the problem. If we don't care so much about the time and steps which are needed to calculate the solution reactive approach is the right one for designing our algorithm.

A proactive approach is focused on preventing and eliminating problems before they even appear. This approach contains much information about the network, such as neighbours of nodes, channels assigned to the PU and to the SU. Furthermore which channel the user can use, the topology of the entire network or only the section of it. The approach works constantly to calculate best solutions, so if the problem appears this approach only takes the information that it already has and sends it where it is needed.

B. Collision problems in Wi-fi

Authors in the article [12] describes another very important problem in Wi-fi technology which is the hides node problem, causing corruption of the frames. Two devices in each others range will know about each other, they can sense the signal, but if there will be a third station in the range with only one of them, the second one will be hidden. The problem will cause a collision in channel assignment, also signalling data sending across environments. The burst of the frame will not be recognised separately, so it will resend the frames again. As the authors describes, there exist three types of loosing frames:

1) collisions (synchronous interference),
2) hidden nodes (asynchronous interference),
3) channel impairments.

First interference is caused by nodes in each other range, when they transmit at the same time as the others. Signals will collide together, become bursts of noise. If an appropriate access method is used, like the code division multiple access (CDMA), there can be more than one signal transmissions on the same medium. All nodes have their own transmission code, it allows them to take from the burst of signals only the part which belongs to them. Hidden nodes problem appears in multi-channel networks. It is a problem which needs to be solved effectively, due to the nowadays phase called Internet of things-style of network devices. Cognitive radio tries to fill the unlicensed spaces (holes) to effectively send data through the spectrum, with this problem it will be hard to fulfill its goal. If free space will sense two devices at the same time, they will send signal data or data itself through this free space together. At the receiver side the signal will not contain only the information from one node as it should be, but also from the other nodes. It will result in a new process of finding free space to send data again, it will lead to data delay (signalling data). The last group of frame corruption or loosing important information is channel impairments. The signal is influenced by fading due to the distance, or buildings in the area of the signal transmit. A city has many buildings so the signal will not be only reflected from them, but also faded. When a collision appears there is always the entire frame corrupted, not only part of it.

C. CORAL platform

Cognitive radio-aware learning (CORAL) is one method of how to select the channel described by authors in [13], this technology is of IEEE 802.11 standards, due to that Wi-fi is flexible and low-cost technology. This platform is sensing data every time, also the calculation will be the same so this method has a proactive approach. Cognitive radio is a technology where channels are dynamically assigned depending on the changing parameters in Wi-fi networks where the mobile nodes are moving in almost every second or at least one of them [14]. CORAL is able to handle different type of architectures such as point to point, point to multipoint and mesh.

The platform consists of four basic elements, where every block has a concrete task to do:

1) Cognitive radio network management system (CRNMS),
2) CORAL terminals,
3) Radio environment awareness map (REAM),
4) Cognitive engines (CE).

CRNMS is an interface for users to configure and also to control networks. This block receives a sensing data from CORAL nodes (devices) and stores them.

CORAL terminals consist of nodes with two antennas, one for sensing and the second one for transmitting. Traditional Wi-fi networks have nodes with only one antenna for transmit or receive, it depends on the actual situation, so nodes need to change antenna between transmitting or receiving mode. Changing modes require information about the network.

The important block is REAM which is the database of all sensing data from the entire environment around nodes that nodes collect. Based on the information from this database can node (terminal) choose the right channel with the small influence of other nodes. The database contains information about nodes in the network so it needs some time to obtain it, also these are store information about the traffic in the network. REAM contains also information about PU such as IP, MAC address, channels. Collecting much information isn't very effective due to complicated calculations for choosing the right channel. There has to be a balance between information needed and time that the algorithm needs to finish one process of channel assignment. The cognitive engine block takes information from REAM and analyses it.

D. Frame information in Wi-fi used to select channel

Books [8], [9] describe very detailed information on wireless technologies, due to the version of 802.11 standard frame contains not same information in every block of the frame used in Wi-fi. Beacon frame contains information which is used in the next analysis of the network, as beacon interval, BSS ID and supported rates. The supported rates contain 8 octets, where every octet represents the data rates. Nodes or routers depend on the type of the network which they will use for their next step in assigning the information needed to proceed the process of channel assignment. Also scheduling the time and select the right device to transmit, or be ready to receive the data through the environments. A frame has also information about the used method of transmitting to another device. The device which receives a beacon from that frame obtains information about the network as if there is an AP or it is an ad hoc network, where every device is equal. This information about the type of networks is on the block called IBSS parameter set. Capability information block in the beacon is full of important information, one of them is ESS with equal importance as the IBSS information. When ESS is set to 1 so it's an infrastructure network with a router (AP) with the task to control and set up access to nodes in the local network. It also sets the channel for them or the settings needed to successfully send or receive data through networks. Almost all controls are in router task, the node needs just to successfully connect to the router. IBSS, in this case, will be 0. When IBSS is set to 1 and ESS is 0 it means that the network is without infrastructure (ad hoc), so every device needs to handle all settings that are needed to send data and connect to another device by itself.

IV. Conclusion

Cognitive radio is the technology of the future when everything will be part of the Internet. The new phase is Internet of Things where are many devices trying to get access to the limited available spectrum. This article is about the basic principles of cognitive radio. My research in this field will continue and focus on the management of channel selection in Wi-fi technology. It will be also about designing an appropriate channel selection method with minimum interference from other devices in the same field. Designing new methods of channel selection for nodes. Then compared them with two possible ways of their selection. First one is reactive where the searching and selecting process begins on demand and the second method is proactive, where the process is running and calculating tables and information all the time.

Acknowledgment

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Analyzing of heat transfer and joints quality in power electronic devices

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***Abstract*—This paper is a summarization of last year of post gradual study. Solved research tasks and published articles are presented here. The aim of this paper is investigation of flow analysis, thermal resistance, and distribution of coolant inside multilayer LTCC (Low Temperature Cofired Ceramic) with embedded channels and thermal vias for power electronic devices. Accurate prediction of temperature's power semiconductor devices in power electronic circuits is important for obtain optimum designs and estimating reliability level. The second aim of this paper is investigation concerning the behavior and joint quality of various die attachment materials on DBC**

***Keywords*—LTCC, thermal vias, cooling channels, die attach.**

I. INTRODUCTION

The electronic devices used in power electronic applications have to work properly in a very wide temperature range from 20 to 200°C. Great temperature changes generate large thermal stress that affects solder joint reliability. Therefore, solder failure risk analysis has be carried out at the preliminary stage of the manufacturing and design of the new materials, devices and technologies [1].

One of the most important requirement in design of high power modules is to achieve a good thermal conductivity for cooling power chips and a dielectric strength for the isolation between semiconductor devices (IGBTs, diodes, thyristors) and device package. Various methods of temperature control can be used to regulation working temperature of the power electronic modules. For this reason is necessary study the thermal management of the power devices.

Study of die attach layer material is an important question for two main reasons that influence a functionality of die attach: mechanical fixation between the die and DBC (Direct Bonded Copper) substrate and dissipation of heat generated in the die.

II. INITIAL STATUS

In nowadays is thermal management in electronic serious problem with the electronics miniaturization, high performance and high reliability. The component density and chip integration in small packages case high power loss in small area and growing amount of heat flux cross substrate. High working temperature changes in electronic packages generate large thermal stress that affect solder joints as well as electronic devices reliability. Standard power devices consist of several materials and parts such as copper terminals, DBC substrates, die attach, base plate, semiconductors and heatsinks. For this reason, the thermal management analysis is important step in development new materials, technologies and devices in electronic [2].

Low working temperature of power modules is necessary to achieve high quality and reliability of die attachment. For this purpose in power electronics use ceramic substrates which have high thermal conductivity, high dielectric strength and high reliability. LTCC substrate with channels and thermal vias allows a promising solution for decreasing the limited temperature from the critical components and improving heat dissipation inside electronic devices [3]

After studying theoretical background about materials, substrates, joints and manufacturing technological steps in power electronic we want to solve these PhD theses:

1. Analysis of thermal joints in power electronic which are created by three technological process.
2. Development, characterization and application of new types of solder alloys prepared by rapid cooling technique and joints created from them.
3. Development, characterization and application of new types of silver sintering joints.
4. Development of prototype of power electronic module based on multilayer LTCC substrate with internal channels.
5. Standard and new developed power electronics' joints analysis after thermal cycling and current loading.

III. SOLVED TASKS IN PREVIOUS YEAR

A. Simulation of cooling efficiency via miniaturized channels in multilayer LTCC for power electronics

The aim of this work is detailed investigation of thermal resistance, flow analysis and distribution of coolant as well as thermal distribution inside multilayer LTCC substrates with embedded channels for power electronic devices by simulation software. For this reason four various structures of internal channels in the multilayer LTCC substrates were designed and simulated. The impact of the volume flow, structures of channels, and power loss of chip was simulated, calculated and analyzed by using the simulation software Mentor

Graphics FloEFD™. The structure, size and location of channels have the significant impact on thermal resistance, pressure of coolant as well as the effectivity of cooling power components (chips) that can be placed on the top of LTCC substrate. The main contribution of this paper is thermal analyze, optimization and impact of 4 various cooling channels embedded in LTCC multilayer structure. Paper investigate, the effect of volume flow in cooling channels for achieving the least thermal resistance of LTCC substrate that is loaded by power thermal chips. Paper shows on the impact of the first chips' thermal load on the second chip as well as. This possible new technology could ensure in the case of practical realization effective cooling and increasing reliability of high power modules.

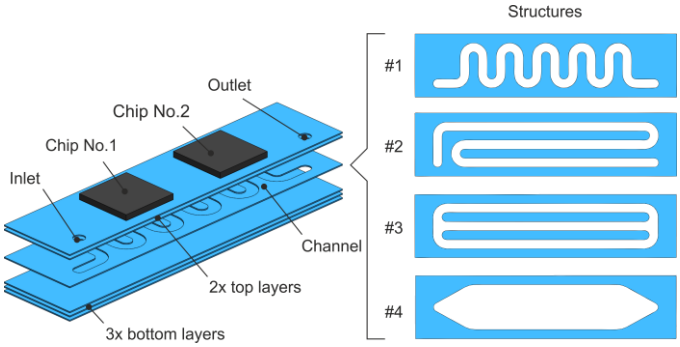

Fig. 1. Multilayer structure of LTCC substrate with embedded microchannels

B. *Possibility of cooling via channels embedded in multilayer LTCC*

For the purpose of analyzing thermal management in LTCC substrates with embedded cooling channels we realized the cooling substrates with different cross section and thermal vias. LTCC multilayer structures with integrated channel and thermal vias were designed, simulated and realized. The impact of the volume flow of coolant, structures of multilayer substrate, thermal vias and power loss of die on thermal resistance of substrate was simulated, analyzed and calculated by using the simulation software Mentor Graphic FloEFD™. The thermal vias application in multilayer cooling structure and volume flow rate of coolant have the significant impact on thermal resistance, pressure of coolant as well as the effectivity of cooling chips which can be placed on LTCC substrate.

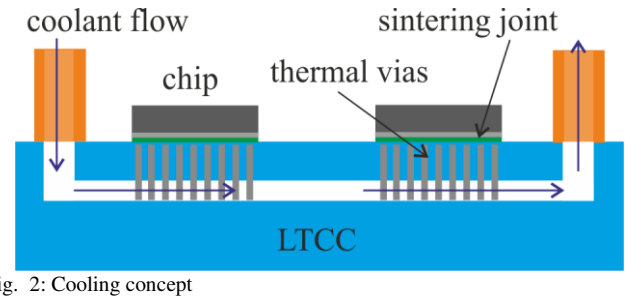

Fig. 2: Cooling concept

For experiments has been used a commercially available material Green tape DuPont 951®. Both of created multilayer substrates consist of 6 layer of DuPont 951® with 0.214 mm thickness, 1 LTCC dielectric layer on top of substrate with 50 µm thickness and 2 SiC chips placed by silver sintering joints on the top of dielectric layer with dimensions 10 x 10 x 1 mm^3. The main role of SiC chips is generating thermal load and measuring of temperature changes. The fluidic channel is integrated in the third layer from the top in first type (#1) of substrate. In the second design (#2) of multilayered cooling structure thermal vias inside the substrate and the fluidic channels are used, which improves the transport of the heat from the chip into the channel and coolant. The cross section area of channel is 7 x 0.214 mm^2. The presented cooling concept is shown in Fig. 2.

C. *Study of Die Attachment on DBC Substrate*

Die attach in power electronic are the subject of interest because they have to fulfilled the requirements e. g. high thermal conductivity, mechanical strength, electrical conductivity and last but not least the high reliability.

We analyzed the behavior and joint quality of various die attachment materials on DBC (Direct Bonded Copper) Al2O3 based substrates. A comparative study of influence of various material on joint quality was realized. Experimental samples were reflowed in a vacuum reflow oven, and in a vapour phase soldering (VPS) chamber. For the first time were applied new developed solder materials (Sn96.5Ag3.5 and Sn95.9Cu3In1Ag0.1 alloys) in the form of thin ribbons. The new metals and alloys were prepared by the rapid solidification technique – melt spinning at a cooling rate of 10^6 °C.s^{-1}. First measurements show that the new materials meet high requirements on joints properties: better thermal conductivity and mechanical strengths, less voids and better thermo-mechanical reliability. The thin ribbons based on the melt spinning (rapidly cooled) materials are a promising candidate for use in the die attachment in power electronics.

Fig. 3: New developed ribbon of the Sn96.5Ag3.5 alloy

IV. FUTURE (WORK)

In the future work we will focus on design, simulation and fabrication of power module based on LTCC substrate with different structure of internal channels with embedded thermal vias.

Our experiments will be oriented to analyzing high thermal conductivity and reliability silver sintering joints using in power electronic devices.

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Applications of Transparent Intensional Logic and Montague Intensional Logic on Natural Language Sentences: A Review

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***Abstract*—This article is dedicated to a brief introduction to logical analysis of the natural language. The natural language is, in semantics, analysed by transparent intensional logic and Montague intensional logic. In the first part of this article, both approaches (which are part of natural language processing), will be introduced, allowing to rewrite logical records from the natural language to the form of logical structures. In the latter part, I compare them in several respects with a goal to review which system is more expressive. And lastly, I think about computer science areas, in which the certain intensional logics could be applied.**

***Keywords*—constructions, logical analysis of the natural language, montague intensional logic, possible worlds, transparent intensional logic**

I. Introduction

Since natural languages (languages spoken in human interactions) are created spontaneously, it is not easy to formally describe or algorithmize them. The logical structure of natural languages is not identical to grammatical structure and therefore the meaning must be revealed by analysis. Logical analysis of a natural language (LANL) [1] is a subtopic of natural language processing. LANL reconstructs meanings of natural language terms through logical and semantic means. The idea of LANL is to find semantic regularities of language and to reveal the dependency between the meaning of a compound term and its subexpressions [2]. The aim of LANL is to formalize ideational image of reality, which is encoded in a certain compound term.

We distinguish two major logical methods to represent the logical structure of natural language terms:

- Montague Intensional Logic (MIL)
- Transparent Intensional Logic (TIL)

II. Natural language processing and LANL

Natural language processing (NLP) [3] is a field of computer science, computational linguistics and artificial intelligence. It deals with issues of analysis and generation of natural language expressions. At the same time, it is important to ensure a certain degree of understanding of the natural languages for computers. For the mentioned aim we use special methods for transformation of natural language sentences into the formal language (artificial language of logic) that it adequately semantically represents. This process is called regimentation. The structures of formal language are independent on the particular natural language.

Natural language is a comprehensive unit that represents more levels of language [4]. We distinguish:

- the lowest level is phonetics and phonology - this is the level of sounds. Object of study in phonetics are all human sounds, phonology analyzes classified sounds,
- morphology - this level is a part of the grammar. Morphology analyzes words and their forms,
- syntax - this level is a part of the grammar. Syntax analyzes structure of sentences and clauses,
- lexicology- this level represents open system focused on vocabulary,
- semantics - this is the level of meaning of various kind - meaning of words, the relationship between their meanings and the way such meanings are combined to give the meaning of sentences,
- the highest level is pragmatics - this level is focused on the use of language in specific situations.

In NLP, it is necessary to analyze the different language levels and for each level it is necessary to know the data already processed at lower levels. The biggest problem of the natural language analysis is the ambiguity of its terms (phonetic, morphological, syntactic, etc.). The ambiguity is alleviated by language analysis on levels higher than the investigated level. MIL and TIL were designed to capture the meanings of terms, therefore we can say that LANL belongs to the semantic analysis.

A. Possible worlds, extension and intension

Possible worlds can be described as worlds alternative to the real world. Possible world represents the maximum consistent (conflictless) set of alternative facts. According to Saul Kripke [5], possible worlds serve to distinguish true sentences from false sentences and the meaning of the sentence is a function of a set of possible worlds in a set of truth values. The semantics of a term depends on the current world. Modal logic work with possible worlds. These, together with the semantics of possible worlds, are mainly developed in the seventies of last century, due to the influence of generative linguistics and analytical philosophy and they are becoming an effective LANL tool.

The semantics of linguistic terms is traditionally a two-component. Gottlob Frege in Über Sinnund Bedeutung article

[6] introduces the concept "sense" (Sinn) and "reference" (Bedeutung). The sense of a term is a way of marking an object and the marked object is the reference. Rudolf Carnap [7] later replaces reference/sense duality by extension/intension. Intension is actually extension relativized to the possible world – to know the intension of a term means to be able to determine its extension in all possible worlds. Therefore, it is possible to say that intensional logic is logic that can cross the border of one (current) world with which extensional logic operates.

TIL and MIL builds on well-known Frege's triangle of reference (Fig. 1). But they represent sense of the term differently.

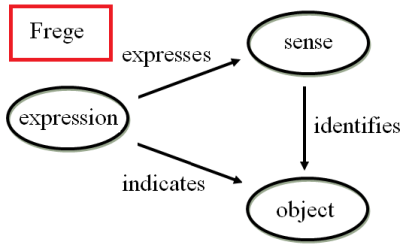

Figure 1. Frege describes the relationship between the natural language term, its meaning and the object to which the term refers. The natural language term marks a particular object by expressing its meaning. This real object that the term refers to is called the reference.

B. Why not first order predicate logic

First order predicate logic (FOPL) [8] is not the right tool for LANL – it is not sufficiently expressive and does not allow accurate analysis of natural language sentences. It is not advisable to use it on LANL even though there are calculi for it, which are semantically correct and complete (all FOPL tautologies of the calculus are provable), and partially decidable (the veracity of formula can be demonstrated in a finite number of steps). These properties are desirable in terms of automation and FOPL meets them in contrast to the TIL and MIL. However, FOPL has, considering LANL, following shortcomings [9]:

- FOPL is an example of extensional logic – all of its true sentences have the same reference, which is unacceptable,
- It is not possible to capture the difference between supposition de dicto and de re of examined term,
- It is not a modal, temporal or dynamic logic – unable to analyze expressions such as "sometimes", cannot solve problems of "non-existence".

Although FOLP is not sufficient for LANL, its calculi are a suitable tool for the analysis of certain formal languages.

III. Montague intensional logic

The founder of logical-linguistic approach MIL is Richard Montague [10], [11], American mathematician, philosopher and generative linguist. He believed that between natural and formal languages can be treated in the same way because there is no difference among them. Montague in his revolutionary approach argues that the syntax and semantics of natural and formal languages are described by the only theory that is mathematically precise. In the article 'Universal grammar' [12], Montague creates a semantic model of universal syntax and semantics that is demonstrated on two examples – first he applies his theory to formal languages and then to a natural language sentence.

MIL uses the concept of possible worlds [13], where not only a specific status of the current world, but the potential conditions of all possible worlds are considered too. FOPL formalisms and typed λ-calculus are used in it. According to λ-calculus, it is possible to reduce logical operations to create a function of abstraction and apply a function to arguments – that enables conversion or combination of multiple predicate.

Montague interprets expressions of English language fragment. To work with other languages, it is necessary to update MIL (correct dictionary, categories, syntactic and semantic rules according to the needs of the examined natural language). However, his theory is not very suitable for languages with free word order (e.g. Slovak).

MIL consists of two components – syntactic and semantic [14]. Syntactic analysis (parsing) describes which subexpressions are needed for a natural language term, which syntax rules were used in the creation of the term and in what order certain subexpressions enter the syntactic derivation. Semantic analysis is based on information obtained by parsing – meaning of a compound term is a subject of its syntax.

Because of syntactically ambiguous natural language expressions, Montague interprets the meaning of natural language indirectly by preformed artificial language of intensional logic. [15] Categorical grammar terms and definition of mapping from set of natural language categories to a set of intensional language logical types are used in the Montague model. All meanings of the ambiguous expression are sequentially sought-after and for each meaning its syntactic derivation is specially formulated. Subsequently, a corresponding logical expression of intensional logic is created for each syntactic derivation through semantic rules. In this way, it is possible to translate any expression from any category described in MIL to an expression in the form of a formal language.

Montague extends extensional logic – an expression in MIL has contexts in which it describes its extension and contexts in which it describes its intension. By this process, Montague creates the so-called local intensional approach [16], where the logical analysis of language is carried out in two stages:

1) In the first step, known as Montague grammar, the natural language is reconstructed through formal categorical language without semantics.
2) In the second step, called Montague intensional logic translation, this language is translated into formal language of intensional logic that has semantics. It being understood that all expressions, while translated, are at first "intensionalised" but part of them are, later on, "extensionalised" back.

Extensional semantics in MIL expand slightly on intensions. Muntague defines 2 operators:

- unary operator $^\wedge$ to increase the intension - it modifies the expression E to expression whose extension is intension E. It can be said that the operator $^\wedge$ "intensionalize",
- unary operator $^\vee$ (inverse to $^\wedge$) to decrease the intension.

The following rules are applied:

$$\begin{aligned} ext \parallel^\wedge E \parallel &= int \parallel E \parallel, \\ int \parallel^\vee E \parallel &= ext \parallel E \parallel, \\ \parallel^{\wedge\vee} E \parallel &= \parallel^{\vee\wedge} E \parallel = \parallel E \parallel, \end{aligned} \tag{1}$$

where E is expression, int intension a ext extension.

While Montague deemed all expressions to be extensional and used intensions only when necessary, natural language

expressions have, in some contexts, strictly intensional, and in other contexts strictly extensional character.

IV. Transparent intensional logic

TIL theory was created by Pavel Tichy [17], Czech logician, linguist and philosopher. It was established a year after the first publication of Montague's fundamental work (therefore in 1971). TIL [18] is a higher-order logic with ramified hierarchy of types and it became the basis for a procedural semantics. It is extremely expressive system – it can sufficiently capture most of the voice phenomena in their logical form.

TIL is, just like MIL, a modal logic (possible worlds logic) with temporal parameters. It means that the truth of expressions depends not only on the world, but also on the point in time, since the truth of expressions can over time change within the world.

Interpretation of an expression is obtained directly in TIL without any intermediate step in the form of translation to an artificial intensional language. To understand compound expression of natural language, it is necessary to know the meaning of its individual components, which we call the principle of compositionality (or universal transparency). Tichy uses a certain kind of procedure whose arguments are part of the examined term and he receives the original meaning of the term as a whole from it. These abstract, structured and language-independent procedures are called constructions [19] and he treats them as a meaning of the expression. Constructions, detectable at λ-calculus typed apparatus, fulfil 2 functions:

- They demonstrate from what parts the compound term is made.
- They construct the final representation of natural language expression.

The term "construction" may evoke an association with the concept of algorithm that consists of a sequence of steps and leads to a result. More specifically, however, it has been described as "manual of instructions", since it contains a manual for constructing the object that the term refers to.

Six types of constructions are defined within TIL. The basic constructions sufficient to analyze most of the natural language expressions are variable ($''x''$), trivialization ($''^0X''$), composition ($''[MN]''$) and closure ($''\lambda x.M''$). The first two types of constructions provide arguments for further constructions, the closure creates functions and the composition is the application of a function to arguments. In specific cases, the constructions execution ($''^1X''$) and double execution ($''^2X''$) are used.

Tichy in his logic, just like Montague, uses certain modification of typed λ-calculus. Unlike Montague, he doesn't interpret the function by λ-calculus, but he uses it in a procedure that constructs this function. Thus, λ-terms in TIL are not only the syntactic symbols, but they are particular objects, records of constructions of certain entities.

Entities in TIL are specific or abstract objects of analysed language. Ramified types hierarchy [20] is introduced, where the lowest typed level contains the basic objects or the easiest entities of natural language. These basic objects form intensional facility-base B whose elements are sets:

- o - set of truth values acquiring values True and False,
- ι -set of individuals – Universum, where individuals don't have to contain any empirical attribute,
- ω - set of points in time or real numbers, each real number corresponds to one point, and vice versa,
- τ - set of possible worlds – the logical space.

Types are not linguistic entities such as in the categorical grammar (verbs, nouns), but abstract objects (individuals, the truth values). The hierarchy of types is built above the base B – 1st order types are a set of partial functions above the base o, ι, τ, ω. Ramified types hierarchy determines the types of higher order. From four mentioned basic types it is possible to create any construction through its assembly and λ-abstraction.

TIL represents intensional logic in the true sense of the word. Tichy gave up the idea that the meaning of any natural language expression was primarily extension and intesion only in some specific cases. Instead, in TIL he created a global intensional approach which always takes expressions' intensions as meanings of them. It can also work with hyperintensional contexts where the function arguments are constructions themselves.

V. Comparing MIL with TIL

Tichy and Montague independently worked on a common goal – they attempted to create theories allowing the correct logical analysis of natural language expressions. Both logicians sought meanings of these expressions and they proposed a concept that describes how meanings of expressions can be formally represented. Their intensional logics which they created on those ideas are not at all similar and a large number of substantial differences can be found among them.

Montague introduces intensional logic language in which he translates natural language expressions at first and then interprets them. Montague considered such an indirect method to represent the meaning of the expressions to be comprehensible. Tichy receives the meaning of an expression by means of direct method through constructions (abstract extralinguistic objects). Montague's indirect method was criticized by Tichy [21], interpretation of an expression through an artificial language was, according to him, not an appropriate solution. It's because the artificial language must then be interpreted and that creates the impression of dragging the issue in a closed circle.

The meaning of an expression in MIL is its extension, intension is used only in specific contexts and that is why this logic is sometimes called contextualistic. This means that the meaning of an expression necessarily depends on the context. According to Montague, every natural language expression has two values - extension and intension. To switch between them, he uses special operators $^{\wedge\vee}$. TIL, on the other hand, is an anti-contextualistic logic. The meaning is, regardless of the context, always its intensity. According to Tichy's critics, the cost for using extensional/intensional operators $^{\wedge\vee}$ in Montague's analysis was the loss of compositionality principle.

Montague presented principles of his logic on the fragment of English. He created syntax (and semantic) rules that are closely related to English grammar. His theory can not be considered as universal as it is created for a particular source language. To expand its narrow fragment of English, it would be necessary to, once again, define the dictionary of used lexical units, syntactic and semantic rules. To use a different source language to English, it would be necessary to completely transform his model. TIL is more expressive system [22] that is not tied to any natural language, so when changing

the language, there is no need for the transformation of his model.

Despite these shortages, MILL is the most widely used approach in the LANL, with a very positive international response. On the other hand, TIL remain on the outskirts of logical and linguistic discourse for many years. This may be because Montague theory was formed first as well as the technical body of TIL is extremely complicated.

Fig. 2 shows a scheme of Frege's triangle of reference modified by Montague's MIL principles and Tichy's TIL principles.

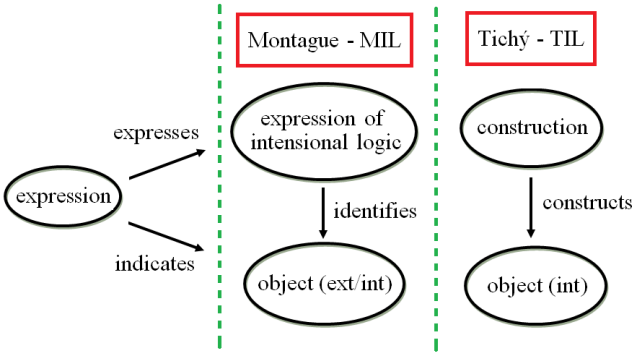

Figure 2. In MIL, the expression is formulated by using formal language of intensional logic and it indicates intension or extension of the subject (depending on context). In TIL, the expression is formulated by constructions and it always indicates intension of the subject.

VI. Application of MIL and TIL in Computer Science

Montague tragically died in 1971, only a year after the publication of the first and second of his three essential works (the third one was published posthumously in 1973). For this reason, it is not clear in what application areas he saw applying of his MIL. We rank Tichy among the analytical philosophers, but in his last, unfortunately unfinished publication "Meaning-Driven Grammar", he outlined the analysis of a comprehensive fragment of the English language while awaiting its subsequent computer processing. Ales Horak [23] (from Brno's Center for natural language processing, which is dedicated to promoting the TIL) flourished this idea and created an implementation of an efficient syntactic analyser of Czech sentences.

I see this as an interesting opportunity to propose a similar semantic machine which could be a further extension (or transformation) of the interpreter of predicate-linear formulas Vorvan [24], developed at Department of Computers and Informatics. It would be necessary to create a link between predicate linear logic (PLL) and TIL beforehand (for example through their intensional nature and use of predicates).

Another alternative (following the link between PLL and TIL) would be locating the natural language sentences into a logical space and time of Ludics theory (as I did it with MIL in [25]).

VII. Conclusion

In this article, I presented two basic steams of LANL - TIL and MIL. It was certain already in their brief characterization that mentioned intensional logics are in many respects considerably different. Their comparison showed that TIL is indeed underestimated logic, but its features make it the most expressive and the finest tool of LANL, and also a suitable base for my further research. The vision is to connect TIL with predicate linear logic - this connection would allow me to apply Ludics theory principles on natural language sentences, which puts them in a logical space and time.

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Applicative Supercombinator Form of Context-free Grammar

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***Abstract*—This paper briefly presents our work and shows our advancement in the field of context-free grammar (CFG) abstraction. This papers serves as a brief summary of authors work during last year. The first part of this paper describes what has already been achieved. The second part builds on these findings, where we explain how any CFG can be abstracted into applicative supercombinator form. We have applied this algorithm on various samples. The results show significant reduction of grammar elements. We conclude this paper with our further research propositions and plans.**

***Keywords*—Applicative grammar, Grammar abstraction, Formal grammars, Supercombinator form**

I. Introduction

With grammar's help we can generate parsers [1] and hence create entire new formal languages. However we might look at this concept from the opposite perspective. We can infer a grammar from already existing, even non-formal, language [2]. The inference can be achieved using various methods, as Stevenson and Cordy show in [3].

Our research correlates with the field of grammar inference. Although our goal is not the creation of a new method for inference but rather to create abstract grammar form, that can be used in tandem with inference methods to achieve better results of the process as a whole. By process we mean improving inference method's speed or space efficiency, or even improving it in terms of inferred grammar.

We have experimented with regular grammars [4], [5] in the past. We have envisioned and created an applicative supercombinator form, that can decompose input grammar into reusable applicative parts. Supercombinators are nothing but plain lambda expressions enriched with grammar operators. In case of the regular grammars, the operations used are concatenation, alternative and transitive closure (a.k.a. Kleene star operator). Further on, we presented how we can consider context-free grammars as an input source for abstraction [6]. Such was the state of our research one year ago. Since then we have already implemented method that can decompose any CFG into supercombinator form.

The main contributions of this paper are:

- We briefly show our extended lambda calculus in the section II.
- In the section III we present short description of the CFG to supercombinator form algorithm.
- We present already published results of our experiments in the section IV, where we point out the advantages of our approach.

TABLE I
SUPERCOMBINATOR FORM OF GRAMMAR $a(b)^*|c$.

name	supercombinator body	possible args.
L^0	$\lambda x_1.x_1$	$\{a, b, c\}$
L^1	$\lambda x_1.(L^0\ x_1)^*$	$\{b\}$
L^{top}	$\lambda x_1.\lambda x_2.\lambda x_3.L^0\ x_1 + L^1\ x_2 \vert L^0\ x_3$	$\{a\,b\,c\}$

II. Solved problems

Supercombinator is a combinator that is composed only of other (super) combinators and constants. Grammar operations are constants, so we can extend the lambda calculus with them. Should we consider EBNF as our starting point, we have four operations there: **Concatenation** (no visible operator), **Alternative** (|), **Closure** ( )*) and **Option** [1] ( )?).

The supercombinator form of the expression $a(b)^*|c$ is shown in the Table II [2]. We see, that each form contains supercombinator that we call L^0. It is an ordinary identity function and it is the end point where our applicative form meets actual data, that have been previously abstracted (third column of Table II). Other supercombinators represent basic decomposed parts of input grammar. The supercombinator called L^{top} is roughly equivalent to the starting non terminal symbol of a grammar. From it we can produce entire input grammar, just by applying it to all of its arguments. The arguments are the part of our supercombinator structure. They are represented as a non redundant set, that is being applied to the top supercombinator.

III. Context-free grammar

We have presented algorithm version that can convert any context free grammar into supercombinator form in [7]. In this section we are going to show brief explanation of how it works.

A thing to realize, when dealing with CFGs is, that each rule is processed separately into subset of supercombinators, but it cannot be processed without the connections to other rules in mind. Since a rule A can call a rule B and that rule B can call a rule C etc., we need to construct a graph, where we can track the connections across the entire grammar. Graph

[1]Although this is a part of standard EBNF definition, we can abstract it as parameterized closure.

[2]Notice, that we have used $+$ operator for sequencing, since empty operator (a space) and . (a dot) are both part of standard lambda calculus.

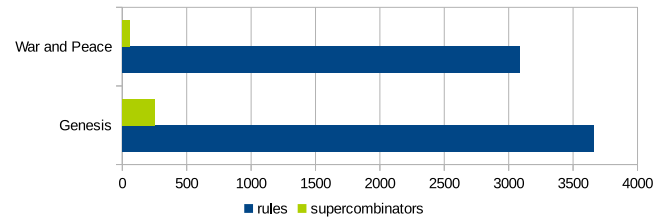

Fig. 1. Grammar rule and supercombinator amount comparison.

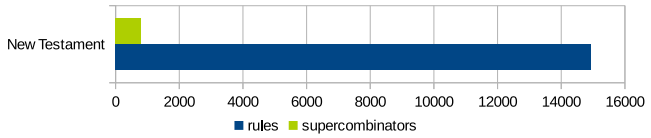

Fig. 2. Grammar rule and supercombinator amount comparison.

can deal with cyclic rules, which may occur in a CFG. Take this following sample grammar for example:

$$A \rightarrow C\ a\ C\ B \tag{1}$$
$$B \rightarrow C\ b \tag{2}$$
$$C \rightarrow c\ B \tag{3}$$

This grammar contains a cycle. Rule A corresponds to the top supercombinator and in order to obtain all arguments possible for this supercombinator, we need to construct a graph. Since all nodes are accessible from A, all terminals are possible arguments of this grammar. In other cases it may not be so, as we see that from both rules B and C, only b and c terminals are accessible.

Knowing arguments is important to find out the arity of supercombinator. Then we can construct forms from each rule separately, replacing non-terminal references by temporary structures. They are replaced only when we have all rules transformed. Then we can start merging identical supercombinators together. We do that, because we do not want to have any two same supercombinators in our set. Merging is an iterative operation, since in each merge iteration some supercombinator might be merged and all references to it are updated. Hence in the next iteration equal supercombinators may occur, that were different in the previous step, as they were carrying different references inside of them.

IV. Experimental results

We have tested our method on various samples. In [7] we have used first 24 chapters of War and Peace by Tolstoy and the whole Book of Genesis from the King James Bible. However, as you might notice, our method performs on grammars, not on the plain text. We have processed our samples with Sequitur algorithm first.

Sequitur algorithm [8] is an algorithm that identifies reoccurring hierarchical structures in plain text and abstracts them into one CFG, hence achieves a level of some text compression. Our process goes one step further where it is applied on Sequitur generated grammar. There it achieves even further reduction of elements. The Fig. 1 shows the reduction of elements used on above mentioned samples. Comparing supercombinators with grammar rules might not seem to be relevant at first sight, but the arguments are a part of our form the same way they are a part of rules. They are merely abstracted and stored non-redundantly. As we have mentioned above in the section II, by the application of arguments we obtain the original rules.

Our algorithm had few drawbacks, that hampered its performance. When used on larger sample, such as The New Testament, memory would bloat and process would slow down to a crawl. By using simpler libraries for graphs and optimizing the process using efficient Haskell data structures we have improved our algorithm. It could process the entire New Testament after the improvements. The results (published in [9]) remained consistent with previous findings, as Fig. 2 shows.

V. Future work

Our work with Sequitur grammar proved, that the concept works. This was an important step within our research. Yet the application of our approach is not evident from the results. The biggest issue lies with the input grammar itself. Our process depends on it after all. The next step for us is to find a suitable grammar that our algorithm can abstract. Currently we are working with Combinatory Categorial Grammars [10], which are excellent for natural language processing. This research is however still unfinished, therefore unpublished.

VI. Conclusion

From this paper we can see that we have created an algorithm that transforms any CFG into applicative supercombinator form. Applied to Sequitur CFG we have shown that it reduces the amount of grammar elements by abstracting repeating structural parts of grammar.

Acknowledgment

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Automatic traffic sign inventory system with use of optical correlator

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***Abstract*—This article deals with a use of optical correlator in automatic traffic signs inventory system. Optical correlator replaces an electronic devices processing and provides the Fourier transform an optical way. Preprocessing of image into binary form is the necessary step for optical image processing. Traffic signs inventory needs an information about position of signs. The exact position of traffic signs is corrected according to relative position of traffic sign and vehicle. Automatic inventory system also allows to evaluate a traffic signs condition. This evaluation is based on traffic sign proportion and homogenity of textures of individual color parts.**

***Keywords*—Optical correlator, traffic sign, preprocessing, GPS position, condition**

I. Introduction

Use of application with optical data processing increasingly grows at present. Optical data devices can bypass the speed and volume limits which starts to appear in electronic devices. Automatic inventory is the necessary process for effective management of transport communication. In addition to the evidence of installed traffic signs it's possible to create reports and to evaluate the failure rate of traffic signs.

This article represents a structure of proposed inventory system based on optical processing. In the first part a block scheme of inventory system and individual function blocks are described. The second part deals with an image preprocessing for input of optical correlator. There are explained methods of preprocessing, which are potentially suitable for our purpose. Also there are evaluated a benefits and shortcomings for use in inventory system we found during our research. The third part deals with specifying a traffic sign position. There is also explained correction of received GPS coordinates. The fourth part contains information about evaluation of traffic sign condition. There are explained parameters and principals of traffic sign condition evaluation we have discovered and proposed in the last year. In the end of article there are evaluated used methods of data processing in inventory process. Also, there are described a new potentialy suitable approaches and recommendations for future work.

II. Block scheme of automatic inventory system

Automatic traffic signs inventory system consists from several functional parts. The main part is a software core. It controls a communication between optical correlator and peripherals and evaluates obtained data.

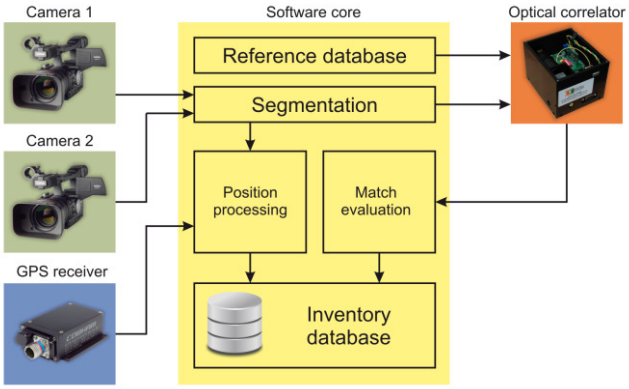

Fig. 1. Block scheme of automatic traffic signs inventory system

A. Optical correlator

Optical correlator is device which is able to provide the optical Fourier transform of two-dimensional image through optical way. It's main advantage is high speed processing. Output of optical correlator is similarity rate of compared and reference sample represented by correlation peaks in output image.[3]

B. Stereoscopic camera system

The main role of cameras in stereoscopic system is to record images of real scene. Areas of interest are then compared with reference samples by optical correlator. Stereoscopic arrangement allows to calculate a distance of recorded objects without need of additional peripheral for distance measurement.

C. GPS receiver

GPS receiver provides a GPS coordinates calculation at regular intervals during the inventory process. It is placed in close distance from camera system.

III. Image preprocessing methods

Since the optical correlator uses a coherent light for it's operation, only images in binary form can be used as an input of correlator. Ouput of camera system are full-color images with objects from whole field of vision. It's needed to extract the wanted shapes of traffic signs and convert them into the binary form.

A. Color filtering

Color filtering is a basic method for extracting an individual shapes representing a traffic signs. It is based on color parts selection from input scene according to specified

conditions. Reliability of this method depends on used color model. The most suitable model for this purpose is HLS, because it matches the human eye perception. This method is basically sufficient for our purpose, but can be supplemented by other methods to increase a conversion quality.

B. Edge detection

This method is based on searching places with sharp change of color. It allows to define shapes of areas with homogenous color surfaces. The input parameter of this method is minimum size of gradient which specifies the wanted border of homogenous color area. Since the operation doesn't depend on specific colors, it can't be used independently for our purpose. But it can be used as an additional method to color filter.

C. Depth map

Depth map is an output of stereoscopic analysis of two images recorded by relatively shifted cameras. The result of this analysis are differences between distances of individual objects. It's possible to extract shapes of objects, which should be similar with shapes obtained in color filtering. The similarity rate of these shapes can confirm or reject the correct recognition of traffic sign from optical correlator. Despite the advantages, this method is useless for high speed processing in real time because of it's computing power requirements.[3]

D. Structure from motion

Interframe motion analysis can also produce a shapes of individual objects. It's necessary to specify a key parameters of input scene. These parameters are subsequently paired between frames. It allows to get a direction and speed of objects motion. Output bursts of motion vectors with similar direction and size represents individual objects. This method isn't suitable for environments with homogenous background, but camera with high dynamic resolution can solve this restriction.[1]

IV. Exact determination of traffic sign position

Automatic inventory process requires to know the exact position of recognized traffic signs. Position is described using a GPS coordinates. Since, the GPS receiver is placed in a vehicle, it is needed to additionaly correct these coordinates.

A. Relative position between vehicle and traffic sign

For success correction it's necessary to know a distance between traffic sign and vehicle. It's also needed to get an actual horizontal orientation. It can be obtained from GPS receiver with built-in compass, or computed from difference between two following GPS coordinates.

B. Stereoscopic measurement

Stereoscopy is suitable and effective method for distance measurement. In this case, there isn't any special requirement to computing power. The distance computation is based on simple difference between two corresponding binary shapes in stereoscopic images. The final distance is calculated according to calibration curve, which represents the relation between a pixel difference and real distance.[4][5]

V. Traffic sign status evaluation

The last described inventory system function is evaluation of traffic sign condition. It's based on two parameters. The first one is the proportion of recorded traffic sign. Second parameter is a texture homogenity and validity of pictograms.

A. Traffic sign proportion

Each type of traffic sign has defined the exact dimensions. Proportion of pixels representing traffic sign dimensions should be the same (or highly similar) as proportion of ideal dimensions. If this condition doesn't apply, we can suppose, the traffic sign isn't oriented correctly.

B. Surface color homogenity

Different type of defect is corrosion or similar material degradation. This defect can be detected by monitoring a color homogenity. If tolerance of color variation is exceeded, we can assume, the condition of traffic sign is unsuitable.

C. Inner content reference comparison

The next type of defect are additional paintings or sticks. We can detect this type of defect by comparison of inner pictograms and white surfaces. If the main shape of traffic sign is recognized, but pictogram is unknown, it's highly possible the sign is damaged.

VI. Conclusion

Described processing methods are suitable candidates for increasing the quality and reliability of inventory process in automatic inventory system. Depth maps and space configuration based validation can significantly helps to decide if the wanted traffic sign exists or not. It's important for cases, when the color filtering results aren't reliable or belong to limit range of decision. The accuracy of position specification and the success of defect recognition depend on sensitivity and resolution of used devices. Using a more accurate devices it's possible to overcome the described disadvantages of image processing methods. [2]

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Basic concept of the active wideband integrated directional couplers

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***Abstract*—The aim of this article is to outline the basic idea about a method how to directly in the monolithic integrated structure effectively distribute and split the transmitted or received stimulus Ultra-WideBand (UWB) signals. Proposed concept of the active wideband directional coupler is described in some details. Active directional coupler was developed and manufactured as an ASIC circuit in $0,35\ \mu m$ SiGe BiCMOS technology. The main advantages of this solution are particularly wide bandwidth, good directivity and low value of the crosstalk between ports under $20\ dB$. This paper includes the outputs of the first experimental measurements.**

***Keywords*—Directional Coupler, UWB Sensor, Differential Amplifier, Detector.**

I. Introduction

In the baseline a directional coupler is a passive device usually with four ports. We can imagine it like a two simple transmission lines close to each other, as close as possible based on frequency. Since two simple transmission lines can form a directional coupler, it is particularly suitable for the use in printed circuit boards or special high frequency substrates [1]. We can use the directional couplers for coupling a small power generally narrowband signals. Most common function of directional coupler is to separate incoming from outgoing signals based on the properties (directivity). In case of passive directional couplers realized as a planar structures there are some drawbacks. Their main problem is the bandwidth. It is a big deal, because we need to use them in ultra wideband applications. If we assume realisation of UWB sensor that work in reflection mode, where the directional coupler is demanded [2]. Therefore a solution based on the active device can be suitable. Moreover possible way will be the integrated coupling element with all system components of the UWB sensor included on the one chip or package (SoC, SoP) [3].

II. Directional coupler

The later applications of the coupling elements is measurements. We can often found it in measurement systems. Also they are implemented directly in the couple measuring devices, for example VNA (Vector Network Analyser). In the path of the signals where separation of the stimulus and the reflected signal is required. The directional coupler is a device for measuring the forward and reflected waves on the transmission line. During the network measurement, a signal is driven through the directional coupler to one port of the DUT (Device Under Test). Part of the incident signal is sampled by the directional coupler. On arrival at the DUT port being measured, some of the incident signal will be reflected. This reflection is again sampled by the directional coupler. This is very useful for obtaining parameters of two port device (operational amplifier, differential amplifier. etc.). Especially we can measure S parameters namely reflection coefficients, gain or isolation of the DUT.

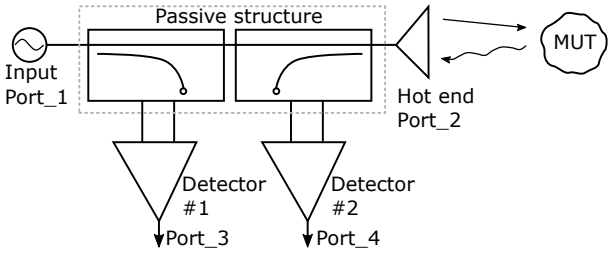

Fig. 1. Block schematic diagram of the proposed active directional coupler

There are four parameters that serve for characterisation of directional coupler (also called coupling or lumped element [4]):

- *Directivity* is the capability to transmission (relative small) power from the input to output port and the coupled port and also reject the power that can come from the through port due to reflections on this. In another worlds directivity is ability to isolate forward and backward wave.
- *Isolation*- it is the power transferred in this case (according to Fig.1) back from the output Port_2 to coupled Port_3, or from the input to coupled Port_4 when the ports Port_1 and Port_4 are terminated by 50 ohm loads and vice versa. Value of isolation has to be small as possible. The equation 1 defines the value of the isolation:

$$I = 10 \log \frac{P_{in,out}}{P_{coupled}} [dB]. \tag{1}$$

- *Coupling* gives its name to the component- directional coupler. This is the most critical parameter of any coupling element in deciding their use and application.
- *Loses*- in this case we need to suppose two types of loses. Insertion losses in path directly from the input trough the coupler. Insertion losses can be expression by the following equation:

$$L_{i2,1} = -10 \log(\frac{P_{out}}{P_{in}}) [dB]. \tag{2}$$

Part of this loss is due to some power going to the coupled port and is called coupling loss and is given by:

$$L_{c2,1} = -10\log(\frac{P_{coupled}}{P_{in}})[dB]. \quad (3)$$

III. Base concept of the active wideband directional coupler

In the Fig.1 is shown the block schematic diagram of the active directional element architecture that we use. There are two main building blocks:

- *Passive structures* based on fundamental parts e.g. resistors, capacitors or possible solution can be use the voltage control resistors (MOSFET transistors). Proposed solution employing input passive stage by interconnected resistors to the Wheatstone bridge [5]. Another mentioned way could be use varactors and tunable active inductors to synthesize the series and shunt reactances, respectively, which allows extensive electronic control of the coupling coefficient [6].
- *Active parts* or detectors. They can be realized as the buffers or differential amplifiers. Differential amplifier is a very good choice because it is always use in applications where is amplified only the difference between two input signals. The differential amplifier can be also called detector with low noise addition in the best case.

As is depicted in Fig.1, stimulus signal is transmitted trough both of couplers and emitted by the radiator. Small part of the transmitting signal is coupled via first coupler and detected on wideband detector. Second detector is used only for receiving reflected signals. On the outputs (Port_3 and Port_4) we have original and reflected version of signals for next signal processing. In this case we neglect the effect of standing wave, but in real terms we have to take into account. Standing wave is a wave in which the distribution of current, voltage, or field strength is formed by the superposition of two waves of the same frequency propagating in opposite directions.

IV. Results from experimental measurements

Measurements were made on evaluation sample of active directional coupler, realized as an experimental expansion module included only these sample and base components [2]. Results of measurements are shown in Fig.2. Since the output of the directional coupler is an differential pair, one half was matched to 50 Ω. Therefore directivity in straight ahead are not absolutely perfect. As we can see in the Fig.2, value of the directivity in case of coupled ports is a little be better. Primary application of this element is an antenna driver for the UWB sensor network. Therefore that, output is differential. It is not easy to measure parameters of devices like that, because we do not have vector network analyzer with differential ports. It can be nice to test it with using an symmetrization element (BalUn).

Isolation between coupled ports (Port_3, Port_4) and input or output ports (Port_1, Port_2) should be reach better values (waveforms s14, s12, s23). Good isolation is between coupled ports each other (curve s43). It is straightforward, because there are two independent detectors.

The active directional coupler was characterized by probing the soldered sample in evaluation module kit and measuring the corresponding four-port S parameters using a two-port network analyzer. In Fig.3 is shown an extension kit for UWB sensors with embedded ASIC structure in QFN package.

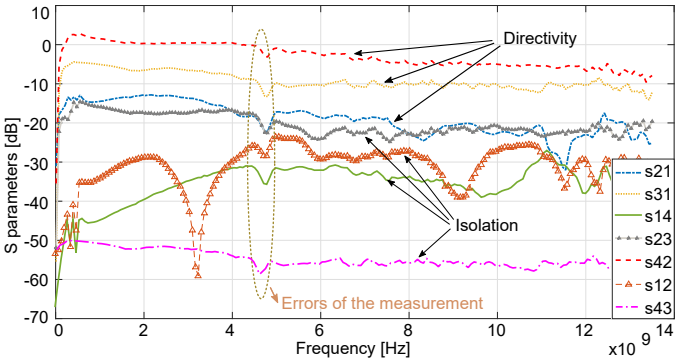

Fig. 2. Measured directivity and isolation at the single-ended output

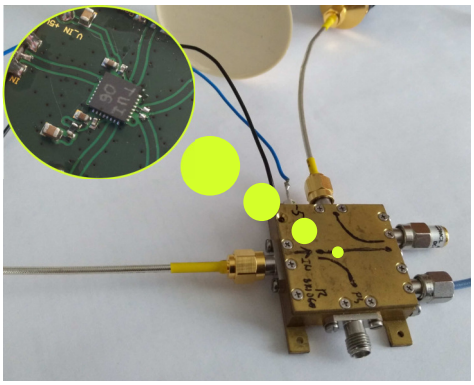

Fig. 3. Experimental measurement setup of the active directional coupler within extension module

V. Conclusion and future work

In this paper a short preview of the active directional coupler was presented. It was a first thing how to split wideband RF signals directly in the monolithic integrated structure without a microstrip line couplers techniques. The first testing and measurements steps has been performed. Future work on this structure will include a new approach to design a passive parts and redesign of the differential amplifier as detector. It will be focused to impedance matching of the input stages and noise factor reduction techniques.

Acknowledgment

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Body Recognition Based On Infrared Light and Hand Gesture Recognition Based On EMG Signal

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***Abstract* — This study brings a general view about gesture recognition which is based on measure of infrared light and electrical impulses of the muscles. Moreover, it introduces an experiment in efficiency of gesture recognition across three platforms – Microsoft Kinect for Windows, Leap motion and Myo Armband. Since these sensors are at first glance entirely different, the study is unique in the way of how the selected sensors were compared. Results which are particular and carefully recorded, finally providing our attitudes to every gesture used in the experiment.**

***Keywords* — Kinect, Leap motion, Myo Armband, Unreal Engine**

I. INTRODUCTION

Gesture recognition provide not only the controlling from distance, playing games, it also can be useful for example with presentations, also for people with some disability, because it requires less skill then mouse and keyboard configuration. Moreover, even in front of the computer the controlling becomes more intuitive. Science community soon realized some of such sensors can be a cheap substitute for expensive and huge depth imaging equipment. We are just a step away from teaching sign languages on computers, making virtual art just with our bare hands or doing long distance medical operations. The most popular motion sensors are Kinect from Microsoft, Leap Motion from Thalmic Labs, Myo Armband and Unreal Engine. Myo Armband is based on muscle tracking via eight electromyography (EMG) muscle activity sensors cooperating with a nine-axis inertial measurement unit for accelerometer, gyroscope and magnetometer – 3 axes each. It can recognize hand gesture due to cues from muscle motion [1]. Myo Armband can recognize gestures like fist, wave in and out, open hand, fingers double click and hand in relax position [2]. Microsoft Kinect performs a fusion of a regular (RGB) color camera and a depth (D) sensor, with a multi-array microphone it enables the users to interact with their computer/console using just their body and voice. Sensor make full body scan with face recognition. Kinect emits an infrared light and this deflects from the object/human. Kinect can recognize open hand, fist and lasso hand gestures. Leap Motion is 3D motion capturing device designed especially for hands and fingers tracking. Leap Motion was intended to be a human-computer interface, not general purpose 3D scanner, so it is optimized for recognizing human hands and pointy objects [3]. Unreal Engine 4 is physics-based engine which is capable of simulating rigid body dynamics, soft body dynamics, and fluid dynamics. It is designed for demanding applications such as high quality real-time rendering [4]. Its built-in support for VR development makes it easy to work with and helps with rendering complex scenes at consistently high frame rates. Although Kinect sensor can follow 6 objects and monitor their whole body, hand gestures and face impressions, reliability of results are not very satisfying. Leap Motion can recognize gestures of both hands with high accuracy [5]. Unique move sensors use Myo Armband, which is monitoring physiological changes on user hand while move or gesture is performed [6]. Users can integrate each sensor to sensor network and increase their usage with application interfaces. Fusion can be a part of CAVE systems (Cave Automatic Virtual Environment), representing fully immersive virtual reality system [7]. The CAVE provides an illusion of being surrounded by a fictional world, providing a fully interactive, scientific visualization. In order to benefit from their full potential, it is appropriate to evaluate accuracy of sensors within available programming environments (including sensor control features). Using sensor technology have big perspective, but we need to focus on analyzing reliability of gestures at creating sensor network with combination of sensors.

II. EXPERIMENT

Main goal was to evaluate the effectiveness of the four gestures – pointing, waving, hand rotation and fist gesture in set of 50 measures for each gesture with 5 different software applications for all mentioned devices. The movements were chosen because they can be categorized and recognized more easily. The movements were chosen because they can be categorized and recognized the most easily. Pointing gesture measurements were performed as aim with the cursor in the application to the desired place and monitor whether hand move cursor to intended destination [8]. Waving movement is very similar to petting an object. Armband defines the wave as bending the wrist with the hand to down or up when holding a

bit on side. In Myo Armband are that moves called wave in and wave out. For Kinect, we took the whole arm waving into account once watching the bone recognition viewing the body joints, then different crates punching activities with our arms. We took hand rotation as turning one's arm around the arm's own axis. For Kinect, there were only a few applications using hand rotation, so we rather focused at bone recognition with this gesture and watched whether the body joints of the arm are moving accordingly. With a little deviation, they copied our movements. Fist recognition we decided not only to scan the process of making and ceasing fist gesture, but also holding the gesture and performing arm motion. It is one of the most used gestures within each of the three devices. Since Leap Motion offers very accurate finger detection it sensed the closed fist or in other words the absence of the fingers very well. For Myo Armband, motion was not such a big problem, since the band tracks the muscles. There were complications when object with holding fist change muscle tension, this lead to release grip for moment. Kinect applied fist gesture mainly on holding things, similarly as Leap Motion uses the grab gesture. In some application, one can hold items with this gesture and while holding and spreading their arms, the object changes size as if it was outstretched or retracted. When waving is concerned, the results were similar, we selected Kinect for a subjective reason. Although Leap Motion had slightly better measured results in hand rotation, we selected Armband the best due to its comfortability. In fist recognition both passive and active, Leap Motion provided the best results. These results are shown in Fig. 1. Partial results were published within [9], major results were published within [10]. Each device is satisfactory in different matters. Leap Motion is best for controlling cursor in front of the computer and for fist making recognition. Long distance cursor controlling like in presentation, Armband or Kinect is better choice. As waving has different purposes and diverse ways of performance through each device, we cannot tell which one is the best. Myo Armband is best choice for hand rotating. We hope the presented experiment results as well as our attitudes will help in the future research. Accurate user and gesture recognition and sensor security is a promising course.

III. Conclusion

Analyzed sensors have their deficiencies, which is one of author targets. Main idea of this experiment and integration sensors is testing their accuracy and reliability in recognizing of environment and user gestures in different configurations. With increasing distance from sensor which is monitoring infrared light spectrum, sensor reliability is decreasing and gesture recognizing is very hard if user hand is not in direct visibility. In such case, we can increase sensor capabilities and quality of recognizing by adding additional sensor which can monitor user gestures directly from his body by accelerometer, gyroscope and magnetometer. Next step is to propose way how to combine sensors which are based on infrared light with sensors which are based on monitoring accelerometer, gyroscope, magnetometer and test and analyze possible increasing reliability of recognizing performed gestures.

Acknowledgment

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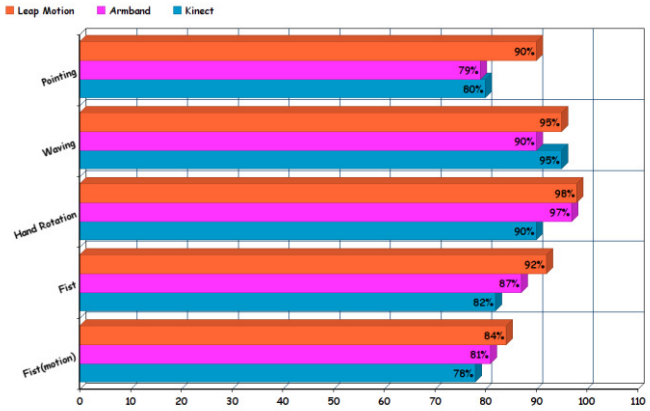

Fig. 1 A graph of efficiency of gestures across Leap Motion, Myo Armband and Microsoft Kinect

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Calculation of economic properties of the transmission line

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***Abstract* — this work deals with the transmission and distribution of electric energy focused on the calculation of operating temperature on the wire of transmission line, which is loaded by the current. Current loaded in the transmission line is limited with allowable operating temperature. The operating temperature is determined by the type of material and operating condition. From mechanical point of view the operating temperature must not exceed the allowable operating temperature of the wire. These calculations were realized by more equations. The aim of this work was simplify of calculation of operating temperature for normal operating condition and also for short circuit. Then this work considers with economic properties of transmission lines, like their annual costs and specific costs. Result of this work is also some programs for fast calculation, with using Matlab software.**

***Keywords* — economic properties, high voltage, load, operational temperature, transmission line;**

I. INTRODUCTION

Between key problems include issues of energy technologies for transmission of electric energy, the transmission loss and economy of transmission lines, as regards the technical characteristics of present high-voltage transmission systems occurs in transmission over longer distances in a significant loss of energy. One from important operating problems of the transmission lines is operational temperature, which has influence to their economic properties [1] [10]. The electric current flowing through the wire gives the rise of temperature. The losses in isolation of isolated wires or losses by surface discharges around of bare wires gives the rise of temperature too. The heat is diverted from the wire to the environment. Spread heat by conduction occurs mainly in the isolated wires and convection and radiation at the bare conductors [3] [6] [14] [16]. Whereas the maximum of the surface temperature is relative small, the share of the heat radiated by radiation is relatively small on compared to convection and conduction. The resulted operating temperature of wire is given by balance between produced heat and heat consumed to heating of the wire and heat divert to environment [2] [4] [5].

II. SIMULATION OF THE OPERATIONAL TEMPERATURE

On the Fig. 1 and Fig. 2 we can see calculated operational temperature ϑ_P in different time t. These graphs are made for current I = 2760 A. We used voltage U = 400000 V between phases for transmission line and voltage U_x = 230940 V is between phase and ground for transmission line. Initial temperature of wire ϑ_W is same than temperature of environment ϑ_E. On the Fig. 1 and Fig. 2 we can see, where is operating temperature ϑ_P of wire stabilized by balance between produced heat and heat consumed to heating of wire and heat divert to environment. Also we can see difference between three and four bundles wire. These calculations simulate results for ACSR 750/43 wire [9].

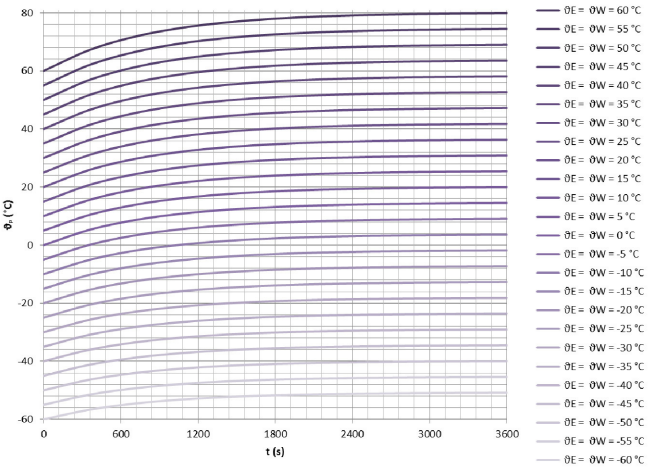

Fig. 1. Calculated temperatures for three bundles wire

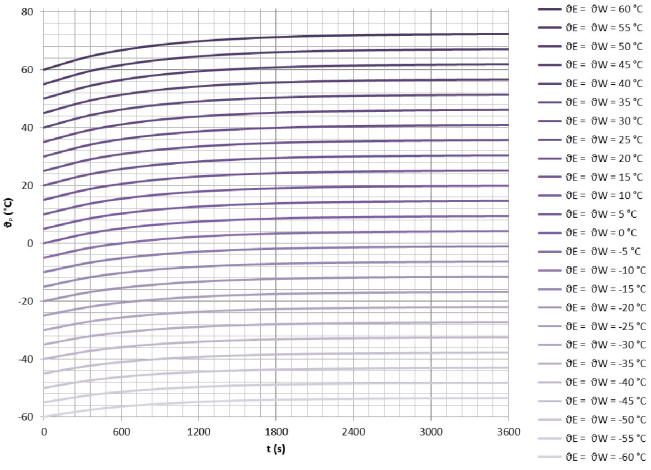

Fig. 2. Calculated temperatures for four bundles wire

III. SIMULATION OF THE ECONOMIC PROPERTIES

On the Fig. 3 and Fig. 4 we can see calculated annual costs N_{ve} and specific costs n_{ve} for different temperature of environment ϑ_E. The operational temperature ϑ_P was ascertain

in time t when was balance between produced heat and heat consumed to heating of the wire and heat divert to environment. This time was t = 3600 s. These graphs are made for power P_m = 1816574,887 kW, power factor cos φ = 0,95 and also current I = 2760 A. We can see difference between three and four bundles wire. These calculations simulate results for ACSR 750/43 wire [9].

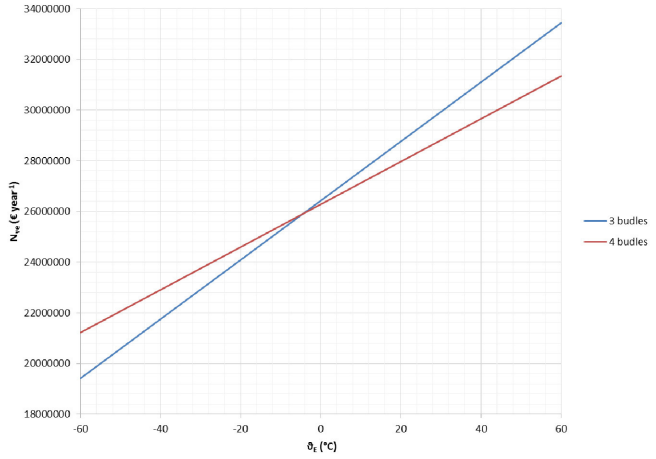

Fig. 3. Calculated annual costs

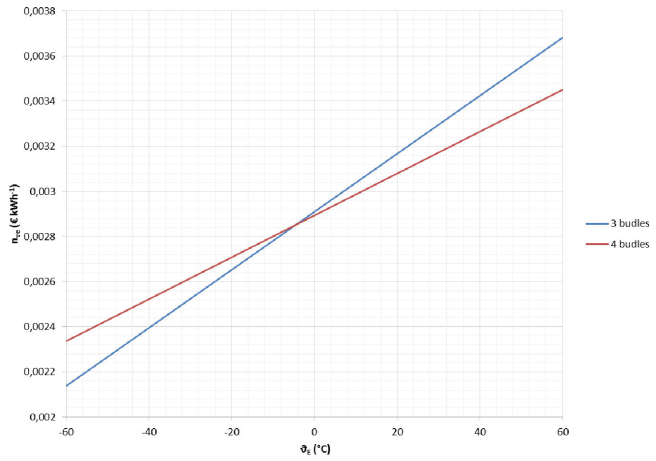

Fig. 4. Calculated specific costs

IV. Conclusion

In these graphs we can see increase of operational temperature ϑ_P in time t. The current I and voltage U_x between phase and ground, have important impact to increasing to operational temperature ϑ_P. This new simulation successfully shows influence temperature coefficient of resistance α_R to operational temperature ϑ_P. The ascertaining of operational temperature ϑ_P is important for design transmission line [7]. For the transport of electric energy with considering to technical parameters of the actual transmission lines, more than 1 percent of the energy is lost in the high voltage transmission lines for longer distances. In the future, the high voltage transmission will cooperate with renewable resources to a larger extent. Currently, there is a change to natural conditions and is expected to further increase in the temperature [10]. This means, there will be less cold winters, but hotter summers. It also changes the consumption of electric energy, which in winter will be the less heat, but in the summer the electric energy will be used to drive air conditioners for cooling buildings. Experience from countries where a large part of consumption of electric energy is used to drive air conditioners show that not all the problems associated resolved through example Smart Grid in power systems [11]. At the same, transmission systems are vulnerable to extreme atmospheric phenomena, which may destabilize in the case disturbance of the power system and cause power failure for huge areas [8] [12] [13] [15]. The operational temperature of the high voltage transmission lines has very important influence to their resistance. On the other side, resistance of the transmission lines influences their energy losses, thus the economy of their operation, and therefore the operational efficiency of the entire power system [6].

V. Further Research

On this basis, there is a presumption use of new calculations for the economy of the transmission lines assuming by changing the parameters of transmission line due to increase of the operating temperature. All of these issues create extremely complex tissue of relation to achieving the proper operation of the transmission line in the power industry. In the final result it is a need for a new comprehensive approach to the transmission lines. At the same, it is a need for a new comprehensive approach to the transformers and the power plants, as well as the economy of the whole power system.

Acknowledgment

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Characterization of Structures and Interactions in Plasticized Starch using Solid-State NMR

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***Abstract*— Starch is promising, widely available, renewable and cheap alternative to conventional biodegradable polymers. Solid-State Nuclear Magnetic Resonance (SS-NMR) is often used in the study of non-magnetic materials with short-range crystalline ordering such as polymers. NMR techniques provide information on such characteristics as crystalline content, binding, mobility of the chains and many other. This paper briefly reports the results of NMR measurements performed on native starch samples and starch samples plasticized using glycerol and urea and the changes in the starch structure due to the plasticization which were inferred from these measurements.**

***Keywords*—starch, plasticizers, polymorphs, NMR.**

I. Introduction

Starch is major carbohydrate in human diet produced by higher plants as energy storage [1]. Naturally it occurs in form of discrete semicrystalline granules made up of glucopyranose, the cyclic form of glucose, which is primary product of photosynthesis [2]. In polycondensation reaction, glycosidic bonds are created between glucose molecules [3] either to create chains (α-1,4 linkages) or branching points (α-1,6 linkages). Starch consists of two types of macromolecules - linear amylose and highly branched amylopectin with relatively short chains [1]. Cis conformation of the α-1,4 linkages in chains allows to organize them into helical structures which can crystallize [2]. Double-helices can be arranged into crystallites either in monoclinic (A-type) or hexagonal (B-type) lattices, also called polymorphs, via hydrogen bonds [4]. Mixture of both polymorphs, A and B-types, is considered as C-type polymorph, which is typical for legumes [5]. Formation of double-helices is typical for amylopectin. Amylose can be part of it as well but it is also able to create single helices. In general, single helices create complexes with other molecules (i.e. lipids) incorporated inside. This polymorph denoted as V-type is characteristic for high-amylose starches [5]. Chains in the vicinity of branching points and non-ordered amylose create amorphous phase. Alternating amorphous and semicrystalline shells creates semicrystalline starch granules [6] which vary in shapes and sizes according to botanical origin [1].

Native starch (NS) does not have thermoplastic properties because melting temperature is higher than temperature of thermal decomposition. However, thermoplastic properties can be achieved by addition of plasticizer that interacts with starch through hydroxyl groups [7]. Plasticizer is usually low molecular hydrophilic liquid, which is able to penetrate starch granules and disrupt inner hydrogen bonds between starch molecules. Starch-plasticizer hydrogen bonds are created instead. Disruption of hydrogen bonds in starch granules occurs under shear stress and at specific temperature. This process is called gelatinization. Native starch modified in this way behaves as thermoplastic polymer. The most common plasticizers are glycerol, sorbitol, urea, citric acid, etc. [8]. In order to obtain environmentally friendly material, plasticizers have to be non-toxic and biodegradable.

Starch offers alternative to the traditional non-biodegradable polymers, especially in short life-time applications as well as in applications when recycling is difficult or it is not economical. Reordering or retrogradation and poor mechanical properties, large sensitivity to ambient humidity are main drawbacks of thermoplastic starches (TPS) [9]. One way, how to overcome them is to use suitable plasticizer or combination of plasticizers.

Mechanical properties of TPS can be also improved by esterification, etherification, oxidation before plasticization which results in high degree substitution of hydrophilic hydroxyl groups with hydrophobic groups. It is possible to control starch humidity sensitivity in this way, but biodegrability is the most important limitation of such procedure [8]. Another possibility is to prepare blends of starch with other polymers either biodegradable (PLA, PHB, etc.) or non-biodegradable conventional polymers like PE, PP, elastomers, etc. [9]. Mechanical properties of TPS can be significantly improved by fillers either in micro or nanoscale where promising candidates are nanoclays - layered silicates like montmorillonite [10-12].

Nuclear magnetic resonance (NMR) is widely used in different fields of science and medicine. In NMR, nuclei possessing magnetic moments behave as small transmitters, which provide information on magnetic field surrounding them. Inhomogenity in local magnetic fields within the sample caused by internal structure is reflected in the NMR spectrum [13-14].

Carbon NMR spectra of organic compound can provide a lot of structural features even though only rare isotope ^{13}C (approximately 1.1 %) can be detected in NMR measurements. High-resolution ^{13}C NMR spectra can be obtained using cross polarization technique (CP) which allows the transfer of magnetization from rich proton system (^{1}H) to diluted carbon (^{13}C). This technique considerably reduces time of experiment, it increases resolution of the spectra but it mostly provides non-quantitative signals in the spectra. The reason is, that magnetization transfer is influenced by factors like molecular mobility, temperature and it is dependent on CP contact pulse

duration (t_{CP}) throughout the magnetization transfer occurs [15].

The main aims of this paper are to quantify double-helix content via CP/MAS ^{13}C NMR spectra and to characterize interactions between components of the plasticized starch.

II. EXPERIMENTAL

A. Samples

Native maize starch Meritena® 100 was used as a reference sample in this study and virgin material for plasticized samples. Native starch is a fine white powder with neutral odor and taste extracted from maize before being purified and dried by Tereos Syrial company, which is major European producer of starch and derivatives.

Native starch, water and plasticizer were stirred in the beaker at the temperature of 60°C and then starch paste prepared in this way was cooled down to room temperate. Then the paste was stirred in plastograph Barbender PLE 331 for 10 min. at 100 rpm and temperature of 130°C in order to achieve homogeneity. TPS plates were prepared by pressing stirred starch paste for 6 min. at the pressure of 100 kPa and temperature of 130 °C. The prepared plate samples were dried to get rid of residual water. Water helps with gelatinization processes but it is undesirable in final TPS therefore samples were dried. Samples were stored in PE bags in dark room at least for 24 hours before NMR measurements.

Glycerol, which is oil-like liquid, is the most common plasticizer due to its low cost and high boiling temperature. Urea is white crystalline powder, amide groups in its structure retards retrogradation process [8].

TPS samples with glycerol (GTPS), urea (UTPS) and glycerol and urea (UGTPS) used in this study were prepared in the Polymer Institute, Slovak Academy of Sciences in Bratislava. The mass fractions of plasticizers related to the starch were the same (0.38) for all TPS samples and the UGTPS sample contains equal mass fractions of glycerol and urea (0.19).

B. Experimental

All measurements were performed on a 400 MHz Varian Solid State NMR spectrometer (external magnetic field of 9.4 T) at resonance frequency of about 100 MHz. Samples were placed in ZrO_2 rotors with outer diameter of 4 mm. CP MAS ^{13}C NMR spectra were detected under magic angle spinning (MAS) at spinning rate of 10 kHz at room temperature. CP contact pulse duration and heteronuclear dipolar decoupling field were 1 ms and 83 kHz, respectively. Experiments were controlled by Varian Vnmrj 3.2 software and data were processed using MestReNova-11.0.1 software.

The contact time duration has the influence on the magnetization transfer from hydrogen to carbon nuclei and it can result in non-quantitative spectra. This can be verified by the CP MAS ^{13}C NMR measurements at different contact time durations t_{CP} [16]. The measurements showed that the contact time duration used in our NMR measurements provided quantitative NMR spectra.

III. RESULTS AND DISCUSSION

Monomer unit of starch consists of six carbons denoted by numbers as shown in the Fig.1. The lines in the NMR spectra related to the particular carbons will be marked by symbols from C_1 to C_6 (Fig. 2.). We can notice that $C_{1\text{-}5}$ carbons are directly bonded to one and C_6 to two hydrogen atoms. However, C_6 carbon is outside the ring and then it can be supposed that methylene groups are more mobile and consequently the magnetization transfer to this carbon is not so effective [15], however, magnetization is transferred from two hydrogens to C_6 carbons which can compensate the influence of higher mobility.

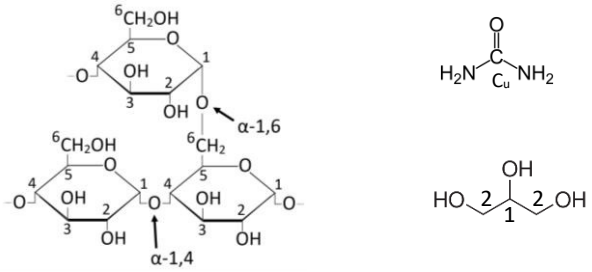

Fig. 1. Monomer units in the starch macromolecule (left) consists of α-1,4 and α-1,6 linkages. Starch plasticizers urea (right up) and glycerol (right down).

Fig. 2. shows spectra measured for NS and TPS samples by CP/MAS ^{13}C NMR technique. Lines positioned around 62 ppm relate to C_6 carbons in starch macromolecules. The strongest signal at position of 72 ppm corresponds to C_2, C_3, C_5 carbons within crystalline and amorphous regions as well as to C_4 carbons within crystalline domains. Peak at position around 82 ppm belongs to C_4 carbons within amorphous regions only. Region of the spectra from 90 to 110 ppm corresponds to C_1 carbons [5,17,18]. The C_{g1} and C_{g2} narrow peaks at 73.2 and 63.8 ppm of the spectra for GTPS and UGTPS are related to two non-equivalent carbons of glycerol (Fig. 1), respectively. The signals denoted as C_u at 162.7 ppm corresponds to urea carbons [26].

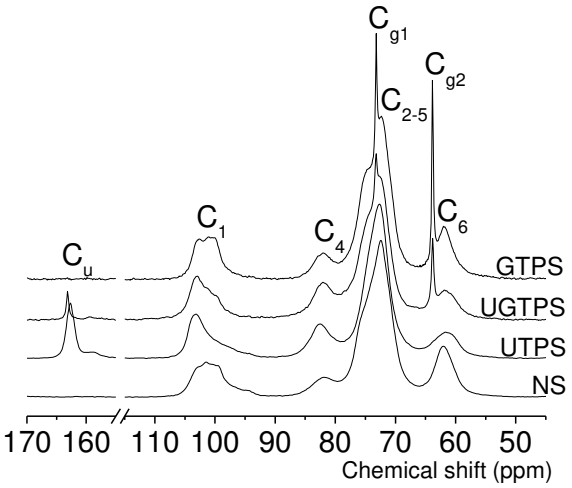

Fig. 2. CP/MAS ^{13}C NMR spectra measured for samples as denoted.

NS and GTPS NMR spectra are in agreement with results published in [17-19], that reported that CP MAS spectra of starch can provide quantitative results. However, comparison of integrals of C_1 and C_6 carbons shows, that urea plasticized starch spectra shown noticeable decrease in the C_6 signal intensity (Tab. I). This lead to the conclusion of enhanced methylene side group mobility which is related to lower crystallinity.

This fact can be proved by two ways. According to Bogracheva et al. it was found that if intensity of C_4 in comparison to overall intensity is 10 %, which is the highest measured intensity, then sample is considered completely amorphous [20]. However, results do not provide information

on crystallinity content but double-helices content instead as referred Spěváček et al. [21]. Those measurements were provided by calculation of the C_4 peak area from its maximum intensity to 90 ppm which is less influenced by carbons $C_{2\text{-}5}$ than other half of the signal. Resulting value was multiplied by two and divided by overall intensity of the spectrum. According to this method, urea plasticized starch samples are entirely amorphous, NS and GTPS shows 28 % crystallinity as shown in Tab. I. This method can be used for preliminary quantitative determination of the double helix content because of simplicity but partial overlap of strong $C_{2\text{-}5}$ affects accuracy of the results.

Generally, CP MAS ^{13}C NMR spectra are not quantitative, but it was shown [17-19] that an analysis of the C_1 lines gives reliable information on the structure of the starch. In light of quantitative analysis, advantage of this line is that it does not overlap with the other lines in the spectra. Except of this fact, as it can be also seen from Fig. 2, the shape of the C_1 line strongly depends on the plasticization. This is the reason that main interest of many papers is focused on this part of the spectrum [5, 17-19, 21-22]. C_1 line of A-type polymorph is characteristic by triplet at positions around 99, 100 and 101 ppm and C1 line of B-type shows doublet at 100 and 101 ppm. Ratios of peak intensities in triplet and doublet are 1:1:1 and 1:1, respectively [22]. The shape of the C_1 line of the NS sample (Fig. 2) reveals A-type polymorph. Significant changes due to plasticization process can be seen in shapes of the C_1 lines detected for GTPS, UGTPS and UTPS samples. The relatively high crystallinity of GTPS, predominantly amorphous nature of UTPS and the features of crystalline as well as amorphous domains can be drawn from the shapes of the particular C_1 lines shown in Fig. 2.

TABLE I

Relative double-helix contents (DHC) evaluated from C_4 examination, C_1 decomposition and intensities of C_6 with respect to the intensity of carbon C_1.

Sample	Preliminary DHC (%)	DHC (%)	Intensity of C_6 in comparison to C_1 (%)
NS	27	56	98
UTPS	amorph.	27	63
UGTPS	amorph.	37	71*
GTPS	26	55	103*

* Intensity of peaks C_6 and C_{g2}

Crystallinities of the samples can be estimated by the deconvolution of the C_1 lines. Fig. 3 shows these deconvolutions for the samples of NS and UGTPS. Triplet related to double-helix chain structure positioned at 99.3, 100.4 and 101.5 ppm with the ratios of the peak intensities approximately 1:1:1 found out by deconvolution confirms A-type polymorph of NS sample. Additional three peaks found at 94.4, 97.1 and 103.1 ppm correspond to the non-ordered chains [22]. Based on this knowledge the double-helix content was calculated and the results are listed in Tab. I. To illustrate this procedure for the spectra of TPS samples the deconvolution of the C_1 line detected for UGTPS sample is also shown in Fig. 3.

Data in Tab. I show that the samples plasticized by urea possess considerably lower crystallinities as compared with that of NS. However, crystalline content of glycerol-plasticized starch is almost identical with that of NS sample. Difference in the crystallinities of the TPS samples can be explained by retrogradion process. It is reasonable to assume that the TPS samples after preparation are completely amorphous and crystalline domains develop in course of retrogradation processes. It is known, that glycerol-plasticized starch undergoes retrogradation much faster when compared to urea-plasticized samples due to the fact that amide groups prevent retrogradation process [8].

The narrow lines C_{g1} and C_{g2} in Fig. 2 are associated with two non-equivalent glycerol carbons. Chemical shifts of the measured peaks differ from the database values of 72.37 and 63.05 by around 0.8 ppm which indicates hydrogen interaction

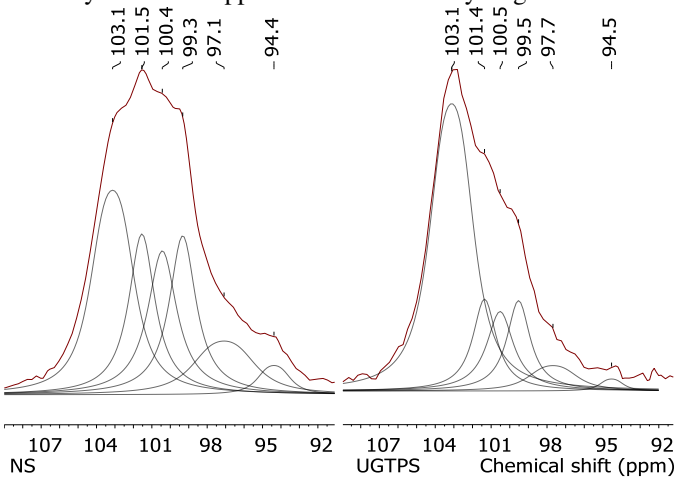

Fig. 3. Deconvolution of the C_1 line of the CP MAS 13C NMR spectrum measured on NS and UGTPS sample into components related to the helical ordered and non-ordered chains.

between glycerol and starch. The mentioned shifts, which are in agreement with the work of Liu et. al. [24], confirm hydrogen bonding between starch and plasticizer.

IV. CONCLUSSION

Plastic waste becomes threat for the environment. Solution is to replace conventional plastics by biodegradable polymers. Starch based biopolymers show wide range of possible modifications which can lead to elimination of disadvantages of resulting material and spread them in everyday life. Approval of structural and dynamic characteristics requires further research, not only by SS-NMR but also comparing these measurements with other methods like DSC, DMA, XRD, etc., which should be provided in near future.

ACKNOWLEDGMENT

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Classification of environmental influences on the maximum permissible current value of the conductor

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***Abstract*— This paper deals with powerline ampacity systems, specifically depending ambient conditions on transmission capacity of power line. In this paper is described a method for determining maximal allowable current value for conductor AlFe 350/59, which include the study of environmental impacts that may affect the maximum allowed current for AlFe 350/59 conductor. This paper described impact of solar radiation and air velocity on current value.**

***Keywords*—power lines, ampacity, actual allowable current value, AlFe 350/59**

I. INTRODUCTION

Extensive development of renewable sources requires expansion of transmission capacity of power lines. Despite the fact that power lines are an integral part of the system but their expansion is in seclusion interests [1] [2].

For these reasons, it is necessary to seek other means of safeguarding the power transmission system. One possibility is using operational methods which we monitor the temperature of the electrical wire and ambient influences. These indicate the current permissible current [1] [2].

To determine the allowable current of the conductor is necessary to determine all factors influencing temperature of the conductor. Subsequent calculation can be determined at any given time under the conditions of maximum load capacity [3].

II. POWERLINE AMPACITY SYSTEM

Conductor ampacity is defined as the maximum permissible load current, which can transmit the conductor without compromising its function. This distortion is mainly caused by exceeding the maximum permissible temperature [4] [5] [6].

The maximum current that can be transferred over the line, is not a constant value as yet, but is determined for the unsurpassable temperature conductors depending on ambient conditions - particularly ambient temperature and wind flow [6].

The ampacity depends on the electrical and mechanical properties of the conductor material, thermal insulation properties (the cables), ability to dissipate within the conductor generated and received from nearby heat, ambient weather conditions [7]

It is therefore apparent that the ampacity is mainly influenced by the thermal condition of the conductors, because it determines the extension conductors and therefore sag power line over the terrain.

In determining the maximum transmission capacity we use a method that is based from thermal equilibrium between the conductors and the environment [7].

At steady state, this equation can be expressed as equality heat gain = heat loss [7].

The full form of the equation is:

$$P_J + P_M + P_S + P_i = P_C + P_r + P_W \qquad (1)$$

Where:
P_J (W) - heat losses in the conductor
P_M (W) - magnetic heating of magnetic field variations AC
P_S (W) - solar radiation
P_i (W) - heating from the corona
P_C (W) - cooling by heat convection – by radiation
P_r (W) - radiant cooling
P_W (W) - cooling from water evaporation

Heating corona P_i, cooling by evaporation of water P_W and heating by changing the magnetic field of alternating current P_M in the equation is usually neglected [7].

Power lines designed by the current applicable standard EN 50341 are controlled by the designed maximum conductor temperature within the project documentation. Recommended temperature of conductor is 70 ° C. Where it is the highest phase current conductor, it is possible to calculate the actual temperature conductor [7].

The calculation is performed for the following conditions:
- The current conductor is the highest loaded
- The ambient temperature is 35 ° C
- Wind speed is 0.5 m / s at 45 ° angle of impact
- Global temperature solar radiation is 1000W / m^2
- Absorption coefficient is 0.5
- Emissivity coefficient is 0.5

III. EFFECTS OF ENVIRONMENTAL CONDITIONS ON THE ACTUAL CURRENT AMPACITY OF POWER LINES

Climatic conditions or the climate is understood as a long-term weather conditions with all the peculiarities that may be in that location and area show. In determining the climate and weather conditions must be based on the geographical location of the area [8].

To determine the effects of environmental conditions on the actual permissible current-carrying capacity conductor we will be based on the initial conditions of the standard EN 50 341.

We will then examine the impact of various factors on the maximum permissible current capacity of conductor AlFe 350/59 at its maximum temperature 70 ° C.

Calculation of the maximum allowable current will be carried out according to standard *IEEE 738 – 2012.*

A. Heat gain of conductor temperature influence of solar radiation

Solar radiation consists of direct and diffuse radiation incident on a surface. Most affected is by the duration of sunshine and cloud cover. The average annual values of solar radiation in the lowlands are in the range 1200 to 1300 kWh/m^2. In the highest position solar radiation is 1100-1200 kWh/m^2.In central mountain ranges, reaching an annual average value of solar radiation 1050-1100 kWh/m^2 [8].

For a determining influence of solar radiation to warming of conductor we begin calculate for intensity of solar radiation from 100 W/m^2 to 1000 W/m^2.

Dependence intensity of solar radiation on the current conductor ampacity is in the following figure (Fig. *1*). As is shown on the following picture, the dependence of ampacity is not a large. Current ampacity for AlFe 350/59 conductor by intensity of solar radiation 100 W/m^2 is 790.07 A for one part of a three-beam 400kV power line. At full intensity of solar radiation will decline permissible current capacity of the conductor to 711.31A.

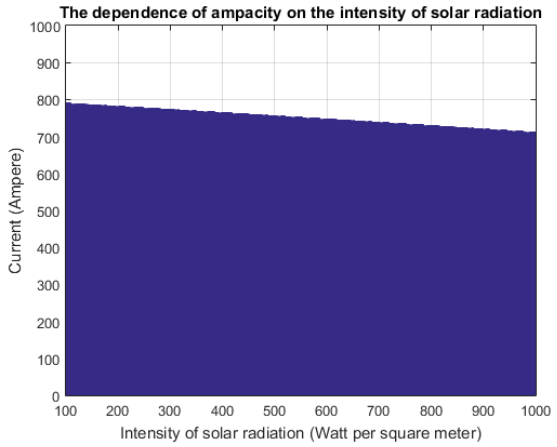

Fig. 1 Dependence of ampacity on the intensity of solar radiation for AlFe 350/59 conductor

B. Heat loss of conductor temperature influence of heat convection

Wind conditions of Slovakia are rather complicated. The main impact is the variability of the weather during the year [8].

To determine the actual current ampacity of conductor AlFe 350/59 under the action of wind, we will investigate the change in air velocity of 1 m/s to 40 m/s with angle of attack wind on the power line 45°.

Results from this calculation are on the following figure (Fig. 2). As we see, current ampacity for AlFe 350/59 conductor in one part of a three-beam is in range of air velocity 1 m/s to 15 m/s more than double greater. Maximum permissible value of current increase from 711.22 A to 1535.79A in range 1 m/s to 15 m/s. In the second the amount of research in range 15 m/s to 40 m/s is growth of dependence of heat convection to ampacity less pronounced. Maximum permissible value of current increase from 1535.79 A to 2099.7 A which represents approximately a third of the increase.

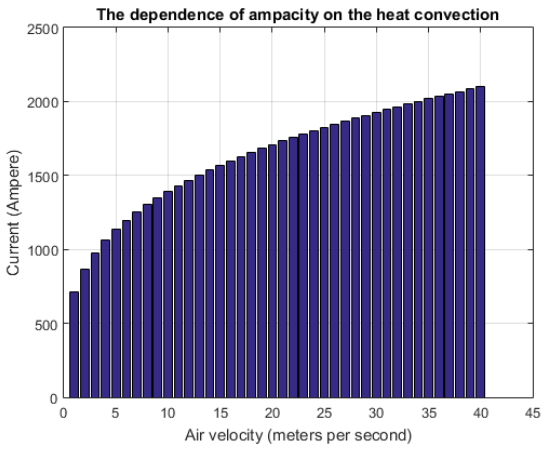

Fig. 2 Dependence of ampacity on the air velocity for AlFe 350/59 conductor

IV. FUTURE RESEARCH

In my future research I want to focus on the determining actual value of current for power lines during a change of load in power system, dynamic ampacity.

The second part of the research consists in creating a mathematical model of the electrical conductor and the subsequent verification of the analytical results of the simulation program.

In the next part will be created a control program to determine the limit of power lines under ambient conditions while building on previous research parts.

V. CONCLUSION

This paper describes a method to specifying maximal current value for UHV power lines, specifically for AlFe 350/59 conductor accordance o ambient conditions.

This article describes the different factors that are involved to heat or cooling a conductor. Research up to date, it is clear that factors most involved in determining the maximum permissible load current for a conductor AlFe 350/59.

ACKNOWLEDGMENT

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Cloud-connected Robots Learning Social Action Selection from their Operator

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***Abstract*—This paper discusses our approach to learning social action selection from the experimenter in social human-robot interaction. The uniqueness of this system lies in the use of cloud computing for CPU-heavy tasks. We briefly review the teleoperation interface and the learning algorithm used in our setting. As a conclusion we outline two human-robot interaction scenarios where the feasibility of the method will be tested.**

***Keywords*—social robotics, cloud computing, Wizard of Oz, learning**

I. Introduction

In recent years, social robots left research laboratories for real-world environments to aid humans in different fields of their life. The majority of these studies dealt with medical issues, such as children cancer treatment [1], helping patients with autism spectrum disorder [2] or assisting the elderly [3]. These experiments used the Wizard of Oz (hereinafter WoZ) approach. The robots were not acting autonomously during the interactions, but were remotely controlled by a human [4]. Although this method is popular and sufficient for research, a need for autonomous (or at least semi-autonomous) robots is increasing. Between 2012 and 2015, 48% of the papers published at the annual Human-Robot Interaction (hereinafter HRI) conference used autonomous robot behavior [5]. This fact relates to the research in long-term social HRI. In such scenarios it is hard to rely only on the operator, since controlling a robot for a long time can be cognitively exhausting and executing the same actions can become boring. To avoid these negative effects and enable long-term human-robot interaction, we have to think about robots that learn from their operator. This way we can move from the WoZ technique towards semi- and fully-autonomous robots (see Fig. 1).

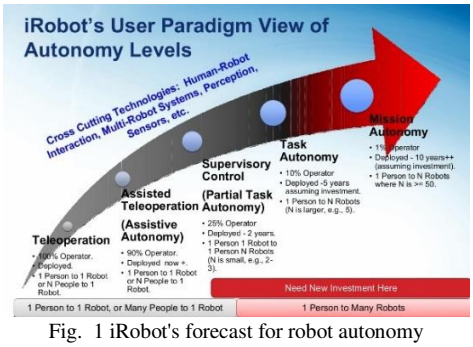

Fig. 1 iRobot's forecast for robot autonomy

In our work, we increase the robot's level of autonomy in social HRI through machine learning. We developed a Wizard of Oz interface (to remotely control the robot) which is connected to a service providing learning capabilities. A high-level structure of the system can be seen on Fig. 2. These cloud services will be discussed in more detail in the following chapters.

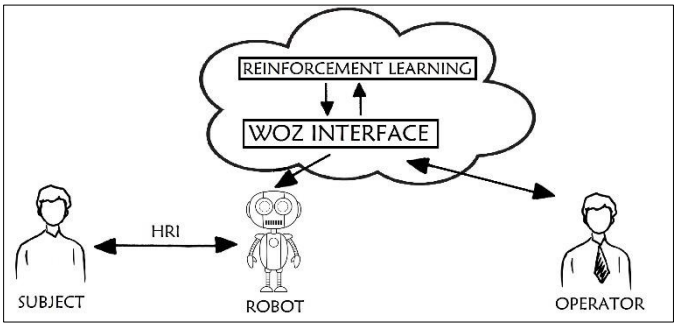

Fig. 2 High-level overview of our system

II. Learning from the Wizard Service

The first cloud service is responsible for the remote control of robots and the second one implements different interactive reinforcement learning algorithms for learning social action selection.

A. Wizard of Oz interface

In general, our WoZ interface is a cloud-based platform built on top of Microsoft Azure for various types of robots. The platform has the following features:

- **Web-based** – after registration every user can work with the system without installing anything on their PC. Communication between the robot and the service must be ensured by a script running on the device.
- **Website content management** – users can upload and share robot behaviors to the database. They can also create their own scenarios – a concrete application of human-robot interaction, e.g. a robot teaching children English words. To create such a scenario, one finds and adds the appropriate behaviors from the database.
- **Robot-independent design** – since the service is web-based, every robot running a Python script can connect to it. Currently it supports the following robotic platforms: NAO, Pepper (Softbank Robotics), Milo (Hanson Robotics) and Q.bo (theCorpora).
- **Desktop version** – offers IP camera streams, direct control of the robot, and a script builder to create custom

behaviors in addition to the full functionality of the web service.

- **World-wide** – users are not limited by their geographical location when using our system. We demonstrated this feature by controlling a robot in Japan from Italy and Slovakia.

For more details about the teleoperation platform, including the working mechanism please refer to [6].

B. The learning algorithm

We use reinforcement learning for learning from the experimenter. It determines how to map situations to actions and also tries to maximize a numerical reward signal [7]. The actions performed by the agent are not defined explicitly, but have to be discovered through exploration to get the most reward.

Hence it is hard to define the human's behavior by a function, we use interactive reinforcement learning in which, contrary to classical reinforcement learning, the reward is not determined by using a reward function, but is given directly by the human operator. He/she evaluates whether the action performed by the robot helped to reach the goal of the interaction.

The feasibility of this method for learning social action selection from the human operator was tested using a modified version of a simulated human-robot interaction originally published by Senft et al. [8]. The results showed that our approach is suitable for increasing the robot's level of autonomy in social HRI [9] [10].

C. The resulting system

In order to use the above mentioned services in a real HRI scenario we had to integrate those into a single one. The resulting system can be seen on Fig. 3.

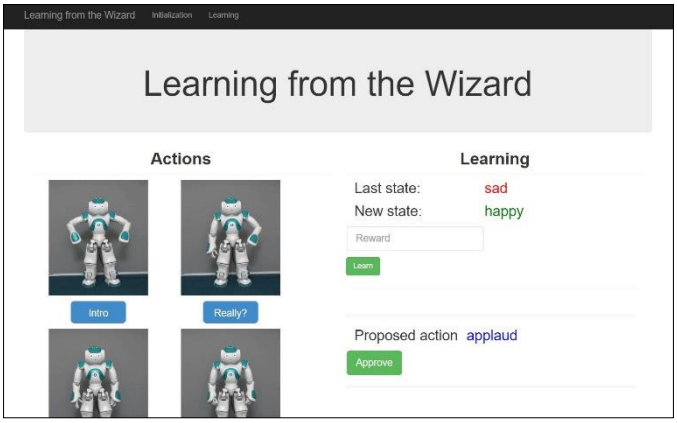

Fig. 3 The resulting system

The service's interface consists of two parts. On the left, the possible actions of the robot in the concrete scenario can be seen. On the right, the teleoperator can control the learning process. The last state label shows the subject's reaction to the robot's action at *t-1*. On the other hand, the new state label shows the subject's reaction to the robot's action at *t*. In the example shown above, the subject's states were defined based on his/her facial emotion expressions. Based on these information, the operator gives a reward for the action which led from the last state to the new one. In parallel with the manual teleoperation, the learning algorithm after each action proposes an action which should be taken. If the operator approves it, the action is executed and there's no need for manual selection.

III. Conclusion and Future Work

In this paper we presented the concept of learning social action selection from the human teleoperator in the cloud environment. We reviewed our platform for remote control of robots and the learning algorithm which is used for increasing the robot's level of autonomy. The main advantage of our approach compared to similar solutions is that nothing has to be installed on the teleoperator's PC or on the robot. Every computational task considered CPU-heavy is carried out in the cloud platform.

The next steps in our research include the testing of our system in a real-world scenario. Currently we work closely with an elderly care facility, where the robots will act as coaches in cognitive exercises for the elderly. These experiments will investigate the impact of robots on the performance of elderly in these exercises and also whether it will be able to learn social behavior from the teleoperator.

Another scenario which we are considering will take place at our university. Students will be asked to interact with the robot which will ask them questions from courses they are taking this semester. These series of experiments are solely focusing on learning social behavior.

Acknowledgment

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Comparison of Control Methods for Switched Reluctance Motor Drive

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***Abstract*—This paper compares the two method for controlling of switched reluctance motor with number of poles $2p_1/2p_2 = 6/4$. Simulations are realized using the ANSYS software which allows to apply multiple modellig techniques. The basic control algorithm and direct torque control method are described below. Simulation results using the ANSYS Simplorer are included in this document as well.**

***Keywords*—Switched reluctance motor, hysteresis current control, direct torque control, ANSYS software**

I. Introduction

Switched reluctance motors (SRM) are gaining more and more popularity among electrical drives. This is due to their simple construction characterized by no magnets and winding on the rotor [1]. SRM is low-cost alternative to commonly used motors like brushless DC and AC motor. Other benefits are possibility of using SRM for a wide range of speeds and ability to resist to high temperatures [2].

This brushless motor is not possible to connect to power source without using electronic converter and sophisticated control which requires to known actually rotor position. Great disadvantage is relatively large torque ripple which is possible to reduce with advanced control methods or change of motor construction [5]. In Fig. 1 is shown 3-phase switched reluctance motor with number of poles on the stator and the rotor 2p1/2p2 = 6/4.

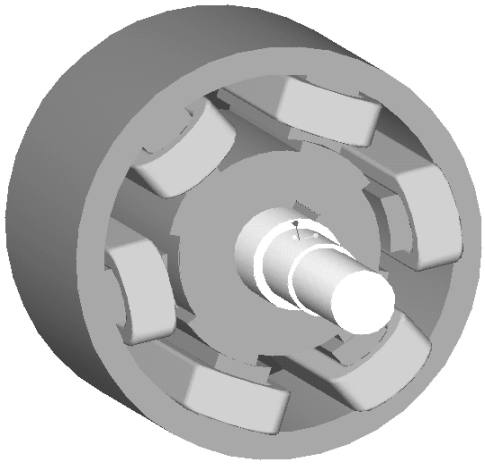

Fig. 1 Model of switched reluctance motor

II. Simulated control algorithms

A. Hysteresis current control

This method is based on the main principle of the SRM: SRM produces positive torque if the current flows in the phase and inductance have rising slope [4]. The actual value of the current is keeping by the hysteresis current regulator so as current is equal to desired value of current ±ΔI. In pursuance of this condition the power semiconductor switches in the asymmetric converter are switched [2]. Main principle is shown in Fig. 2.

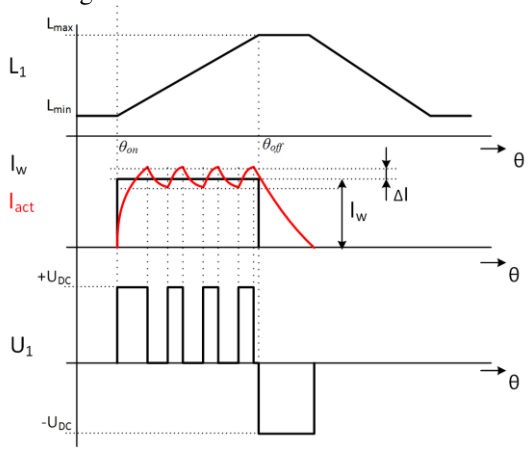

Fig. 2 Principle of hysteresis current control

B. DTC method

Conventional DTC (Direct torque control) method is based on control torque during the phase commutation. The interval $<\theta_{on1}, \theta_{on2}>$ is divided into 3 regions and is needed to know which phases are incoming and outgoing. Output torque is reached by switching of three states of converter depending on the actual torque. States of asymmetric bridge converter is shown inFig. 3. The regulations rules described in TABLE I were published in [3],[7], [9].

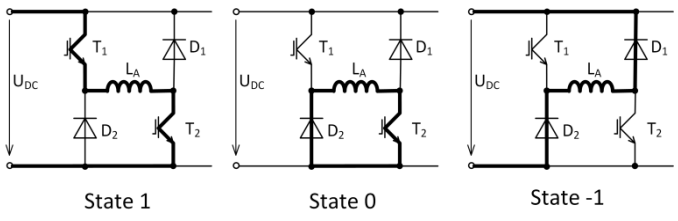

Fig. 3 States of asymetric bridge converter for one phase

TABLE I
DTC SWITCHING RULES

Region	Condition		Phase	
	T_{err}		*Outgoing*	*Incoming*
Region 1	>0	<ΔT	0	1
		>ΔT	1	1
	<-ΔT	<0	0	1
		<-ΔT	-1	1
Region 2	>0	<ΔT	0	0
		>ΔT	1	1
	<-ΔT	<0	0	1
		<-ΔT	-1	0
Region 3	>0	<ΔT	-1	0
		>ΔT	-1	1
	<-ΔT	<0	-1	0
		<-ΔT	-1	-1

III. Simulation Results

The control methods have been simulated using ANSYS Simplorer. All parts of the electric drive are included in simulations – motor, converter, and regulation. There is used the cascade regulations structure, where is added the PI speed controller. The model of SRM was tested on ramp speed refence and after starting was applied the mechanical torque as load.

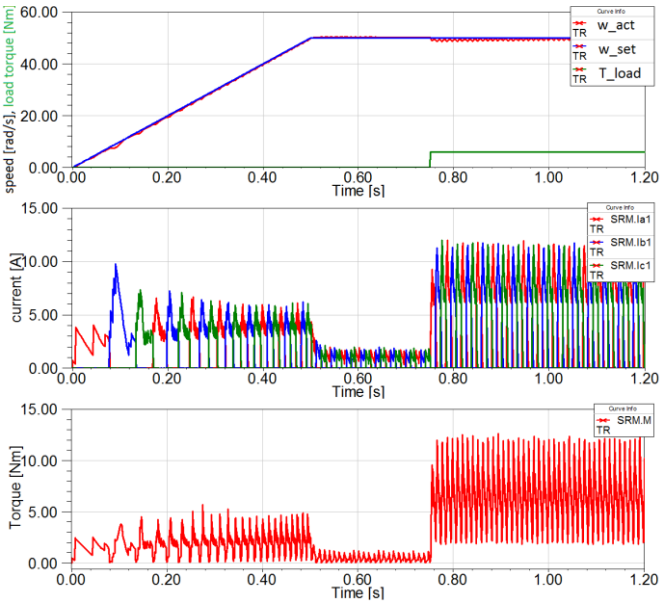

Fig. 4 Simulation results – current hysteresis control

In Figs. 4.-5. was applied the 0.5 s ramp speed reference and motor was loaded in 0.75 s, but was used different control methods. We can observe in torque waveforms, where the current hysteresis control method appears the higher torque ripple. Using the DTC method provides more accurate regulation process and lower error.

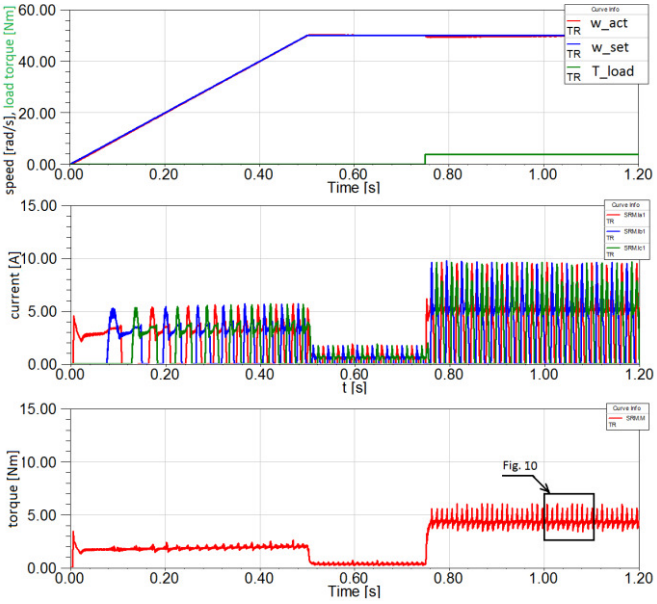

Fig. 5 Simulation results – DTC method

IV. Conclusion

ANSYS Software allows to simulate different models included analytical or finite element analysis models Motor control algorithms can be debuged before the physically machine is created. Hysteresis current control reaches higher torque ripple what causes inaccuracy of speed regulation. It is suitable to use DTC method which appears acceptable properties at the low speeds.

Acknowledgment

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Comparison of new valuation methods of wheeling transactions in cross-border transmission

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***Abstract*—This paper deals with my work over last year, which deals with issue of valuation wheeling transactions in cross border transmission. They are analyzed two new valuation methods which are representatives of two approaches of solutions to this issue. It is method average participation (AP) and method with and without transit (WWT). These methods are compared and evaluated their positives and negatives.**

***Keywords*— average participation method, cross border transmission, with a without transit method**

I. INTRODUCTION

In considering about valuation of cross-border transmission we must take into account structure of the transmission systems, which was designed to meet requirements of vertically integrated energy system. Therefore, it's in each transmission system is only one system operator (monopoly), which ensure operation and reliability of transmission system and it's is main transmission authority.[1] All market participants utilizing transmission services in management area pay the transmission authority wheeling fees. On the other hand it is declared open access to transmission services and it's is established deregulation in area of production and delivery, which means that market participants aren't restricted to trade with electricity only one transmission system and can carry out their business in frame of co-operating transmission systems. Cross-border transmission has opened a new issue, and how to valuated it and redistribute payments between transmission systems.

II. NEW METHODS OF VALUATION OF WHEELING TRANSACTIONS IN CROSS-BORDER TRANSMISSION

Standard valuation strategies are based on methods used in vertically integrated system. It appears from this that standard methods insufficiently reflects the use of transmission system in case of cross-border wheeling transactions, when it is necessary to determine rate of utilization of each transmission system. To eliminate deficiencies of classical valuation strategies have been proposed several new valuation strategies. It is average participation method (AP), simplified average participation method (SAP), modified average participation method (MAP) [4], marginal participation method (MP), with and without transit method (WWT) and average participation applied to transits (APT). Essentially, can these valuation strategies divided based on solving this issue into two groups. First group consists of methods AP, SAP, MP and MAP, which to determining rates of utilize transmission system use real flows of performance. The second group consists of methods WWT and APT, which use concept of transit and without transit flows to determine utilization rate of transmission system. In my work I focused on new valuation strategy namely to compare method AP and WWT. These methods I have chosen by reason that represent two approaches to solve issue of valuation cross-border wheeling transactions.

A. Average participation method (AP)

This method outgoing from assume, that fee per wheeling transaction is determined by utilization rates of each transmission line. Flows of power were monitored by means of tracking algorithms which are based on the idea that flow of electricity behaves like fluid flow in pipeline. Tracking algorithm thus can determine rate of individual flow factor and counter flow on each line. Subsequently are established for each transaction average participation namely following procedure. For each generator i we establish possible number of physical paths which cross all lines up to end loads. Consequently we same way construct physical paths for loads namely monitoring counter flow of power consumed by loads. Compilation of physical paths is realized on basis of criteria which allocate costs actual flows based on proportional redistribution. This criterion don't requires selection of source node. Disadvantage of method is fact, that in case of grouping generators and loads in one node there may occurs to inconsistent results. Another disadvantage is inaccurately set allocation rules, but which are key element of method. [2] [3]

B. *Method With and without transit (WWT)*

Method outgoing from concept of transit flows and therefore method is defined as minimum between total import and export into transmission area. Consequently are constructed two networks, one makes original network and second network constitutes network without transit flows. Removing transit may result in increase of power flow and electric losses in monitored area. Effect on transmission flows critically depends on direction of transit. In one direction flows have tended to rise and in opposite direction have tended to fall, however for reasons of non-linearity of these flows, it is possible to argue only approximately. These non-linear flows complicate calculation of real flows in network.

TABLE I
Comparison of calculation methods AP and methods WWT

6-bus IEEE model of transmission system								
			Calculation of flows with method AP				Calculation of flows with method WWT	
Bus		Flows [MW]	Bus		Generator	Flows [MW]	With transit	Without transit
From	To		From	To			Toky [MW]	Toky [MW]
1	2	200	1	2	G4	200	200	179
1	3	150	1	3	G4	150	150	171
2	3	350	2	3	G2	194,44	198,77	166,78
2	6	100	2	3	G4	155,56	151,23	113,6
3	5	200	2	6	G2	55,56	55,56	57,8
4	1	500	2	6	G4	44,44	44,44	38,23
			3	5	G2	77,776	78,786	56,36
			3	5	G4	122,224	121,2	122
			4	1	G4	500	500	380

Comparison of both models and determination of size of wheeling fees occurs to finding of financial imbalances, based on which states size of wheeling fees in cross-border transmission. Fundamental problem is objective quantification of impact of transit on compare models. One possibility is determining size of flows caused by themselves transit flows. Disadvantage of this method is difficulty of calculating both models and undefined procedure for determining size of transmission fee. [5]

III. COMPARISON OF METHOD AP WITH METHOD WWT

As was mentioned above, these new valuation methods access to solve issue in different ways. Method AP tracing each transaction and its impact on transmission system, and it therefore means that set rate of flow and counter flow. Solution to impact of each transaction with complexity of transmission system exponentially increasing. On other hand method WWT works with two models of transmission system. One model constitutes transmission system with transit flows and second constitutes transmission system without transit flows. We made comparison on 6-bus IEEE model of transmission system Fig.1, and results are shown in TABLE 1.

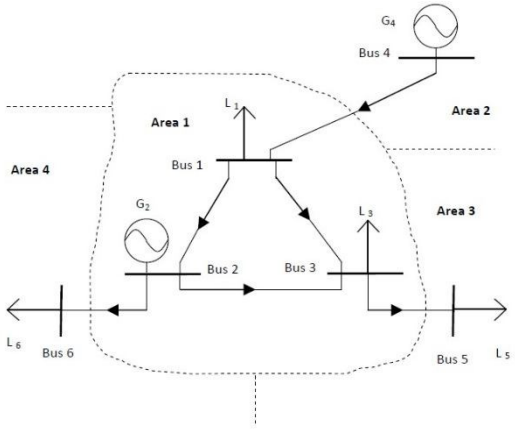

Fig. 1. 6-bus IEEE model of transmission system.

IV. CONCLUSION

Based on comparison of these two methods, it can be stated that method AP better reflects real flows in cross-border power transfer as method WWT both economically side as well as technically side. First advantage of method AP is fact, that it can provide accurate traffic data for each transmission line. Method WWT this capability doesn't have, whereas method WWT can determine only rate of contribution of transit flows into transmission system. Second advantage of method AP is pointless creating a model of transmission system without transit flows. It follows that in case of erroneous data input method AP offers error feedback method, while method WWT due to creating model of transmission system without transit isn't able to provide error feedback. Therefore is possible state, that results from method AP providing more reliable results than in case of method WWT.

V. FUTURE WORK

My future work will focus on issue of valuation of transmission based on marginal price difference due to congestion in transmission system. This is method local marginal price a financial transmission rights.

ACKNOWLEDGMENT

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Contribution to Analysis and Development of Inductive and Capacitive Sensors Based on Film Technology

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***Abstract*— This paper is a summarization of last year of post gradual study. Solved research tasks and published articles are presented here. This work involves the theoretical background of inductive and capacitive sensors principles, and design and realization of planar inductive sensor for proximity sensing based on low temperature co-fired ceramics.**

***Keywords*—capacitive sensors, inductive sensors, LTCC, proximity sensing**

I. Introduction

Actual trends in electronics industry give demanding requirements on sensors used for process and devices control. Depending of sensing application, immunity against environment impact, reliability and long life cycle, robustness, small physical dimensions, low energy consumption and low manufacturing price are the main requirements for modern sensors and sensing systems. Inductive and capacitive sensors meet these requirements.

Inductive sensors are for the ability to sense only metal (conductive) targets mainly used in industry for event counting (rotary speed detection [1], flow meters), industry switches, metal detection, linear position detection, angle detection, engine tests (valve position), roller gap process control (thickness [2], shape, texture), quality inspection (deformation, cracks) or vibration sensing applications. Capacitive sensors are for the ability to sense the presence of both conductive and non-conductive objects used in industry, but they are mainly used in people´s everyday life, e. g. for washing machine control.

II. Initial Status

Sensors are implemented into every day used devices, e. g. mobile phones or personal computers and tablets. As the screens of these devices uses non-contact technology for a long period of time, the basic component for personal computer control – the keyboard – by nowadays still uses mechanical components. As mechanical switches are very reliable components and mechanical keyboards are very cheap, these keyboards cannot be used in environment where vibrations occur (non-reliable, often multiple pressing) or in places where the environment temperature is very high. For that reason we decided to develop two types of sensors – inductive and capacitive ones, that could be used as a keyboard replacement in the applications where vibration occurs (capacitive sensor) or where the environment temperature is very high (inductive sensor). Because of mechanical components absence, lifetime of developed control panels would be almost unlimited. LTCC technology offers high temperature endurance and stable material parameters. After studying theoretical background about inductive and capacitive proximity sensors and about possibilities of implementation these types of sensors using LTCC [3], we want to solve these PhD theses:

1. Development and realization of thick film capacitive proximity sensor as the basic part of the system.
2. Implementation of thick film capacitive proximity sensor into non touch control panel.
3. Development and realization of thick film multilayer inductive proximity sensor and its implementation into touch control panel for use in harsh environment.
4. Comparative analysis of touch panels based on thick film inductive and capacitive proximity sensors.

III. Solved Tasks in The Previous Year

Tasks summarized in the following sections were solved in previous year of postgraduate study based on dissertation theses.

A. Development of Multilayer Planar Inductive Sensor for Proximity Sensing

For the purpose of touch control panel implementation for use in high temperature environment, planar six layer inductive sensor based on DuPont GreenTape™ 951PX LTCC was designed and measured [4].

Fig. 1 shows developed planar six layers coil based on DuPont GreenTape 951 PX LTCC for use in inductive proximity sensing. Developed coil was fabricated using DuPont™ 6145 silver cofireable conductor paste. Coil has circle shape with 15.82 mm diameter, 250 μm conductor´s width and spacing between conductors. To characterize electrical parameters of developed coil, we decided to use SMA connector to limit parasitical effects of connection to measurement device. During measurement process there had not been placed additional capacitor on sensing coil. Inductance of coil in the frequency range from 300 kHz to

15 MHz was measured by vector network analyzer (VNA) N5231A by Keysight Technologies (Fig. 2). Fluctuations in Fig. 2 are caused by measurement step of used VNA. At frequencies higher than 14 MHz parasitic effect of capacitance given by planar structure of coil appears that limits the use of this coil at higher frequencies. Optimizing coil´s shape to minimize resistance causing loses to obtain the best performance, developed coil reaches the quality factor of 3.

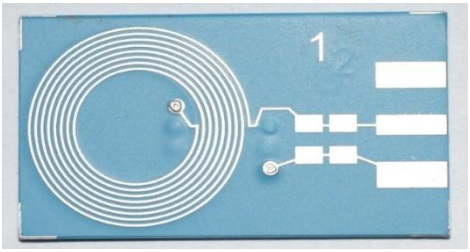

Fig. 1. Developed planar six layers coil based on DuPont GreenTape 951PX LTCC for use in inductive proximity sensing.

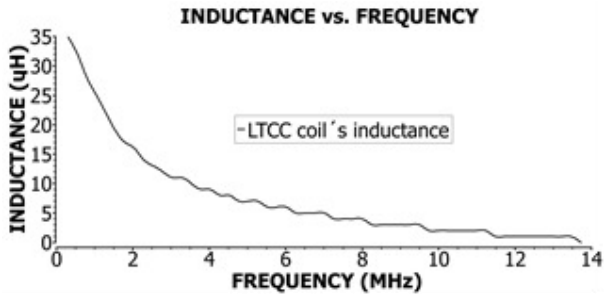

Fig. 2. Developed planar coil´s inductance in dependence of driving frequency.

B. Development of Driving Circuit for Planar Inductive Proximity sensor

Inductive sensor for its operation requires driving circuit. Based on driving circuit performance, whole sensing system behavior can be determined. Proper considerations should be taken for choosing appropriate driving circuit. There are several possibilities to drive an inductive proximity sensor [5]. For inductive proximity sensing application we decided to use and implement Texas Instrument´s LDC1000 inductance to digital converter controlled by ATMega328 microcontroller based board. This converter offers many advantages (28 bits inductance resolution, 1.8 V up to 4 V oscillation amplitude, 1 kHz to 10 MHz sensor driving frequency range). With minimum external components required, this converter offers highly reliable solution for inductive sensor driving and processing measured values in single compact converter package. Complete developed planar inductive proximity sensor is shown on Fig. 3.

Inductive sensor for use in touch control panel does not require such an inductance resolution, but this resolution was necessary for characterization developed planar inductive proximity sensor using three different target materials – aluminum, copper and solder material. Measurement results in Fig. 4. shows inductance difference when sensing in distance from target of 4 mm to 10 mm, so developed sensor can be also used in very specific application for material characterization.

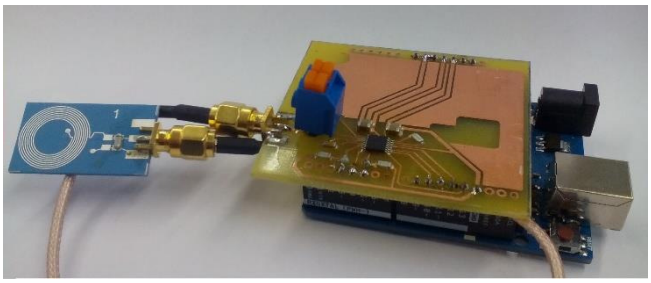

Fig. 3. Complete developed LTCC – based inductive proximity sensor.

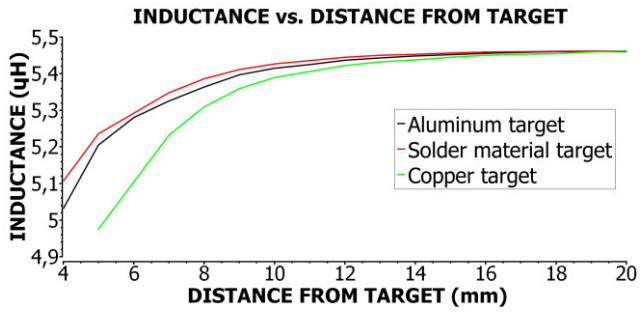

Fig. 4. Inductance *L* of developed coil in dependence of distance from target for different targets.

IV. Future Work

In future work we will focus on optimization of planar inductive sensor design for use in control touch panel. Also, different capacitive sensor structures implemented on different substrates will be analysed and obtained results will be implemented into LTCC technology with respect to PhD thesis.

Awards

Excellent Poster Award for Young scientists for the paper "Development of Planar Inductive Sensor for Proximity Sensing Based on LTCC", 39th International Spring Seminar on Electronics Technology, 18-22th May, 2016, Pilsen, Czech Republic.

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Contribution to Fault Diagnosis Methods of Dynamic Systems

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***Abstract*—This paper summarizes the author's research activities during the last year and shortly presents the fault diagnosis algorithms design for the actuators or sensors fault estimation. Paper also mentions activities related to the working on projects, where the author is a member of resolving team.**

***Keywords*—fault detection and isolation, fault estimation, vibration diagnosis**

I. Introduction

A part of the fault diagnosis research is oriented to design algorithms for fault detection, isolation and estimation.

In general, the control design of the dynamic systems is important step to the correct functionality of the fault diagnosis algorithms. Controlled dynamic systems without fault occurrence are considered as nominal systems, which are useful for determination of the threshold values in fault detection.

The actuators and sensors are the most sensitive parts of the dynamic system and they can be monitored by the diagnosis system, which consists of the fault diagnosis algorithms.

II. Previous analysis and achieved results in research field

The fault diagnosis methods based on the states estimation, model parameters identification and vibration analysis of the dynamic system were studied extensively in the past. The overview of fault diagnosis methods was shortly presented in previous SCYR article [1].

Also, it was selected the suitable laboratory models for the fault diagnosis algorithm verification and their mathematical models were derived. The control of the laboratory models is important for the successful fault diagnosis algorithms design and verification. In [2], [3] were presented results of the optimal control design for the selected laboratory models.

The diagnosis system concept is the starting point for the fault diagnosis algorithms design and implementation. In the Fig. 1 is illustrated the concept of the diagnosis system, which was determined in the past. According to this concept was selected suitable methods for fault detection, isolation and fault estimation.

III. Solved tasks and results

The algorithms for fault detection, isolation and estimation of the dynamic system were designed and also implemented in the MATLAB/Simulink environment during the last year. The fault diagnosis method presented in [4] was used for the

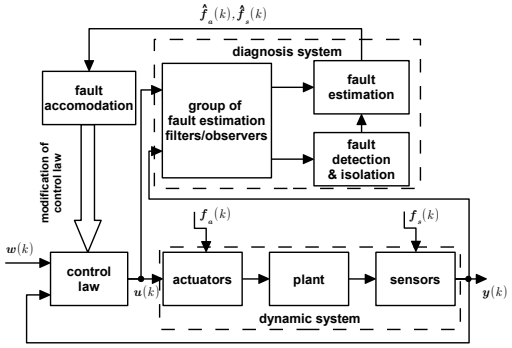

Fig. 1. Concept structure of the diagnosis system

sensors or actuators fault estimation algorithm design. It is very important to specify faulty model of the dynamic system.

In case of the sensors faults, the faulty model of the dynamic system can be expressed, according to [4], in form:

$$\begin{aligned}\mathbf{x}(k+1) &= \mathbf{A}_d\mathbf{x}(k) + \mathbf{B}_d\mathbf{u}(k) + \mathbf{v}(k)\\ \mathbf{y}(k) &= \mathbf{C}\mathbf{x}(k) + \mathbf{F}_s\mathbf{f}(k) + \mathbf{o}(k)\end{aligned} \tag{1}$$

where $\mathbf{A}_d \in \mathbb{R}^{n\times n}$, $\mathbf{B}_d \in \mathbb{R}^{n\times p}$, $\mathbf{C} \in \mathbb{R}^{n\times m}$ and $\mathbf{F}_s \in \mathbb{R}^{m\times q}$ represents the system dynamic, input, output matrices and sensors fault matrix. The vector $\mathbf{f}(k) \in \mathbb{R}^q$ consists of magnitude of the sensors faults. It is considered that the system noise $\mathbf{v}(k) \in \mathbb{R}^n$ and measurement noise $\mathbf{o}(k) \in \mathbb{R}^m$ are uncorrelated white noises with covariance matrices $\mathbf{Q}, \mathbf{R}$, which are set according to the white noises normal distribution [6].

Faulty model of the dynamic system (1) can be rewritten in the descriptor form:

$$\begin{aligned}\mathbf{E}\tilde{\mathbf{x}}(k+1) &= \tilde{\mathbf{A}}\tilde{\mathbf{x}}(k) + \tilde{\mathbf{B}}\mathbf{u}(k) + \tilde{\mathbf{G}}\mathbf{v}(k)\\ \mathbf{y}(k) &= \tilde{\mathbf{C}}\tilde{\mathbf{x}}(k) + \mathbf{o}(k)\end{aligned}, \tag{2}$$

where:

$$\mathbf{E} = \begin{bmatrix}\mathbf{I}_n & \mathbf{0}\\ \mathbf{0} & \mathbf{0}\end{bmatrix},\ \tilde{\mathbf{A}} = \begin{bmatrix}\mathbf{A}_d & \mathbf{0}\\ \mathbf{0} & \mathbf{0}\end{bmatrix},\ \tilde{\mathbf{B}} = \begin{bmatrix}\mathbf{B}_d\\ \mathbf{0}\end{bmatrix},$$
$$\tilde{\mathbf{G}} = \begin{bmatrix}\mathbf{I}_n\\ \mathbf{0}\end{bmatrix},\ \tilde{\mathbf{C}} = [\mathbf{C}\ \ \mathbf{F}_s],\ \tilde{\mathbf{x}}(k) = \begin{bmatrix}\mathbf{x}(k)\\ \mathbf{f}(k)\end{bmatrix}, \tag{3}$$

For the estimation of the vector $\tilde{\mathbf{x}}(k)$ of the dynamic system in descriptor form (2), it is possible to design filter using principles of Kalman filtering in form:

$$\begin{aligned}\hat{\tilde{\mathbf{x}}}(k+1|k) &= \mathbf{T}\tilde{\mathbf{A}}\hat{\tilde{\mathbf{x}}}(k|k-1) + \mathbf{T}\tilde{\mathbf{B}}\mathbf{u}(k) +\\ &+ \mathbf{L}(k)\left(\mathbf{y}(k) - \tilde{\mathbf{C}}\hat{\tilde{\mathbf{x}}}(k|k-1)\right) + \mathbf{N}\mathbf{y}(k+1),\end{aligned} \tag{4}$$

Matrices $\mathbf{T},\ \mathbf{N}$ have to be designed under assumption:

$$\mathbf{TE} + \mathbf{N\tilde{C}} = \mathbf{I}_{n+q} \tag{5}$$

Gain matrix $\mathbf{L}(k)$ of the fault estimation filter (4) is computed in each k step:

$$\mathbf{L}(k) = \mathbf{T\tilde{A}P}(k|k-1)\tilde{\mathbf{C}}^T \left[\tilde{\mathbf{C}}\mathbf{P}(k|k-1)\tilde{\mathbf{C}}^T + \mathbf{R}\right]^{-1} \tag{6}$$

where estimation error covariance matrix $\mathbf{P}(k+1|k)$ is computed by iterative procedure:

$$\begin{aligned}\mathbf{P}(k+1|k) &= \mathbf{T\tilde{A}P}(k|k-1)\left(\mathbf{T\tilde{A}}\right)^T - \\ &\mathbf{L}(k)\tilde{\mathbf{C}}\mathbf{P}(k|k-1)\left(\mathbf{T\tilde{A}}\right)^T + \mathbf{T\tilde{G}Q}\left(\mathbf{T\tilde{G}}\right)^T + \mathbf{NRN}^T\end{aligned} \tag{7}$$

The method for sensors fault estimation, which is shortly presented in this article, is modified for the case of the actuator fault estimation. In this case, it is considered the faulty model of the dynamic system in form:

$$\begin{aligned}\mathbf{x}(k+1) &= \mathbf{A}_d\mathbf{x}(k) + \mathbf{B}_d\mathbf{u}(k) + \mathbf{F}_a\mathbf{f}(k) + \mathbf{v}(k) \\ \mathbf{y}(k) &= \mathbf{C}\mathbf{x}(k) + \mathbf{o}(k)\end{aligned} \tag{8}$$

where $\mathbf{F}_a \in \mathbb{R}^{n\times q}$ is the actuators fault matrix. The faulty model (8) of the dynamic system can be also arranged, according to [5], into the descriptor form (2), where:

$$\begin{aligned}&\mathbf{E} = \begin{bmatrix}\mathbf{I}_n & \mathbf{0}\\ \mathbf{0} & \mathbf{I}_q\end{bmatrix},\ \tilde{\mathbf{A}} = \begin{bmatrix}\mathbf{A}_d & \mathbf{F}_a\\ \mathbf{0} & \mathbf{I}_n\end{bmatrix},\ \tilde{\mathbf{B}} = \begin{bmatrix}\mathbf{B}_d\\ \mathbf{0}\end{bmatrix}, \\ &\tilde{\mathbf{G}} = \begin{bmatrix}\mathbf{I}_n\\ \mathbf{0}\end{bmatrix},\ \tilde{\mathbf{C}} = [\mathbf{C}\ \ \mathbf{0}],\end{aligned} \tag{9}$$

The computation of the $\mathbf{T}, \mathbf{N}$ is implemented as *kfe_paramA* function in Matlab. Inputs for the *kfe_paramA* function are matrices of the faulty model (1) or (8) and outputs are matrices of the faulty model in descriptor form (3) or (9) with matrices $\mathbf{T}, \mathbf{N}$. Computation of the gain matrix $\mathbf{L}(k)$ and covariance matrix $\mathbf{P}(k+1|k)$ is implemented as Matlab function called *FE_Kalman_Gain*. The fault estimation filter (4) are implemented in Simulink environment using designed functions.

The vector $\hat{\tilde{\mathbf{x}}}(k|k-1)$ estimated using fault estimation filter (4) is useful for the residual generation in form:

$$\mathbf{r}(k) = \mathbf{y}(k) - \tilde{\mathbf{C}}\hat{\tilde{\mathbf{x}}}(k|k-1), \tag{10}$$

Residuals are used for the fault detection. The result of the fault detection are symptoms s_i for $i = 1, 2, ..., m+p$, which are generated as follows:

$$\begin{aligned}&||\mathbf{r}_i(k)|| > \tau_i,\ \text{then}\ s_i = 1, \\ &||\mathbf{r}_i(k)|| \le \tau_i,\ \text{then}\ s_i = 0,\end{aligned} \tag{11}$$

where τ_i represents appropriate threshold value. The symptoms s_i are used for the fault isolation [6].

In vibration diagnosis area was the research oriented to the noise filtering from the signals obtained by the accelerometer. At present, the experiments are prepared for the vibration measuring and frequency analysis.

During the last year of the PhD. study was prepared two papers, the first paper with title "*Sensors Fault Diagnosis Algorithm Design of Hydraulic System*" was accepted in the journal *Acta Electrotechnica et Informatica*. The flowchart of designed sensors fault estimation algorithm is presented in this paper. The second paper with title "*Intelligent Positioning Plate Predictive Control and Concept of Diagnosis System Design*" is reviewed in the *Journal of Manufacturing and Industrial Engineering*. Both papers are dedicated to the methodology for the diagnosis system design.

The research tasks are solved related to the project *USP TECHNICOM for Innovation Applications Supported by Knowledge Technology - II. phase* with subactivity *Center for Nondestructive Diagnostics of Technological Processes*.

A part of the author research capabilities were focused on solving tasks in terms of the project *Experiment ALICE on LHC in CERN : Study of strongly interacting matter at extreme energy densities*, related to cooperation of FEEI, TUKE with European Nuclear Research Center in Geneva (CERN).

IV. Proposal for next steps

Results of the algorithms design for the fault estimation can be used for the modification of the optimal control laws to the fault tolerant form. The next steps of the authors research are oriented to the control design with capability of the actuators and sensors faults accommodation.

Further steps in the research will lead to verification of the designed algorithms for fault diagnosis using simulation and real laboratory models of the CMCT&II of the DCAI.

The author object of interest will be dedicated to the dynamic system measurement and analysis using algorithms based on the Fourier transformation. For this purpose should be use the actuator of the Elevator laboratory model.

Another research activities will be oriented to the project in cooperation with CERN, where will be solving tasks related to the broadening of existing communication and control infrastructure. The control processes includes tasks of its diagnosis and these tasks will be also solving.

Acknowledgement

This publication is the result of the Project implementation: University Science Park TECHNICOM for Innovation Applications Supported by Knowledge Technology - II. phase, ITMS: 313011D232 (40%) and "Centre of Information and Communication Technologies for Knowledge Systems", ITMS: 26220120020 (20%), both supported by the Operational Programme Research & Development funded by the ERDF, grant TUKE FEI-2015-33: Research Laboratory of Nonlinear Underactuated Systems (30%) and grant KEGA 001TUKE-4/2015 (10%).

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Contribution to Hybrid Models of Cyber-Physical Systems and their Implementation into Distributed Control System

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***Abstract*—This paper presents results obtained during the last year in the field of cyber-physical systems, specifically modelling and control of the hybrid systems. Within modelling of the hybrid systems various mathematical representation were proposed for hybrid hydraulic system and within hybrid system control supervisory, optimal and predictive control was tested either on the mentioned hydraulic system or on the laboratory model of the inverted pendulum which is a part of the *Multipurpose Workplace for Nondestructive Diagnostics*.**

***Keywords*—cyber-physical system, detector control system, hybrid system, optimal control**

I. Introduction

With a growing complexity of today's world problems in engineering, especially in the system engineering, it was needed to establish a new look on the current state of the art. One of the such a fresh look was an introduction of the cyber-physical systems (CPS) which are considered to be a part of the phenomena Industry 4.0. The term CPS was defined as a response to more complex embedded systems [1] which represent an integration of the physical and computational processes.

Behaviour of the CPS is described with a physical and cyber part of the system. Physical part of the CPS represents HW components including mechanical parts, biological and chemical processes, even human operators. Subsequently CPS contain one or more computational platforms which consist of sensors, actuators and computers. The last part of the CPS is represented by digital networks which provide a way of communication of system's various parts. Together, computational platforms and digital networks form the cyber part of the CPS [2]. To exploit all of the CPS advantages, it is needed to have a model of such a system. Since CPS are complex systems they cannot be described with either continuous or discrete dynamics but hybrid systems framework has to be used.

II. Previous analysis and achieved results in research field

To model and design embedded systems, finite state machines (FSM) framework is commonly used. However, FSM are not suitable to model and design CPS where a dynamical system contains continuous as well as discrete dynamics. By augmenting each of the FSM discrete state by continuous dynamics it is possible to define hybrid system (HS) framework which is suitable to model and design CPS.

One of the most widely used representation of HS is discrete hybrid automata (DHA). DHA represent an interconnection of the FSM and switched affine dynamical systems (SAS) via event generator (EG) and mode selector (MS) [3]. Individual parts of the DHA framework, depicted in Fig. 1, are thoroughly described in [4] and [5].

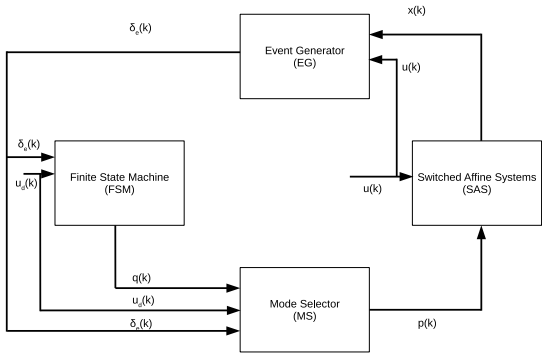

Fig. 1. *Discrete hybrid automata* framework.

Although DHA framework provides a convenient interface to capture system's dynamics, it is not useful when it comes to analysis of hybrid systems or synthesis of control laws based on the optimal or predictive control algorithms.

III. Solved Tasks and Results

According to the statements about DHA provided in the previous chapter, several other HS representations were defined whereas between the most significant ones belong [3]:

1) piece-wise affine systems (PWA),
2) mixed-logical dynamical systems (MLD).

The important characteristic of this enumeration is proven two-sided equivalence of the frameworks DHA, PWA and MLD [6]. In the last year, an example of a hybrid hydraulic system described in [5] was mathematically modelled in the mentioned representations with an emphasis to their utilization within optimal and predictive control algorithms [6]. An excerpt of the obtained results is depicted in Fig. 2 [9].

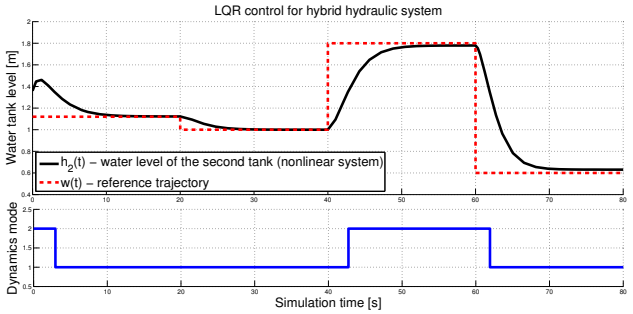

Fig. 2. Application of the linear LQR synthesis on the nonlinear hybrid system represented by hydraulic coupled tanks

Next, the author dedicated focus on hybrid control of the *Single inverted pendulum with linear synchronous motor* which is a part of *Multipurpose workplace of nondestructive diagnosis* solved within a project *USP TECHNICOM, Centre for nondestructive diagnostic of technological processes with standard software package for control and communication*. The hybrid control was based on the switching between controllers, i. e. between stabilizing and swing-up control law [7]. Time behaviour of the real system states and the control input is shown in Fig. 3 and the results were published in [8].

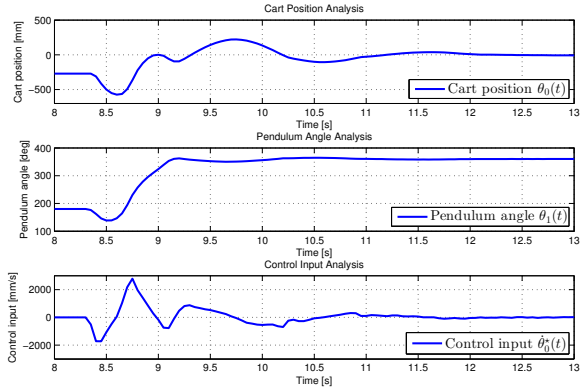

Fig. 3. Time behavior of the cart position, pendulum angle and control input

During the last year, author also focused on solving the tasks within the project *Experiment ALICE on LHC in CERN : Study of strongly interacting matter at extreme energy densities*, in cooperation with European Nuclear Research Center in Geneva.

A testing workplace was created for this project which has a similar infrastructure like the ALICE Detector Control System [10]. This workplace can use the data from sensors and actuators of the laboratory models of the DCAI like a substitution of the sensors and actuators of the ALICE Detector Control System. The main infrastructure, shown in Fig. 4, consists of three branches: communication, power and cooling systems. Within the last year author focused on the implementation of the communication architecture starting at the detector and ending at *Detector Control System* (DCS).

IV. Future Research Steps

This paper briefly summarizes the author's research activities during the last year.

The following research steps will be mainly focused on various hybrid control techniques on different hybrid systems

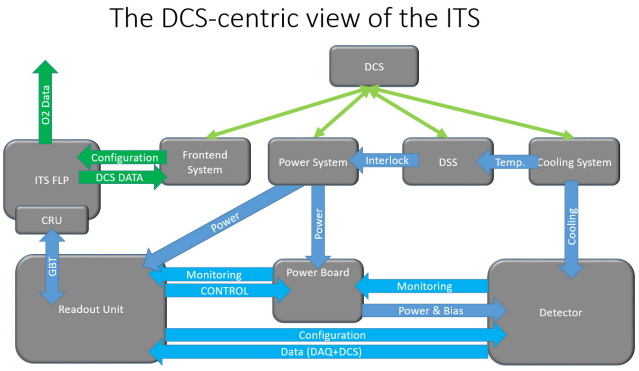

Fig. 4. The DCS-centric view of the Inner Tracking System

representations. Tested modelling and control algorithms will be verified on the real applications within *Center of Modern Control Techniques & Industrial Informatics* (CMCT&II) at DCAI. Another research activities will be dedicated to solving project tasks within the workplace at CERN which will be concentrated on broadening of existing communication and control infrastructure. Subsequently part of the research will be focused on using methods of artificial intelligence and their possible utilization in modelling of hybrid systems.

Acknowledgment

This publication is the result of the Project implementation: University Science Park TECHNICOM for Innovation Applications Supported by Knowledge Technology - II. phase, ITMS: 313011D232 (40%) and "Centre of Information and Communication Technologies for Knowledge Systems", ITMS: 26220120020 (20%), both supported by the Operational Programme Research & Development funded by the ERDF, grant TUKE FEI-2015-33: Research Laboratory of Nonlinear Underactuated Systems (30%) and grant KEGA 001TUKE-4/2015 (10%).

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Control of Intelligent Complex Systems

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***Abstract*—In this paper we present a current state of our research in the area of control and modeling of intelligent complex systems using means of Artificial Intelligence, mostly the Fuzzy Cognitive Maps. We outline our previous work which resulted in a program library and user interface utilizable for the purpose of system control and modeling. We have also developed the modified version of the method aimed towards simplicity of model design. We further explain the recent work which revolves around implementation of the proposed program library as a cloud service and its use in control of multi-agent robot system in intelligent space which is currently being developed at our workspace.**

***Keywords*—fuzzy cognitive maps, modeling, control, complex systems, intelligent space**

I. Introduction

Artificial intelligence (AI) and its methods have significant impact in many areas of everyday life. Technical systems which are used to implement AI are also progressively becoming more complex. These intelligent systems (IS) are getting increasingly interconnected via various networks (including the Internet) and these connections are progressively becoming not only mutual (system to system) but also open to other systems including systems implemented as cloud services. The ideas of the Internet of Things and consequently the Internet of Everything are well on its way of becoming de facto standards in the development of technical systems in close future.

The research presented in this paper, deals with control of complex systems implemented over networks using AI methods. The focus has been oriented specifically towards Fuzzy Cognitive Maps (FCM) and its adaptations since its graph structure is well suited for system modeling and control. As the scientific goals, we have stated 1) the modification of basic FCM concept with goal of enabling modeling and control of complex systems and consequently 2) the evaluation of the proposed method on selected nonlinear dynamic system. As the technical goals, we defined: 3) the implementation of program library oriented towards system modeling using FCMs and also 4) the extension of the library as a cloud service. Finally, we also aim to propose at least a basic draft for implementation of complex system composed of networked components within the specified area, specifically an intelligent space based at the Center for Intelligent Technologies.

II. Initial State of Research

In the previous period, we focused on finding a solution to several drawbacks [1] related to the vanilla FCMs, which are tied to its capabilities to model dynamic nonlinear relations within complex systems. In order to tackle these problems, we proposed a novel Term Relation Neuro-Fuzzy Cognitive Maps (TTR NFCM) method [2] which solves several of the issues.

In order to evaluate this method and to tackle the problems and deficiencies of existing tools which are available for FCM modeling, we proposed (see Fig. 1) and implemented a new general multi-purpose FCM library [3]. We successfully deployed the library for simple computations and modeling within the Matlab environment.

Along with the library we also developed a graphical user interface based on Windows Forms with help of Microsoft Automatic Graph Layout (MSAGL) library [5]. The MSAGL provides a support for online user interaction with the designed FCM and also allows to render the updates of the activation values in the real-time during the simulation.

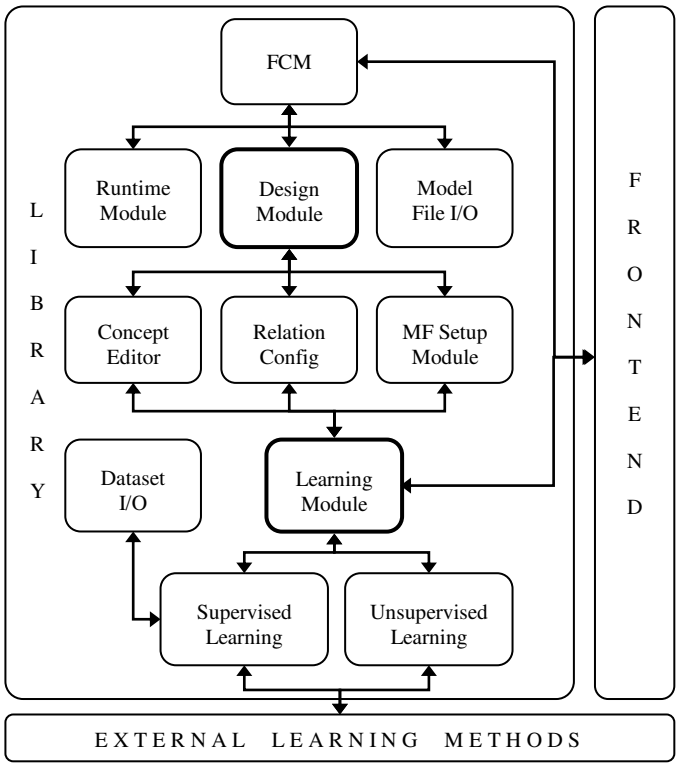

Fig. 1. A system proposal of FCM library [3].

III. Current State of Research

Our current work is tied to the implementation of a specific complex system, namely the intelligent space [6] based at the Center for Intelligent technologies. The space is composed of several types of sensors, including 16 IP Cameras with microphones, 6 Kinects and also other IoT sensors, for acquisition of environment variables such as light intensity, temperature, air quality, loudness, ultrasound, infrared light, etc. In addition, we expect utilization of RFID cards and readers, E-beacon technologies and more. It is also equipped with service robots such as TheCorpora Qbo, Robotnik TurtleBot and Hanson Zeno, but also other robots including simple Lego Mindstorms NXT and EV3, and older models such as Sony AIBO and Aldebaran Nao. The implemented Intelligent Space will gather various data including video streams (see Fig. 3), depth map streams (from Kinects), audio (from microphones built in cameras and Kinect) and other data from remaining sensors. Therefore, it is necessary to define viable strategies for transmission, processing and storage of this data. This is going to be mostly the goal of future work (which is not directly related to this paper), however, preliminary system proposal is depicted on Fig. 2.

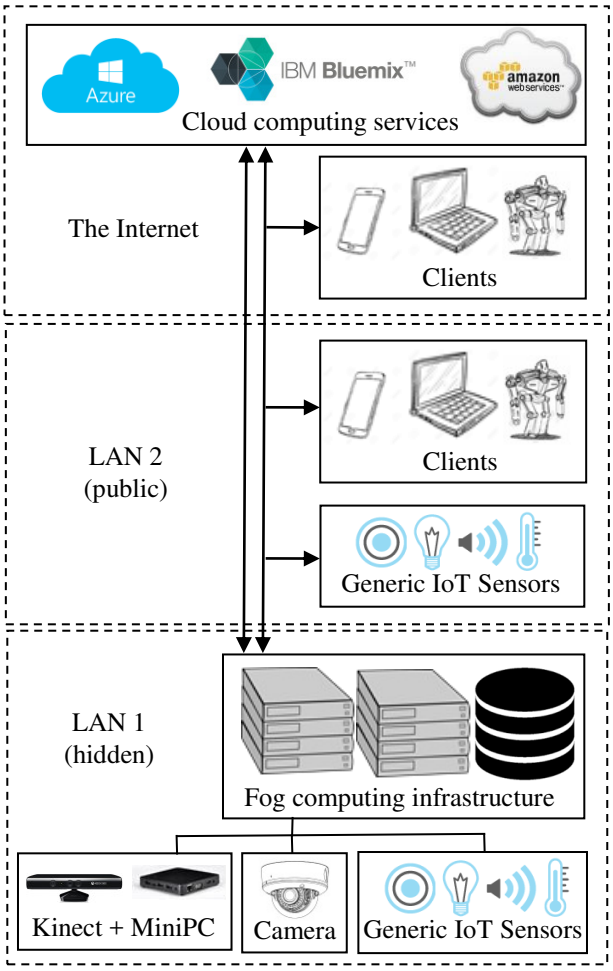

Fig. 2. Intelligent space at CIT – Networking proposal

What is currently being done is the selection and creation of suitable methods and tools in the form of network services (a.k.a. AI bricks) which would be necessary to perform sufficient control of the space. When it comes to robot control and navigation, we propose the usage of FCM and specifically the novel TTR NFCM method. We are also considering the use of cloud technologies [7], whenever possible. However, in order to respect the network limitations (since estimated data generation of 16 cameras and 6 Kinects is more than 250 Mb/s) we also aim to utilize private could servers and fog computing methodologies [8].

Fig. 3. Camera monitoring system in CIT.

IV. Future Work

We have already successfully fulfilled two of the stated objectives including 1) the proposal of modified TTR NFCM and 3) the implementation of standalone FCM library. We are currently working on 4) the extension of the library as a cloud service which will be consequently used to 2) perform experiments using the proposed method in multi-agent robot system based in implemented intelligent space. Viable use cases of the intelligent space are being investigated, but currently we propose mostly problems tied to robot navigation, path planning and human-robot interaction.

Acknowledgment

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Control of Web-Accumulators in Continuous Strip Processing Lines

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***Abstract* - The paper presents an overview of web-accumulator control methods in continuous strip processing lines. The basic characteristic and principle of web accumulator are described below. The paper describes dynamics of carriage and web span, mechanical influences, control strategies and practical examples of two different types of control web accumulator also.**

***Keywords* - strip processing line, web accumulator control, tension control**

I. INTRODUCTION

A continuous web processing line is a large-scale complex interconnected dynamic system with numerous control zones to transport the web while processing it. A continuous web processing line typically consists of an entry section, a process section, and an exit section. The entry section consists of an unwind stand, a tension leveller, and an entry accumulator. Operations on the web such as wash, coat, and quench are performed in the process section in the case of aluminum and steel webs, and printing, perforating, and laminating in the case of other consumer products.

The exit section consists of an exit accumulator and a rewind stand. A typical process line layout of a strip processing line is shown in Fig. 1. Accumulators are primarily used to allow rewind or unwind core change while the process continues at a constant velocity. Dynamics of the accumulator directly affects the behavior of web tension in the entire process line [6] [12].

Typical process line is composed of an entry section that unwinds unprocessed strip, an entry accumulator that releases web into the process section when the entry section is stopped, a process section where strip processing is performed, and an exit accumulator that stores web when the exit is stopped for a rewind changeover, and an exit section that winds the processed web into the rolls.

The web accumulator allows nonstop operation on the production line. Most of the time the accumulator carriage is positioned at his nominal position and the web pass across the accumulator following the roll. Consider the entry accumulator, if the unwinder wound core is almost empty, the accumulator have to store web and his carriage is moved up vertically to maximize the web length into the accumulator. Then the accumulator carriage is moved down in order to restitute the stored web for a constant web line velocity. When the unwinder core is changed, the accumulator carriage is moved to his initial position.

This stage of changing the unwinder core will take place in very short time depending on the accumulated web length. The web tensions inside the accumulator are easy to control in standard operating conditions (when the accumulator carriage is at its constant nominal position). During the transitions phases web tensions variations can appear and generate web folds or breaks due to the inertia and friction of the free rollers.

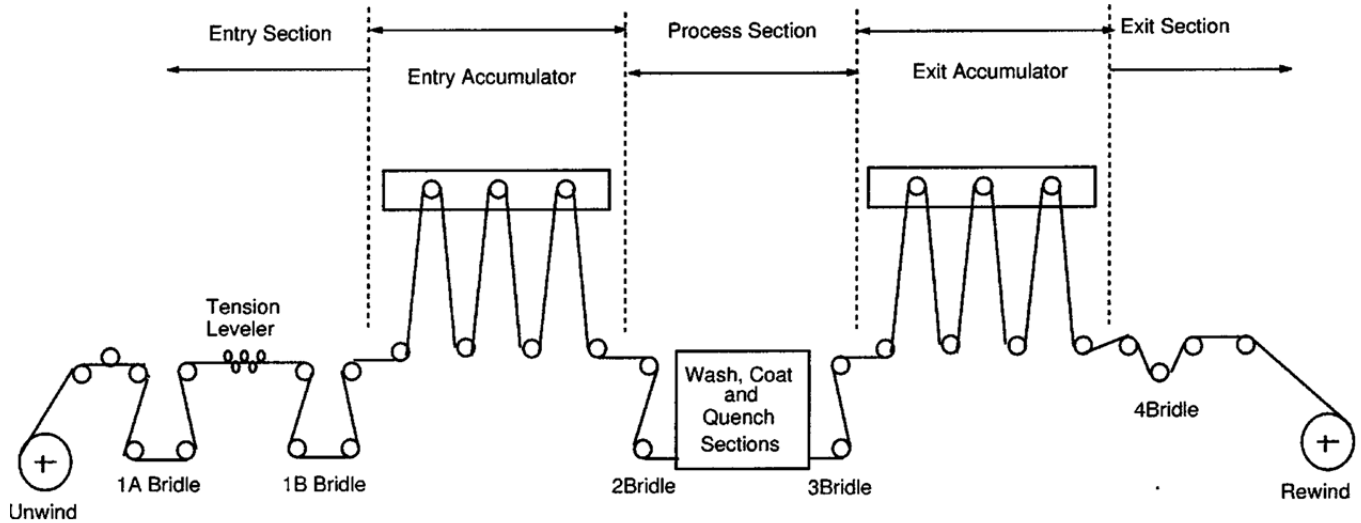

Fig.1. Typical process line layout [5]

II. ACCUMULATOR PERFORMANCE ANALYSIS

A. Dynamics of carriage and web spans

A schematic of the carriage, web spans, and rollers within an accumulator is shown in Fig. 2. The accumulator carriage dynamics are given by

$$M_c \frac{d^2 x_c(t)}{dt^2} = F_c(t) - F_d(t) - M_c g - \sum_{j=1}^{N} t_j(t) \quad (1)$$

where M_c is carriage mass, x_c is carriage position, v_c is carriage velocity, F_c is controlled force ($F_c = F_r + F_p$), F_d is disturbance force, g is acceleration due to gravity, N is number of spans, t_j is strip tension in the j^{th} span and R is roller radius.

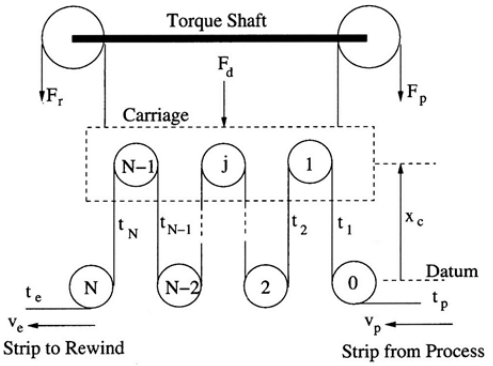

Fig. 2. Sketch of an accumulator

The torque shaft shown in Fig. 2 is included in the accumulator design to synchronize the side-to-side lifting action so that only vertical motion needs to be considered in the control system design. The number of rollers on the carriage is *N/2*. The number of rollers in the accumulator is *N+1*. The strip tension and the roller dynamics in the j^{th} accumulator span is given by

$$\frac{dt_j(t)}{d} = \frac{AER}{x_c(t)}\left[\omega_j(t) - \omega_{j-1}(t)\right] + \frac{R}{x_c(t)}\left[t_{j-1}(t)\omega_{j-1}(t) - t_j(t)\omega_j(t)\right] + \frac{AE}{x_c(t)}\dot{x}_c(t) - \frac{1}{x_c(t)}t_j(t)\dot{x}_c(t) \quad (2)$$

$$J\frac{d\omega_j(t)}{dt} = -B_j\omega_j + R\left[t_{j+1}(t) - t_j(t)\right] \quad (3)$$

where $j = 1/N$, A is area of cross-section of the strip, E is modulus of elasticity of the strip, R is radius of the roller, ω_j is angular velocity of the j^{th} roller, J is moment of inertia of the roller, and B_j is viscous friction coefficient of the j^{th} roller.

B. Influences of mechanical parameters

Depending on the type of accumulator, mainly two control strategies are applied: one using $V_{in\ accu}$ as control signal (controller output), the other using L. The synthesis of both control strategies need to calculate two transfer functions: a first one between the accumulator output tension T_{out} and the accumulator input velocity $V_{in\ accu}$ and a second one between T_{out} and the web span length L.

1) Influences of the elasticity modulus

The web elasticity influences the web dynamics (tension and velocity) in the transient phases. The static gain and resonances (gains and frequencies) are depending on the Young modulus. In the industry, Young modulus changes during the manufacturing process and therefore the control performances should be adapted if the controller is not enough robust.

2) Variation of span length

Like the Young modulus, the web span length in the accumulator (related to the position of the carriage) has a significant influence on the web dynamic. A long web span will have a weaker resonance frequency and a lower gain. This dynamic sensitivity to the web length variation should to be taken into account in a robust controller synthesis.

3) Influence of roll inertias

The free rollers inertia also influences the web dynamics. These inertias should be as low as possible. Indeed important inertias strongly decrease the bandwidth of the system. This low bandwidth will make it difficult to control the accumulator.

4) Influence of viscous friction

The shaft/roller frictions have low effect on the system bandwidth. A change of the friction value during the production will thus have a minor influence on the controller robustness.

Detailed study of influences describe with Bode diagrams can be found in [8].

III. CONTROL STRATEGY

As mentioned previously, the accumulator can be controlled in two different ways: the controller can affect either on the web span length (by using the accumulator carriage as actuator) or the input velocity (by using the unwinder as actuator). More precisely, the accumulator output web tension controller is synthesized using the input velocity of the accumulator as control signal, whereas the second control strategy uses the web length (by moving the accumulator carriage) as control signal. In industrial applications, both control schemes are used. These two control schemes are illustrated in Fig. 3 and Fig. 4 [1].

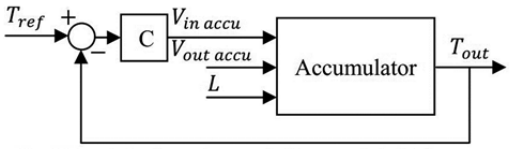

Fig.3. Control scheme: Input velocity as control signal

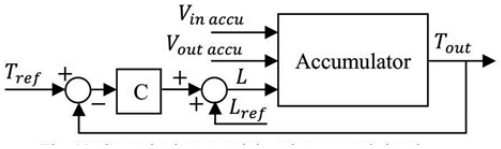

Fig.4. Control scheme: Web length as control signal

Nevertheless, is also possible use combination of these two controls strategies. During the regular production phase (when the accumulator carriage is located at its nominal position), we use the unwinder (accumulator input velocity) as actuator, whereas, during the wound roll change, the carriage is chosen as actuator. The on/off switching strategy of the two controllers is performed by weighting the controller output with a coefficient continuously varying from 1 to 0 [1] [2].

A. Linear time invariant PI controller

Industrial controller, in our case a PI controller, is used to control the output web tension. This controller has the following form:

$$C(s) = \mathrm{K}\frac{1+\tau.s}{s} \quad (4)$$

The PI parameters K and τ are determined with an optimization approach for realistic non-linear model. The PI parameters are optimized by making a grid of couples of

different K and τ parameters. The quadratic error between the output web tension and the reference is calculated for each simulation. The best couple of K and τ is the one for which the tension error is minimal.

This method using an optimized PI controller gives some good results, but the web length has a significant influence on the tension (static gain and bandwidth depend on the span length). Therefore this controller should not be optimal for web length changes.

B. Multi-model PI controller

To improve the output web tension controller, another solution is seeking for an optimized PI controller for the minimum span length. Then a second optimized PI controller is searched for the maximum span length. This strategy gives a better control performance.

C. Linear time invariant H∞ controller

To improve the control performances and the robustness to the mechanics, a $H\infty$ controller has been synthesized. The $H\infty$ controller is calculated using the linear model according to the framework proposed in Fig. 5. The weighting functions W_p, W_u and W_d that are used for loop-shaping appear in the closed-loop transfer function between the exogenous inputs r and w, and the performances outputs z in the following manner:

$$T_{\left(\frac{r}{w}\right)\to z} = \begin{bmatrix} W_p S & -W_p R W_d \\ W_u K S & -W_u K R W_d \end{bmatrix} \quad (5)$$

where S is the sensitivity function $S=(1+KG_{u\to y})^{-1}$ and $R=G_{d\to y}S$. The weighting function W_p is usually taken with a high gain at low frequency in order to reject low frequency disturbances. The weighting function W_u is used to avoid large control signals. W_d is selected to minimize the effect of d on z_1 mainly [9] [10].

The synthesized $H\infty$ controller improves the accumulator response time and static error. Nevertheless, at the maximum web length, a tension oscillation appears because the controller is not anymore adapted to the accumulator. It's the same case that with a linear time invariant PI controller.

Exogenous inputs r and w are web tension reference and disturbances inputs respectively (which are either speed changes or web span lengths variations depending on the used control scheme, see Fig. 3 and Fig. 4). The $H\infty$ problem consists of finding a stabilizing controller K which minimizes the $H\infty$-norm of the transfer function between external inputs r and w and performance outputs z [3].

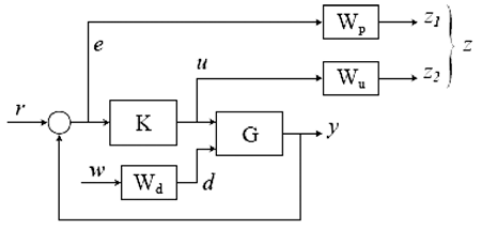

Fig.5. H∞ framework

D. Multi-model H∞ controller

The synthesis of a multi-model $H\infty$ controller is based on the same approach as for a linear time invariant $H\infty$ controller. One $H\infty$ controller is synthesized for the minimum length of web and a second controller for the maximum length of web. The same control strategy as for a multi-model PI controller is used. With this approach, the web tension oscillations for the maximum span length are significantly reduced [11].

IV. PRACTICAL EXAMPLES

In this part are described two difference practical examples in control of carriage in accumulator. One is focused on the moving carriage using electrical motors [7], and another uses hydraulic system for carriage control [4]. For both systems, according to the difference between speeds of outputting and inputting web, the carriage is moving up and down.

A. Control of an accumulator by electric drives

1) Control scheme

The control structure is shown in Fig. 6. The output of the tension controller is the reference speed, which is corrected by the speed difference between accumulator entry and exit. As the carriage is driven by two drives, it could leads to a position deviation of one drive against the other. To avoid this, the control structure is usually completed by the carriage position control enabling synchronization of position of both drives where one of drives works as a master and the second one as a slave, following the position of the first one.

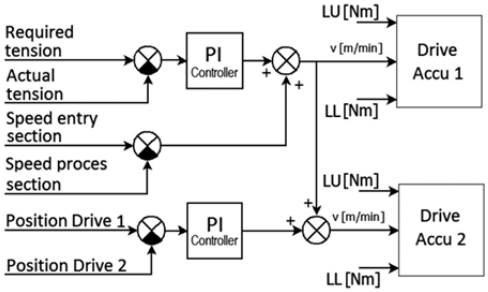

Fig.6. Principal diagram of control of accumulator drives [7]

2) Losses of accumulator

The weight of the carriage and the friction value can be estimated by measurement of accumulator loses. This measurement can be done by increasing the speed of the drive in steps. The motor is kept during a period of few seconds on a constant speed value and then the actual value of the motor torque is measured. The result of the measurement is a table with values of speed and corresponding friction torque values, which also contain the torque from the carriage weight [7].

3) Drive system

The carriage is lifted by a chain which on each side is driven by a motor through a gear. There is mounted a cog-wheel on output of each gear which is belted by a chain. The chain is fixed on the top of the accumulator carriage. Each motor is equipped with a speed sensor on the motor shaft and the position sensor placed on the gear output.

Both drives should lift the carriage car simultaneously. Any difference in the position of the left and right side of the carriage lead to a damage of the accumulator mechanics. In the previous part, mentioned master-slave system is introduced in the drive system and thus it avoids any mechanical problems.

The drives are completed by a pneumatic brake that has to carry the weight of the mechanism after stopping. For the reason, the carriage would not cause any drop at opening the brake (even falling to the ground of the accumulator), the drive must develop the force that is larger than the weight of the mechanism. The drive starts its rotation in both directions by a small positive speed and offset that creates a torque in a positive direction. Then the pneumatic brake can be opened and drive accelerates to the required speed. The process of opening the brake is described in [7].

B. Control of an accumulator by hydraulic

1) Hydraulic system

A schematic of the accumulator hydraulic system and the carriage is shown in Fig. 7. It consists of two symmetrically placed cylinders, a directional proportional valve, and a pressure-compensated pump. The pressure in each cylinder is regulated by the same directional proportional valve [4].

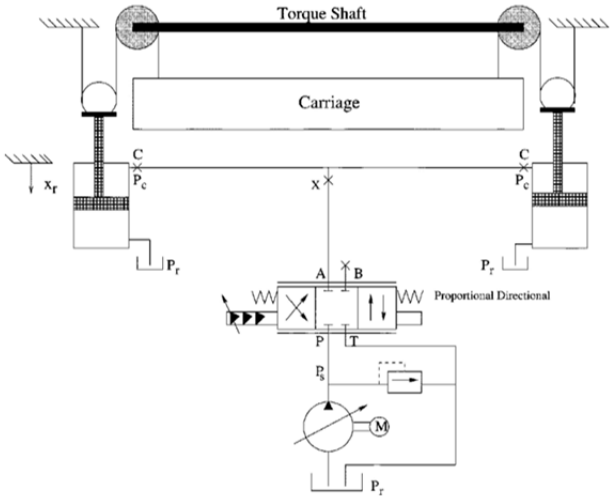

Fig.7. Accumulator hydraulic scheme

2) Negative effects

The friction between the ram and the cylinder during carriage motion plays a major role in the strip tension change through the accumulator. For example, friction for up and down motion is different. Seal design and rod lubrication are big factors. Specific loss compensation is required to avoid disturbance to the web tension during carriage motion. Loss compensation is done by either raising or lowering the reference pressure in the cylinders. A technique that can provide the amount of loss compensation and when it should be applied is useful. Further, breakaway friction prevents the ram from moving on small sheet tension variations. This results in an undesirable consequence of passing tension changes through the accumulator. Also, the large mass of the carriage and rolls limits the accumulator ability to respond to higher frequency sheet tension disturbances. Roller bearing friction is also a major factor in the tension change through the accumulator [4].

Pressure drop due to friction in the long pipe from the proportional valve (point *A*) to the entry point of the cylinder (point P_c) and dominant damped resonant frequency of the system have important role in calculation of controller. The low value of the dominant resonant frequency is mainly due to the long ram stroke in the cylinder. This leads to low system rigidity, which may result in poor response of the ram to accelerations and decelerations. Further, stick–slip can be expected at low travel speeds of carriage.

3) Pressure boost

When the carriage is stationary, the fluid pressure in the cylinders is regulated at a constant reference pressure. When the accumulator is moving up, the reference pressure is increased by a constant amount to maintain sheet tension. In the following, this increase in reference pressure will be referred to as pressure boost. Pressure boost serves to compensate of friction in the cylinder and rod seals, and for the acceleration component of the carriage. The ram is fully extended when the carriage is at its bottom position. As the dry ram moves into the cylinder the accumulator starts moving up. Dry breakaway friction may cause such sudden drop in sheet tension when carriage starts to move up.

As soon as the exit speed exceeds the process speed, i.e., carriage starts to move down, and the reference pressure boost is no longer required. Also, there is no appreciable drop in tension when the accumulator is moving down. This may be due to the fact that the ram coming out of the cylinder is well lubricated. Further, the seals may have low friction when the ram is moving out of the cylinder and high friction when the rod is moving into the cylinder. Since pressure boost is required only when the carriage is moving up, it appears that the requirement of additional force to compensate for acceleration may not be significant when compared to frictional force [4].

V. Conclusion

An immediate issue is to design an efficient control algorithm for the dynamic model of the accumulator. Currently, a proportional–integral–derivative (PID)-based control strategies are extensively used in the industry. These strategies are easy to tune and develop, but have their own limitations in system performance and robustness.

Further, the dynamic model of the accumulator is highly nonlinear, especially the pressure dynamics, which may lead to undesirable performance.

Our future work will should be include proposal regulation of dynamic model with nonlinear parameters.

Acknowledgment

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Control system of skid steered wheeled robotic vehicle with ROS interface

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***Abstract* — The paper presents principles and features of designed control system for skid steered wheeled robotic vehicle. Vehicle should serve as a testing platform for research of localization, mapping, planning and control algorithms in mobile robotics. Robotic vehicle has capabilities to be connected to a Robotic Operation System (ROS) which is widely used by researchers and developers of robotic systems.**

***Keywords*— robotic vehicle, skid steering, ROS, motion control.**

I. INTRODUCTION

Nowadays when autonomous robotic vehicles became popular, the research in this field is focusing mainly on its localization and mapping problems. But for development of new algorithms for autonomous robotic vehicle operation, a physical model of vehicle is needed, where created algorithms can be tested in real-world conditions. The independence from higher level control, open architecture for realizing customized control interventions and compatibility with most often used tools of scientists are required for these testing platforms. Because of this, a model of skid steered wheeled robotic vehicle was developed with its own power stage and low level motion control system. The control system of vehicle communicates over a serial bus with higher level control, where interface for ROS was developed and implemented to ensure compatibility with research and development tools.

II. SKID STEERED WHEELED VEHICLE

Skid steering is a special case of differential chassis, where the travel direction of robot is given by difference of speeds on each side of vehicle. If speeds have different value, the vehicle is turning. Typical example is a panzer where tracks are instead of wheels. Main advantages of application of skid steering principle are mechanical simplicity and good traction on rough and loose terrain. On the other side if the vehicle is skidding, it is hard to predict the axis and degree of vehicle rotation, because it is very depending on surface friction [1]. Another disadvantage is a high energy consumption when skidding, which is partially eliminated by using electrical drives capable of recuperation of energy. A pivoting suspension was used for maintaining simultaneous ground contact for all four wheels in rough terrain. (Fig. 1)

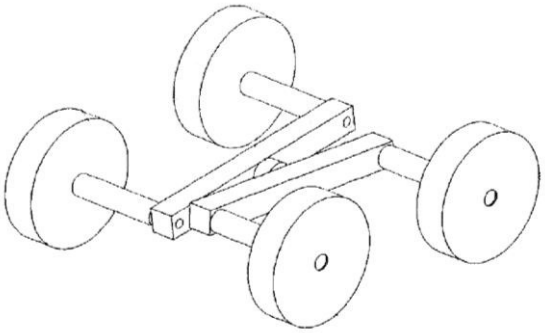

Fig. 1. Skid steered pivoting chassis [2]

III. POWER STAGE

Permanent magnet synchronous motors of vehicle with planetary gears are embedded directly into the wheels. For motor control of skid steered vehicle, dual axis servo controller was developed (Fig. 2). It can be embedded in chassis which improves heat dissipation and there is no need for active cooling. Inverters are designed for nominal voltage 60 V and nominal current 10 A for each axis. There is one dual axis inverter per side on robotic vehicle. A packet of LiFePo4 battery was used to ensure robot mobility. A battery management module was developed for optimal energy flow between cells,

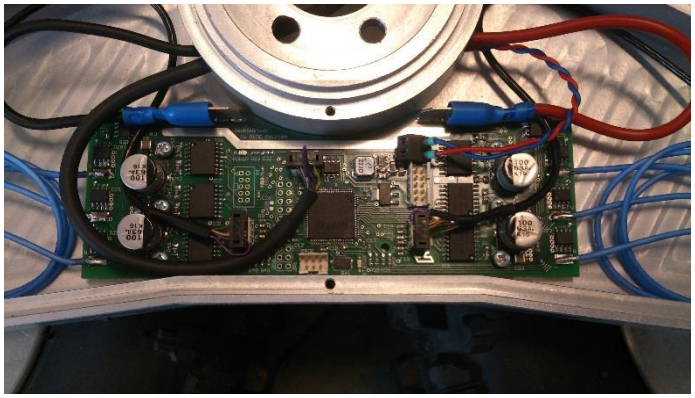

Fig. 2. Dual axis servo controller

IV. SERVO CONTROLLER

Motor control algorithms were implemented on ARM Cortex-M4 microprocessor. Controllers has configurable structure and parameters. It is possible to set speed control, current control, pure PWM generation and master/slave

structure, which is the preferred structure for skid steered vehicle. [3] Structures are implemented for vector control mode and for block commutation mode. In master/slave structure the selected master drive operates in speed control mode with PI controller (1). The slave drive operates in speed control mode with P controller and has the same reference speed as the master drive. Master drive shares its integral component with slave drive with adjustable amount (2).

$$I_{qr1} = \left(K_{\omega 1} + \frac{K_{I\omega 1}}{s}\right)(\omega_{r1} - \omega_1) \quad (1)$$

$$I_{qr2} = K_d\left(\frac{K_{I\omega 1}}{s}(\omega_{r1} - \omega_1)\right) + K_{\omega 2}(\omega_{r1} - \omega_2) \quad (2)$$

Cycle time for current control loop is 50 µs and 200 µs for superior speed control loop. Safety functions were also implemented. Controller switching off its power stage by pushing central emergency stop button. In case of communication loss with higher level control system drives are immediately braking till stop.

V. Communication

Communication with higher level control system, is realized by RS-485 serial bus, through custom communication protocol. Controller send messages about its internal state and some important physical measurements such as currents, voltages or motor speeds. Messages to controller define the mode of operation and set setpoints for selected structure. Configuration of controller in service mode can be done over this bus also. Maximal cycle time of communication with two servo controllers is 1ms at bus speed 921600 baud.

VI. ROS Interface

A higher level control is performed in our case on the Raspberry Pi3 embedded computer with installed robotic operation system (ROS). Raspberry Pi3 offers very good computing power to energy consumption ratio and ROS has very good distributed computing mechanism. [4] It was necessary to implement the custom communication protocol in ROS environment to make robotic vehicle "ROS-Enabled". Developed program is a ROS node that converts data from robotic vehicle to ROS message and vice versa. This approach enables that multiple ROS nodes placed anywhere in network can read data and control the robotic vehicle. A teleoperation ROS node was implemented to perform basic motion function and for testing purposes. The remote control is done by gamepad. Operator can remotely control the robot and has a feedback from vehicle with added video signal from camera also. (Fig. 3)

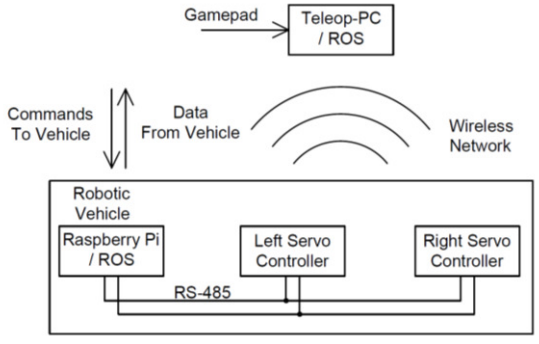

Fig. 3. Block diagram of communication

VII. Conclusion

Proposed robotic vehicle offers a testing platform for research and development of new localization, mapping and navigation algorithms in real world conditions. The ROS interface is the main advantage of this solution, because ready to use packages of ROS can decrease development time and offers more space for research. The ROS interface is compatible with well known research tools such as MATLAB or LabView.

VIII. Future Work

The major goal in the future is to develop and implement a simulation and localization algorithms based mainly on data from stereo and time of flight cameras. [5] The minor goal is to improve quality of trajectory tracking of skid steered wheeled robotic vehicle [6] by using visual odometry [7] and data from inertial measurement units.

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Controlling a function model of rehabilitation system

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***Abstract*— The article describes design and realization process of a control system for function model of lower limb rehabilitation system. Designed control system allows motion control of patient movements, based on signals from sensors, which are localized in heel and in upper plantar arch region of the foot. Furthermore the article describes the graphical user interface and its possibilities. In the last part of the article the next steps for future work are determined.**

***Keywords*—rehabilitation system, microcontroller module, motion control**

I. Introduction

Spinal cord and spine injuries are one of the most serious injuries. Functional disabilities are generally the extent that affected invalidating. Some are dependent on the use of the wheelchair, some need another person to help and some are confined to bed permanently [1]. The result of spine and spinal cord injuries is limbs and trunk paralysis of varying size, the emergence of paraplegia (complete paralysis of both lower limbs) or tetraplegia (complete paralysis of all four limbs).

The overall aim of rehabilitation is full or at least partial return of the lost function. Timely and comprehensive rehabilitation of paraplegic patients with correct application of physical motion therapy and the assistive devices may shorten the time spent in the hospital. Medical rehabilitation with the individual levels of motion therapy elements greatly influences the final effect of the treatment [2].

The motion element in the medical rehabilitation includes the implementation of passive movements with limbs and a process of allocating active movements to the rehabilitation program. In the last phase of rehabilitation it is possible to use the rehabilitation system, which allows patients to move to different distances.

II. Present State of Problematic

The trend of the current design and the development in rehabilitation robotics is a device that can restore lost motor functions of the patient. These devices should have the same effect as a qualified therapist. In the field of rehabilitation robotics two elementary techniques of rehabilitation exists. The first uses controlled movements with the limbs of the patient and the other functional electrical stimulation limb muscles.

The commonly used rehabilitation systems, which allows patients to move different distances, use the first elementary technique.

III. Design and Realization of Control System

The objective of the proposed system is the motion control of patient movements, based on wireless signals. The control system allows to determine the foot contact with the floor during gait. During the gait cycle the foot position is analyzed, and if the position is stable the next step is autonomously initialized. Functionality of the proposed system is shown in flowchart (Fig. 1).

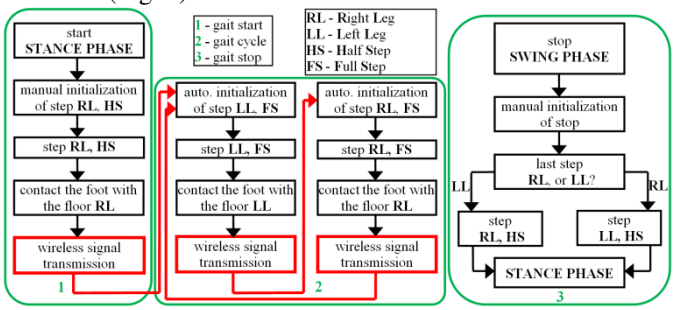

Fig. 1. Flowchart of the control system

Gait by using of rehabilitation system starts from the standing phase and the first step must be manually initialized. After manual initialization the control module performs the first step according to predefined parameters. After performing step (RL, HS), the control system is waiting for the evaluation of the foot contact with the floor. Subsequently the sensor module, which is located at the lower part of the foot sends the signal to the control system. Received information automatically initiates the next step (LL, FS) and this is repeated until the gait cycle is not stopped manually. After manual initialization of stop the control system evaluate the last step before stopping and perform necessary moves in order to be returned the rehabilitation system to the initial standing phase.

A. Sensor module

The application require the integration into slim insole what results into some specific requirements:

1. compact and low profile given by localization in plantar region of foot,
2. robustness due to high mechanical stress,
3. resistance to humidity variation in full RH range.

Considered specifications were resulted into a four channel sensor module including sensing, control and communication unit. It is physically realized as two sensing modules and a control module what imply all the signal handling and power sourcing functions.

Sensing part is composed of two double sensing modules at

the base of resistive elements sensitive to mechanical stress. As the resistive elements silicone polymers which contain carbon particles are used. They are placed in serial arrangement between conductive electrodes and encapsulated in impermeable module from glass-fibre epoxy FR-4 substrate. Arrangement of elements is not in balanced in self compensated bridge, so the temperature compensation is essential. These modules are intended to be localized in heel and in upper plantar arch region of the foot.

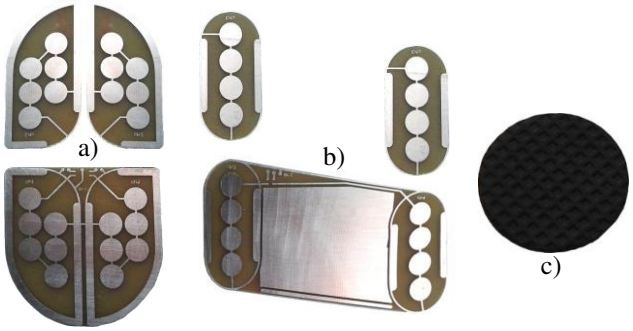

Fig. 2. The individual parts of the sensing module. Description: a) sensing part of the heel, b) sensing part of the upper plantar arch region, c) carbon filled silicone polymer.

Sensing part include main ATmega328P RISC microcontroller module with configured analogue and communication digital channels, communication USB-UART driver, HC-05 BlueTooth wireless module, power management circuitry including battery and TP4056 charger module.

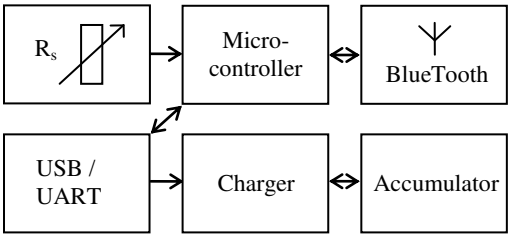

Fig. 3. Load sensing system circuitry block schematic diagram.

Actual values of mechanical stress are directed through analogue channels to the microcontroller, subsequently transformed into digital form and translated into real values.

The microcontroller program structure includes channels initialization, communication protocols setting, data acquisition, translation and wireless transmission through BlueTooth.

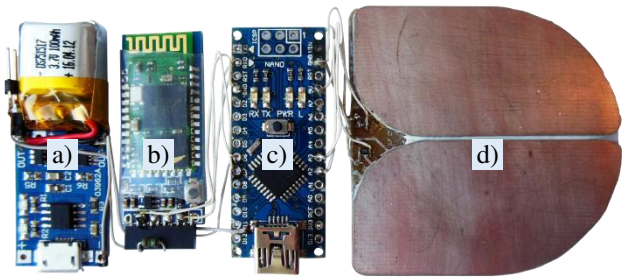

Fig. 4. Sensor circuitry with sensing part of the heel. Description: a) LiIon accumulator and charging module, b) BlueTooth module, c) microcontroller module, d) sensing module of the heel.

Power source is supplied by embedded 100 mAh LiIon accumulator. It is charged by USB interface through charging controller. USB interface is also intended for microcontroller programming and potentially for data acquisition. Considering 4 sensor elements with peak current consumption of 0.42 mA, microcontroller peak consumption of 9 mA the total power consumption at 4.2 V supply is up to 50 mW, what results up approx. 8 hours of accumulator operation.

B. Graphical user interface

Using LabWindows/CVI the graphical user interface was created. GUI is used to adjust the communication parameters, basic motion parameters and potentially to control the rehabilitation system. Created graphical interface except settings and control provides a graphical feedback of the position of each joint and shows the actual gait cycle. The scroll bars allow setting the maximum angle of flexion and extension, while virtual knobs allow the speed, acceleration and deceleration settings of movement.

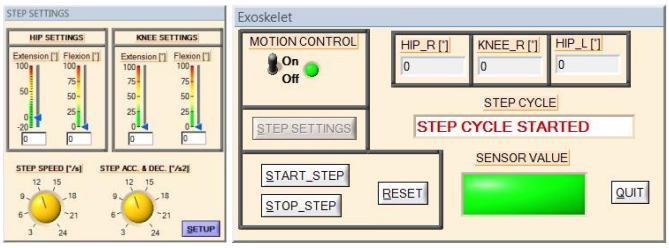

Fig. 5. Conrol panel for adjustment of the step parameters, the main control panel of the GUI.

The main control panel is divided into three basic parts. In the first part the adjustment functions are located. The second part includes three control buttons which allow start and stop walking and, if it is necessary to reset the actuators into initial standing phase. The third part of the control panel is made up of graphical feedback tools.

IV. PROPOSAL FOR THE NEXT STEPS

The proposed control system for function model of lower limb rehabilitation system will be extended by an audio feedback for patient. Using audio feedback the patients can correct movements in case of an unstable position of the feet.

In the next step the integration of the whole control system to a portable microcomputer will be realized, which has the control capability for rehabilitation system to transfer the patient to different distances. In addition, a manual initialization of individual commands will be solved by using joystick, what can be located on crutches. The objective is integration of portable microcomputer into control system to replace the functions of the desktop computer. As the portable microcomputer which provides the control of the EPOS2 digital positioning controllers the Raspberry PI3 is planned.

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Cooperative covariance-based spectrum sensing

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***Abstract*—This paper presents a summary of the authors' recent research work in the area of cooperative spectrum sensing based on the properties of the covariance matrix of the received signal. A brief overview of the state-of-the art literature showing the importance of the selected topic is provided. The major authors' contributions are presented.**

***Index Terms*—Spectrum sensing, signal detection, cooperative sensing, sphericity test**

I. Introduction

The need for higher data rates is increasing as a result of the transition from voice-only communication to multimedia type applications. Also every day more and more devices are equipped with some form of wireless communication capability and with the rise of Internet of Things concept and increased demand for data volume, the current spectrum management schemes are no longer sufficient. One of the solutions for this problem is opportunistic spectrum access scheme together with the Cognitive radio (CR) technology. The key feature of the CR is *spectrum sensing*, which is an ability to measure and sense its radio environment in order to identify potential spectrum access opportunities [1]. This paper presents a short summary of the authors' recent research in the area of cooperative covariance-based spectrum sensing together with a brief overview of the research results that indicate the the proposed method outperforms conventional cooperative sensing schemes based on the OR and AND data fusion logic.

II. Basic principles of spectrum sensing

The basic principle of spectrum sensing can be described as process, in which SU analyzes its radio environment, creates a test statistics from the received signal and based on this statistics, decides between two hypotheses: *PU transmitting* or *PU idle*. This process can be performed either locally by a single SU (single-user spectrum sensing) or by exchanging local sensing data in across a network of SU nodes (cooperative spectrum sensing).

A. Problem formulation

Let us consider the general model for q-users cooperative spectrum sensing in the presence of m primary users (PU). Let us denote $\mathcal{H}_0$ as the hypothesis of primary signal being absent and $\mathcal{H}_1$ as the hypothesis of primary signal being present in the signal received by the secondary users. The signal received by i-th secondary user can be then expressed as:

$$\mathcal{H}_0 \quad : \quad \mathbf{x}_i = \mathbf{n}, \tag{1}$$

$$\mathcal{H}_1 \quad : \quad \mathbf{x}_i = \mathbf{H}_i\mathbf{s} + \mathbf{n}, \tag{2}$$

where $\mathbf{x}_i \in \mathbb{C}_i^p$ is the data vector received by the i-th user, p_i is the number of the receiving antennas of the i-th user. The matrix $\mathbf{H}_i \in \mathbf{C}^{p_i \times m}$ contains the coefficients of the channel between the m primary users and the i-th secondary user. The $m \times 1$ vector $\mathbf{s}$ denotes the signals transmitted by m primary users and finally the $p \times 1$ vector $\mathbf{n}$ is the complex Gaussian noise with zero mean and covariance matrix $\sigma^2\mathbf{I}_{p_i}$, where the scalar σ^2 is the noise power. By combining the received data vectors from all i secondary users we obtain the combined received data vector

$$\mathbf{X} = [\mathbf{x}_1^T, \mathbf{x}_2^T, \ldots, \mathbf{x}_q^T]^T. \tag{3}$$

The problem of signal detection (and spectrum sensing) is to find function (test statistics) $\Lambda(\mathbf{X})$ and threshold ϵ such that following error probabilities are minimized

$$P_{fa} \quad = \quad P\big\{\mathcal{T}(\mathbf{X}) > \epsilon|\mathcal{H}_0\big\}, \tag{4}$$

$$P_m \quad = \quad P\big\{\mathcal{T}(\mathbf{X}) < \epsilon|\mathcal{H}_1\big\}. \tag{5}$$

The probability P_{fa} is the probability of false alarm, i.e. the probability of falsely detect the presence of primary signal under $\mathcal{H}_0$. Reversely, the probability P_m is the probability of missed detection, i.e. the probability of falsely reject $\mathcal{H}_1$ hypothesis. The test statistics can be e.g. energy of the received signal, ratio of the maximum-to-minimum eigenvalue of the covariance matrix of the received signal, or some other quantity, which clearly differentiate between $\mathcal{H}_0$ and $\mathcal{H}_1$. In order to calculate the optimal threshold ϵ that minimizes P_{fa} and P_m, or that at least provides some predefined value of P_{fa}, it is necessary for the probability distribution of the test statistics to be known or at least approximately known. Moreover, let us define the probability of correct detection P_d as $P_d = P\{\mathcal{T}(\mathbf{X}) \leq \epsilon|\mathcal{H}_1\} = 1 - P_m$.

B. Covariance-based spectrum sensing

While there are several signal detection and spectrum sensing methods based on various characteristics of the received signal (e.g. energy-based detection [2], cyclostationary detection [3] or matched-filter detection), the author focuses on so called covariance-based detection [4], [5], which with its blind (i.e. no a priori information about the PU signal are required) nature provides outstanding signal detection performance in various scenarios.

Population covariance matrix of the signal received by the i-th CR under both hypotheses can be expressed as:

$$\mathcal{H}_0 : \Sigma_{ii} = \mathrm{E}\left[\mathbf{X}_i \mathbf{X}_i^{\dagger}\right] = \sigma_{w_i}^2 \mathbf{I}_p, \tag{6}$$

$$\mathcal{H}_1 : \Sigma_{ii} = \sigma_{w_i}^2 \mathbf{I}_p + \sum_{j=1}^{m} \gamma_j \mathbf{h}_{i,j} \mathbf{h}_{i,j}^{\dagger}, \tag{7}$$

where γ denotes signal-to-noise ratio and $\mathbf{h}_{i,j}$ denotes vector of channel coefficients between each receiving antenna and each primary user. Population covariance matrix of the signal received by all q CRs can be expressed as:

$$\Phi = \begin{bmatrix} \Sigma_{11} & \Sigma_{12} & \cdots & \Sigma_{1q} \\ \Sigma_{21} & \Sigma_{22} & \cdots & \Sigma_{2q} \\ \vdots & \vdots & \ddots & \vdots \\ \Sigma_{q1} & \Sigma_{q2} & \cdots & \Sigma_{qq} \end{bmatrix} \tag{8}$$

Based on the matrix Φ the test statistics for the so called multisample sphericity test can be expressed as:

$$\Lambda_{\text{full}} = \frac{|\Phi|}{\prod_{i=1}^{q} \left[tr\left(\frac{\Sigma_{ii}}{p}\right) \right]^{p_i}} \tag{9}$$

In order to compute determinant of Φ, the node performing the calculation of the test statistics must have access to all received samples. This is not feasible in practical scenario since the communication overhead would be too high.

C. Proposed method

By using the fact that the determinant of the matrix can be approximated by the product of the determinants of the diagonal submatrices of the original matrix, the following test statistics is proposed:

$$\Lambda_{\text{approx}} = \frac{\prod_{i=1}^{q} |\Sigma_{ii}|}{\prod_{i=1}^{q} \left[tr\left(\frac{\Sigma_{ii}}{p}\right) \right]^{p_i}}. \tag{10}$$

The calculations in the proposed method are based solely on the determinants and traces of the diagonal submatrices of the global covariance matrix. Determinants and traces can be precomputed locally on the CR nodes and the resulting values are then sent to the central node for the calculation of the global test statistics. The communication overhead caused by sharing the sensing data is 2q double precision values per sensing interval.

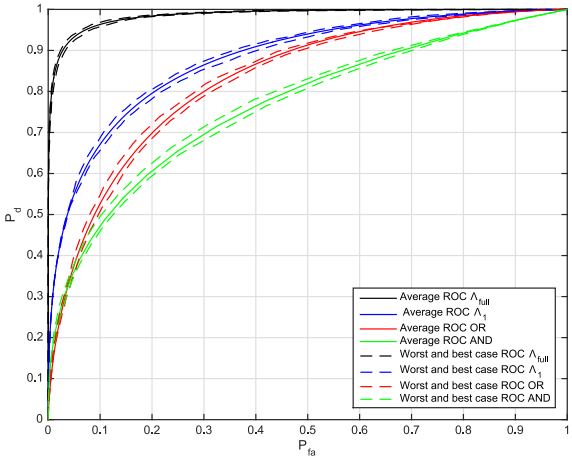

Fig. 1. ROC curve for the scenario with 4 CR terminals

III. Performance evaluation of the proposed method

Since spectrum sensing is an application of signal detection problem, the performance of a given spectrum sensing algorithm can be evaluated by the means of receiver operational curves (ROC) and quantities derived from it (e.g., area under ROC curve and other statistical parameters of the ROC curves). The performance of the proposed method was compared with the traditional multisample sphericity test as a reference method and also with traditional AND and OR decision fusion rules. The local spectrum sensing method employed in AND and OR fusion schemes was sphericity test. The analysis of the performance of the proposed method was investigated using computer simulation with the following parameters:

TABLE I
Simulation parameters

Parameter	Value
Number of collected samples N	50
Number of sensing terminal q	1,2,...,8
Number of antennas per terminal p	2
Number of primary transmitters	1
Noise variance	1
Signal-to-noise ratio	-10dB
Number of simulation runs	1000
Number of sensing periods per simulation run	10000

The results of the simulations are shown in Fig. 1 and Fig. 2.

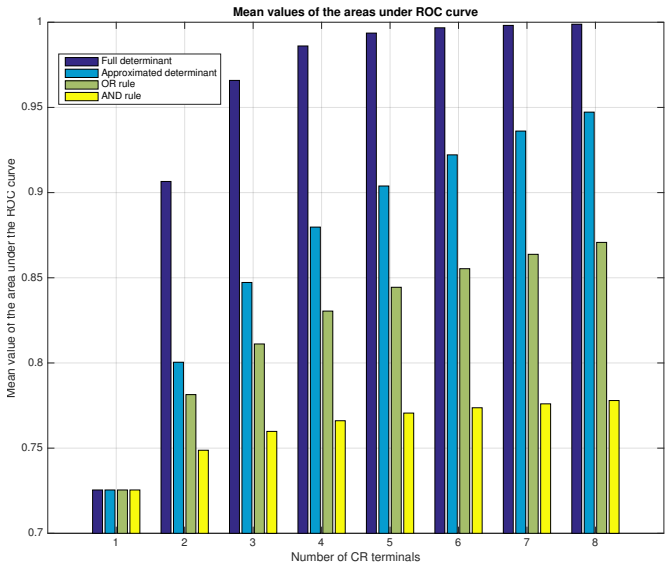

Fig. 2. Relationship of the mean value of the area under ROC curve and the number of CR terminals

IV. Results and conclusion

- The results indicate that the proposed method for cooperative spectrum sensing clearly outperforms conventional cooperative spectrum sensing data fusion schemes using OR and AND decision fusion logic.
- While the inaccuracy introduced by the approximation of the determinant of the covariance matrix is obvious in the ROC curves comparison, the proposed method still provides better detection accuracy than cooperative sharing of the local sensing decisions in combination with AND and OR decision fusion rules.
- Even though the communication overhead of the proposed method is higher than in case of decision fusion, it is still reasonably low and the proposed method can provide an effective way for identifying unoccupied frequency channels in the multiuser cooperative scenario.

Acknowledgment

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Data Mining in Selected Medical Domain

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***Abstract*—According to World Health Organization, Cardiovascular Diseases (CVD) are the biggest killer of people in a few last decades. Many researchers attempt to analyze data from various medical domains, often from cardiology, to classify patients (not) suffering from CVD or to predict increased risk of formation of acute coronary syndrome. These research using various data mining methods in order to the creation of a model to predict or classify. This article summarizes several the most commonly used methods for analyzing data from the medical area and underlines the necessity of attending to this topic.**

***Keywords*—medical data mining, coronary heart disease, coronary artery disease, data mining methods**

I. Introduction

The most common reason of death in the few last years are cardiovascular diseases (CVD). According to World Health Organization (WHO), CVD is the number 1 cause of death globally. An estimated 17.5 million people died from CVDs in 2012, representing 31% of all global deaths. Of these deaths, an estimated 7.4 million were due to coronary heart disease and 6.7 million were due to stroke [1]. In 2015, ischemic heart disease (IHD; one of the types of CVD [2]) and stroke (could be implication of atherosclerosis or other type of CVD [2]) were the biggest killers of the population. WHO said that combination of these two diseases killed over 15 million people. In the last 15 year, IHD with stroke is the top cause of death globally [3].

Analyzing the medical data from this domain in order to prevent CVD is therefore a very important research topic with huge possible impact. This underlines a fact that e.g. Kurt at al. [4] dealt with this topic in early 2008. As well as before they research CVDs and risk factors which can cause the CVDs, so after their work, many researchers follow them and we will look to their work in next parts of the paper.

II. Cardiovascular Diseases

Many of published research results are performed in cardiology area and often focus on CVDs. CVDs are classified as a heart and blood vessel diseases. Cardiovascular diseases and their complications (chronic or acute) produce by occlusion in coronary artery´s ischemia of myocardial muscle. This group of diseases we can classify to *acute ischemic coronary artery diseases* and *chronic ischemic coronary diseases*. The first, acute group, include:

1. *myocardial infarction;*
2. *unstable angina pectoris;*
3. *sudden cardiac death.*

The second, chronic or non-acute group, covers:

1. *stable angina pectoris;*
2. *microvascular angina pectoris;*
3. *Prinz metal's angina pectoris;*
4. *syndrome X et al.*

The Atherosclerosis is an inflammatory, proliferation and degeneration process on artery´s and the progression of atherosclerosis on coronary arteries can lead to acute coronary syndrome. There are many risk factors of atherosclerosis some are modified (e.g. hypertension, smoking, increased levels of LDL cholesterol) and some are unmodified (e.g. genetic predisposition). Typically and a major clinical symptom is a chest pain (pressure, astringent or stabbing type of pain subsequent to physical activity)[2][5].

III. State of the Art

At the start of the previous section, we indicated that many types of research of this topic were conducted. In many of these, authors research effects of some risk factors to CVDs. The relatively known dataset which contains many attributes or symptoms, factors lead to CVD, is *Cleveland dataset*. This dataset is freely available (*UCI Machine Learning Repository*) and so, this data were used in several types of research.

For example, in [6] authors used not only *Cleveland dataset*, but also others, like Hungarian, Long beach VA and Statlog project dataset, which are free available on UCI Machine Learning Repository too. Investigators in [6] did experiments on all of these datasets and on the basis of their results they choose five most important factors from each dataset. Subsequently, they merged datasets into one and they use it for next experiment. Experiments which were used for analyzing datasets were Fast decision tree (FDT) and C4.5 decision tree. When researchers analyzed the datasets separately, the highest accuracy was achieved with algorithm C4.5 for Hungarian dataset (78.57%). After merging datasets into one, the highest accuracy which authors achieved, was 78.06% for FDT with using the most important factors affecting CVD. Results are displayed in Table I and Table II.

TABLE I
ACCURACY OF CORONARY ARTERY HEART DISEASE DATA SETS, [6]

Dataset	Accuracy (%)	
	C4.5	**FDT**
Cleveland	78.54	77.55
Hungarian	78.57	78.23
Long beach VA	71.5	69.5
Statlog project	76.6	76.6

TABLE II
COMPARISON OF THE ACCURACY OF THE DATA SETS, [6]

DT	Average accuracy of separated data sets (%)	Accuracy of merged data sets with the best attributes (%)
C4.5	76.3	77.5
FDT	75.48	78.06

Authors of article [7] focused on Cleveland dataset, but they do this after their own research. Investigators focused here on creating a model to diagnosis of Coronary Artery Disease (CAD) and identifying prime risk factors causing CAD. For creating the model, they used several methods, and so they called the model *Hybrid data mining model*. The model was created in several phases, in which authors changed or joined some methods. At the first, they used all attributes from data gained from Department of cardiology in Indira Gandhi Medical College in Shimla in India and applied Multi-layer perceptron (MLP). MLP achieved 77% accuracy for all attributes. Then they used Multinomial logistic regression (MLR) model with 83.5% for all attributes, too. This accuracy was the highest for all attributes because next methods, Fuzzy unordered rule induction algorithm (FURIA) gave 77.9% accuracy and decision tree C4.5 gave 77.3% accuracy. Authors wanted to increase the accuracy and they decided to identify the primary risk factors using some methods, for example, correlation based feature subset (CFS), selection with particle swam optimization (PSO), k-means clustering and classification or combination all of these. This decision helped to improve the results and the highest accuracy provided method MLR (88.4%). The results are shown in Table III.

TABLE III
ACCURACY OF THE RESULTS OF HYBRID MODEL EVOLUTION, [7]

Methods	Accuracy (%)		
	All attributes	**CFS + PSO + Classification**	**CFS + PSO + k-means + Classification**
MLP	77.0	79.7	84.11
MLR	83.5	84.17	**88.4**
FURIA	77.9	80.29	82.8
C4.5	77.3	77.9	80.68

After their own research, they use *Cleveland dataset* and applied all methods to gain results. From all 14 features, attributes included in *Cleveland dataset*, they used only 7 risk factors (attributes were selected on the base on reduction with algorithm CFS, PSO, k-means, and classification). Using selected attributes, authors gained 90.28% accuracy on *Cleveland dataset*.

Next article related to CAD is [8]. Investigators applied decision tree C4.5 of data gained from Rajaie Cardiovascular, Medical and Research Center in Teheran and aimed to classify the patients into 2 classes:

1. Patients with artery stenosis;
2. Patients without artery stenosis.

The second aim of [8] was to predict the necessity of performing angiography based on the high-risk cases. Their research had several phases. At the first, authors used data with all attributes and algorithm C4.5. Next, they accomplished bagging and investigators gained the highest accuracy 78.51% after bagging for the left anterior descending (LAD) artery. Furthermore, analysts reduced the number of features and selected only the most important ones. They used *Information gain* and *Gini index* for selecting features. The highest resulted accuracy was 79.54% for C4.5 algorithm after bagging and using *Information gain* for LAD artery.

Researchers Atkov et al. in [9] classify patients into 2 classes:

1. Patient sufferers CHD;
2. Patient not sufferers CHD.

They used data from Central Clinic Hospital No. 2 of Russian Railways JSC which contains information about patients hospitalized for diagnosing CHD by coronary angiography. Atkov et al. used multilayer perceptron for classification. They used feed-forward neural network with 2 hidden layers and 10 factors. Accuracy with these settings was 94%. Researchers in next step reduced the number of factors to 5 and they gained accuracy 78% what was significantly lower. Authors describe that they used several other settings of neural networks, but neither gave higher accuracy.

The other type of CHD, Ischemic Heart Disease (IHD), is mentioned in [10]. Authors of this article tried to reduce numbers of features to identify IHD and by this to decrease the time and costs of medical treatment. Data was gained from Madras Medical College in Chennai in India. Researchers used multilayer perception network and when they used all features from datasets, they gained 70% accuracy for the training set (70% of the data) and 69% accuracy for the testing set (30% of data). In the next step, Rajeswari et al. removed feature *'age'* and accuracy decreased to 63% for training and 58% for testing set. Then they started the second iteration in which researchers removed pairs of features (e.g. pair age and gender). Similarly, investigators continue removing features in six iterations. By this reduction analysts gained 12 best features to diagnose IHD and among them also *age* and *gender*.

IV. THE MOST USED METHODS FOR MEDICAL DATA MINING

Data mining uses many methods and approaches to gain new information from data. The most often used methods in medical data mining are decision trees (for example C4.5), Naïve Bayes, Neural networks (the most common method is Multilayer perceptron) or Regression. All of these methods, we can divide into 3 groups:

1. *Classification methods;*
2. *Regression methods;*
3. *Clustering methods.*

A. Classification methods

These methods map examples of data on the target class(es). Classification methods are quite easy to understand and very strong tool in data mining.

1) Decision Tree

Methods, which belong to the group of Decision Trees (DT), present a very simple way to gain new information. DT is a type of classification method. DTs are simply readable and understandable and therefore comprehensible also by clinicians or medical experts. The output of DT looks like a normal tree, but the root (root node) is on the top of the graphical output and leaves (leaf nodes – represent target classes) are on the bottom of the graphical output. In the middle of the graphical output are intermediate nodes which represent the attribute tests.

The most common type of DT is algorithm C4.5. The algorithm uses information gain ratio for selecting test condition. Algorithm C4.5 was a successor of the algorithm

ID3 (Iterative Dichotomizer 3). Both were created by Ross Quinlan and C4.5 is more complex like ID3, which used information gain as selection criteria. C4.5 can work with continuous variables and missing values. Next table represents differences between ID3 and C4.5:

TABLE IV
DIFFERENCES BETWEEN ID3 AND C4.5, [11]

	ID3	**C4.5**
Missing values	No	yes
Type of values	Categorical values	Continuous and discrete attributes
Splitting criteria	Information gain	Inf. gain ratio
Pruning	No	Error based

C4.5 was used in [8] as we mentioned early. Alizadehsani et al. used data from Rajaie Cardiovascular, Medical and Research Center in Teheran and achieved accuracy 79.54% with bagging when they not used all attributes from the dataset, but they selected only 20 the most important attributes on the base on information gain. Using C4.5, very similar accuracy, but on Hungarian dataset, was achieved by El-Bialy et al. [6], namely 78.57%.

2) Naïve Bayes

Naïve Bayes is a technique which works with a probability of occurrence of phenomena, so this is stats classifier. Technique Naïve Bayes gain its name after the discoverer, Thomas Bayes and it is built upon the strong assumption that different features are independent of each other [12]. On the base on this assumption, Naïve Bayes gain their epithet 'naive'. The advantage of Naïve Bayes is that each class is characterized by simple probability description [13] and is also quite easily interpretable for medical doctors. This technique is used to a lesser extent as previous DT, but it was used by Thakkar et al. [14] to classify patients of swine flu into 3 categories: least possible, probable or most probable. Using Naïve Bayes classifier, authors achieved accuracy 63.33%.

3) Neural Networks

The human brain consists of millions of neurons which are connected to each other. Neural networks (NNs) try to emulate structure and topology of the human brain. In general, NNs look like oriented graphs with nodes and edges. The structure of NNs is not so simple and the most used types of NNs are NNs with a regular structure, for example, (feed-forward) multilayer NN. This type of NN has 3 layers: *an input layer*, *an hidden layer*, and *an output layer*.

Likewise, we can divide neurons into 3 groups: input, hidden and output neurons [15]. In general, one hidden layer is sufficient to the realization some function, but sometimes it is preferable to use 2 hidden layers for better results [16]. NNs are powerful tools for data mining task, but there is one important disadvantage. Interpretation of NN-based models is problematic. Following this, in the medical area, NNs are not used so often like other methods. For determination of diagnosis it is important for a doctor to know all circumstances and consider all aspects of patients' state.

As it is stated in [17], multilayer perceptron (MLP) represents the most commonly used form of NNs and a supervised learning algorithm is used for its training (backpropagation algorithm). Input neurons receive set of values and pass them to neurons in hidden layers. There, input values are used to learn non-linear function and result is sent to output layers. MLP can have several hidden layers. There is a direct correlation between the amount of hidden layers and complexity of the algorithm. MLP was used in [9] with 94% accuracy when MLP had 2 hidden layers and 10 factors. Atkov et al. tried to add or remove factors but accuracy did not increase. Another analysis using MLP is mentioned in [10]. In this study, the highest accuracy was 69% for the test set with all attributes. The aim of using MLP was to identify the most important risk factors leading to ischemic heart disease.

B. Regression

Regression is a technique which predicts some numerical values. The output of regression is a function which tries to describe some behavior of data and subsequently it tries to predict future behavior or some evolution of events. For creation of a regression function we need 2 types of values: one dependent (to be predicted) and independent variables. In general, dependent variable is only one, but we have several independent variables. According to the type of function used for regression model, there are:

- *Linear regression*;
- *Non-linear regression.*

The output of linear regression is a linear function, which can be represented by a line in n-dimensional space of variables.. This type of regression is very simple and it can be used only for numerical dependent variable, not categorical. For categorical dependent variable, logistic regression can be used (a type of non-linear regression). Logistic regression (LR) can be divided into 2 types: *binominal* and *multinominal*. It depends on the number of values of the independent variable. For binominal regression, there are 2 variants of the predicted variable: *event occurred* or *event not occurred.*

Multinominal regression can have 3 and more variants of the predicted variable values, for example, the patient with *low risk*, *medium risk*, and *high risk* [18].

Maybe, the most used type of regression is LR. It is used in [19] for predicting Albuminuria in Type 2 Diabetes Mellitus. Investigators try several data mining methods with dividing data set into 3 groups: the training (60%), the testing (20%) and the validation set (20%). From various methods, they gain different result: for the training set, by LR was achieved the accuracy 80.79% and for the validation set 74.24%. LR model was the 3rd best model for their data set. The best accuracy was achieved by MLP with accuracy 84.85% and the 2nd best was radial basis function (the type of NN) with accuracy 75.76% (a very similar to LR).

C. Clustering

Clustering is the next technique of a series of data mining methods. Its task is not to classify new case into the target class or predict some future behavior of data, but it searches for similar cases and provides grouping of them. Clusters may be created on the base of distances between cases (like Euclidean, Manhattan or Mahalanobis distance). One case (real or something like etalon – typical representative of the group) is voted as a centroid. Creating clusters happens in several iterations, in which centroid can be changed. Typical algorithms of this type of clustering are *K-Means* and *K-Medoids*. At the start of the algorithm *K-means*, centroids can be set with random values or it can be some of the cases. In each iteration examples are first assigned to the closest centroid and new centroids are calculated afterwards for each cluster of examples. Number *k* represents the number of clusters and it can be set manually, or algorithm specifies the best numbers of clusters [20][21][22].

This algorithm is used in [20] where authors are comparing several clustering methods, like Hierarchical and Density-based clustering, Ordering Points to Identify the Clustering Structure or expectation–maximization clustering. As a result of their comparison, the fastest algorithm was *K-Mean* with 2 clusters (distribution of cases to clusters in ratio 42:58(%)) and zero unclustered cases.

Using clustering methods in other medical domain is described in [21], where scientists applied several clustering algorithms on data about patients with breast cancer. Data set contains 198 cases with 2 classes (non-recurrent events and recurrent events) and 34 input features (WRBC database from University of Wisconsin Hospitals, Madison). The result of *k-means* was 2 clusters corresponding to the target classes and condition at the start of the algorithm was the maximizing the initial cluster distances. Ultimately, the accuracy of the *k-means* algorithm was 62% (the last one from 3 methods: Self-Organizing Map, Cluster network, and k-means).

V. Future Work

The aim of my thesis is to analyze medical data which will be obtained from several departments and propose the model for indicating selective coronarography (SCG). Some departments are placed in Louis Pasteur University Hospital in Košice, some are placed in East Slovak Institute of Cardiovascular Diseases. Data will be obtained from laboratory tests, too. Sensitive personal information about patients will be masked in the preprocessing phase of the knowledge discovery process. We will use preprocessed data about patients for learning classification model classifying patients into 2 groups:

1. Patients suitable for SCG,
2. Patients not suitable for SCG.

At first step of the process we will gain structured information about the patients from their medical records. Medical records are very specific for each doctor. It is written as continuous text which contains information about medical family history, some previous diseases of the patient and planned therapy or next medical treatment. Each doctor uses his own shortcuts of diagnosis, his own composition of sentences and so on.

Next step, we will have to pair information about the same patient from various departments. Then, we will propose data mining model for classification of patients. We will try several methods which are suitable for processing medical data. From this, we will choose one or two which will be the best.

The last step of the process will be an evaluation of the chosen model from various perspectives, not only by data miners from using measures like classification accuracy, but also from the medical perspective (verification of results based on medical expertise), as well as from the applicability perspective (improved quality of health care, costs saving).

The result of my thesis will be the model for classification of patients recommended for SCG and those, recommended for computer tomography (CT) or another non-invasive method is more satisfactory or more suitable. This decision will bring some benefits, like better diagnostic and selection who need noninvasive and invasive therapy. In addition, this will bring economic benefit, because of some of the medical examination, like SCG, are relatively expensive and decision that the execution of SCG is important or not can save considerable costs.

VI. Kosice Selective Coronarography

My thesis is a part of the project entitled *Kosice Selective Coronarography (KSC Multiple Risk Study)*. KSC is a common project where the following institutions are participating: *East Slovak Institute of Cardiovascular Diseases (in Slovak VÚSCH)*, *Medical faculty of the Pavol Jozef Šafárik University* and *Department of Cybernetics and Artificial Intelligence (DCAI) of the Technical University in Košice*. The aim of KSC will be creation classification model to indicate selective coronarography and define the signification of parallel presence of several risk factors for atherosclerosis.

A focused group of people will be men and women with suspected coronary artery atherosclerosis indicated for selective coronary angiography to be confirmed (undiagnosed) coronary heart disease.

Departments from VÚSCH and Medical faculty will be responsible for collecting data about patients and our department (DCAI) will be responsible for data preparation, modeling, and commonly we will evaluate the results and suggest their use in practice.

VII. Conclusion

This paper renders the needed of medical data mining, mainly from the area of civilization diseases which undoubtedly included cardiovascular heart diseases, too. In next, the paper summarized several types of research in this field of interest and provides an insight into the most used methods for data mining tasks. It follows that the data mining in the medical area is very important. It can help predict some disease or some health problems using various symptoms, the result of surveys and so on.

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Data classification and semantic information extraction

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***Abstract*—The task of data classification play a significant role in much real-life application. However, in some important application fields, such as medicine, control applications or in financial management, classifiers should provide not only high classification accuracy but also some straightforward and easy explanation of the computed output for better acceptance by users. The goal of this paper is to provide an overview of techniques of rule extraction from data using Artificial Neural Network (ANN) and Support Vector Machine (SVM), which are considered as a "black-boxes," because it is not possible to implicit extract knowledge from them. Subsequently, we discuss an MF ARTMAP as the method considered as a "white-box" classifier and outline the technique of rule extraction from this classifier. In the end, we mentioned new classifier with the similar characteristic as MF ARTMAP but with the ability of higher classification accuracy, which will be presented in an upcoming paper.**

***Keywords*—classifiers, neural networks, rule extraction, support vector machine**

I. Introduction

One of the categories of machine learning is classification. In this task, we try to build a software machine called classifier, which is supposed to divide input data into two or more classes. Such a classifier has two modes: training mode and processing mode. During the training mode, the classifier is building a model from training data. Created model is evaluated using testing data. A goal is to find the best model that provide us highest classification accuracy, which will be used in processing mode. During processing mode, a classifier can classify the unknown input element to one of the learned classes, and it is ready to be employed in a real world problem applications.

In some crucial application fields, such as medicine, control applications or in financial management [1] classifiers should provide not only high classification accuracy but also some simple and easy explanation of the computed output; for instance, in the form of *if-then* rules or the other form of semantic information. In [2], authors explain the importance of such rules or semantics. They argue that even limited explanation can positively influence the system's acceptance by the user. Furthermore, it can also provide a check on the internal logic of the system as well as it can give a novel insight into the solving problem.

The primary goal of this paper is to provide an overview of techniques of rules or semantics extraction from a variety of classifiers. Many researchers used as the basis for the rule extraction classifiers, such as an artificial neural network (ANN), Support Vector Machine (SVM) or Fuzzy ARTMAP, etc., which are considered as "black-boxes". It means that it is not possible to implicit extract knowledge from the base of classification machine; in contrast with "white-box" algorithms, such as decision trees or rule-based algorithms, which implicit work with rules as one of the semantic representation. For explicit extraction of semantics from "black-box" classifiers, many techniques were used in many applications.

II. Rule Extraction from Neural Network

Neural networks are well-known for their universal approximation property. However, a major drawback associated with the use of neural networks in some applications is their lack of explanation capability. While they can achieve a high predictive accuracy rate, the reasoning behind how they reach their decisions is not readily available [3].

A. Form of rules

In [4], rule extraction from neural networks is defined as "… given a trained neural network and the data on which it was trained, produce a description of the network's hypothesis that is comprehensible yet closely approximates the network's predictive behavior." Authors also present an overview of some form of logical rules, such as *IF-THEN rules*, *M-of-N rules* or *Decision trees*:

IF-THEN rules

It is a conditional statement model, which is easily comprehensible. The general form of IF-THEN rule is:

$$\text{IF } X \in S(i) \text{ THEN } Y = y(i). \tag{1}$$

If the given condition is true, in this case of X is a member of $S(i)$ then the output will be labeled to a particular class. As a simple example, a single neuron in a neural network with a linear activation function can be modeled by IF-THEN logical rule. The weighted sum of j^{th} neuron is calculated as:

$$S_j = \sum_i^n (X_i * W_{ij}). \tag{2}$$

Where X_i is an input and W_{ij} is a corresponding weight of connection between i^{th} and j^{th} neuron. The output Y of neuron is a function of the weighted sum given as:

$$Y = f(S_j). \quad (3)$$

So that, the output can be expressed by simple IF-THEN rule as follow:

$$\text{IF } Y = f(S_j) \geq \alpha \text{ THEN } Y = 1 \text{ ELSE } Y = 0, \quad (4)$$

where α is a threshold value.

M-of-N rules

It searches for rules with a Boolean expression. The expression is satisfied when M of N sets are satisfied. The rule has the following form:

$$\text{IF } M \text{ of } \{N\} \text{ THEN } Z \quad (5)$$

Decision tree

It is a most widely used tree structure classifier in Machine learning and Data mining. This model classifies an instance starting at the root of the tree and follows down to the branches till the end. Decision tree uses a "white box" system that is easy to explain.

B. Rules evaluation

In the research of rule extraction from neural networks, a framework called FACC for evaluating the quality of the rules extracted from the neural network is used. It comprises four criteria, namely Fidelity, Accuracy, Consistency, and Comprehensibility (FACC) [5].

Fidelity describes how well the rules mimic the behavior of the neural network, which is usually defined as the percentage of test examples on which the classification made by the rules agrees with its neural network counterpart. While accuracy describes how well the rules can generalize, which is usually defined as the percentage of test examples that are correctly classified by the rules. Consistency is given if the rules extracted under differing training sessions produce the same classifications of test examples. Comprehensibility is determined by measuring the number of rules and the number of antecedents per rule [6].

In [7], the author identifies the fidelity-accuracy dilemma. The author illustrates that although both fidelity and accuracy are key elements of the prevailing rule quality evaluation framework, in many cases is impossible to obtain high fidelity and high accuracy simultaneously. Moreover, he reveals that current research of the rule extraction, unfortunately, confuses two goals, namely trying to obtain accurate and comprehensible learning systems and trying to understand the working mechanism of neural networks. Therefore he argues distinguishing two tasks: rule extraction using neural networks and rule extraction for neural networks according to their differing goals.

C. Categories of rule extraction algorithms for NN

Rule extraction algorithm for neural networks can be roughly categorized into three categories, namely *decompositional*, *pedagogical* or *eclectic* algorithms. The decompositional algorithms split the neural network to neuron level and extract rules from each neuron and then aggregate them. Representatives of this category include *Subset*, *COMBO*, *RX*, etc. The pedagogical algorithms treat with a neural network as a black box. The focus of this approach is to extract rules that map inputs directly into outputs. The internal structure is not analyzed. Representatives of this category include *VIA*, *TREPAN*, *STARE*, etc. The *eclectic* algorithms incorporate elements of the both decompositional and pedagogical ones, for instance, *DEDEC*. The fourth category was also described, named as *compositional* algorithms. These algorithms are not strictly decompositional because they do not extract rules from the individual unit with subsequent aggregation to form a global relationship, nor do them fit into the eclectic category because there is no aspect that fits the pedagogical profile. Representatives of this category mainly include algorithms for extracting deterministic finite-state automata (DFA) from recurrent neural networks [4][7].

III. Support Vector Machine

Rule Extraction from Support Vector Machine (SVM) has been an active research topic in recent years. SVM is based on the statistical learning theory developed by Vapnik at AT & T labs. According to the theory of SVM, it minimizes the structured risk i.e. the probability of misclassifying yet-to-be-seen a pattern for a fixed but unknown probability distribution of the data. On the other hand, traditional techniques for pattern recognition are based on the minimization of the empirical risk i.e. on the attempt to optimize the performance on the training set. SVMs have gained wide acceptance because of the highest generalization ability and are applied to a wide range of applications [8][9].

An SVM first maps the input data into a high-dimensional feature space and finds a separating hyperplane that maximizes the margin between two classes in this space. Maximizing the margin is a quadratic programming (QP) problem and can be solved by solving its dual problem by introducing Lagrangian multipliers. Without any knowledge of the mapping, the SVM finds the optimal hyperplane by using the dot product functions in feature space that are called kernels. The solution of the optimal hyperplane can be written as a combination of a few input points that are called support vectors [10][11].

As well as neural networks, SVM may provide a high accuracy compared to other data mining techniques, but their comprehensibility is also limited [12]. Therefore, it is also considered as a "black-box."

A. Rule extraction algorithms for SVM

Núñez et al. [13] introduce an approach for rule-extraction from SVMs: The SVM+ prototype method. The basic idea of this method is to use the output decision function from an SVM and then use K-means clustering to determine prototype vectors for each class. These vectors are combined with support vectors to define an ellipsoid in the input space which is then mapped to if-then rules. This approach does not scale well: in the case of a large number of patterns and an overlap between different attributes, the explanation capability suffers.

The algorithm RulExtSVM [14] extracts IF-THEN rules using intervals defined by hyper-rectangular forms. RulExtSVM algorithm is divided into three steps. In the first step, given a support vector of a class, a hyperrectangle is generated using the intersection of the support vector with the SVM decision boundary. In the second step, the initial rule is tuned to improve the rule accuracy. This is accomplished by excluding outclass data points and shrinking the hyperrectangle. In the final step, the redundant rules are removed to obtain more concise rule set.

In [10], authors proposed a hybrid classification technique to extract fuzzy rules from the SVM and evaluated the rules against decision tree classifiers constructed from the same

SVM. The hybrid approach proceeds in three major steps. In the first step, training patterns with class labels were used to build an SVM model that gives the support vectors with acceptable accuracy by way of tuning the SVM. Using the extracted support vectors as input to the Fuzzy Rule Based System (FRBS), fuzzy rules were generated, and the same set of support vectors were used to construct Decision Tree (DT) in the second step. In the final step, the resulting rule set was tested using the test data of the problem. Testing of the hybrid classifier on benchmark data sets shows better or similar results comparing to stand-alone classifiers.

IV. Another approaches for rule extraction

In [15] is presented the application of the symbolic knowledge extraction approach to Radial Basis Function Neural Network (RBFNN). The proposed method retrieve a set of concise and interpretable IF-THEN rules from RBFNN by dealing with neuron centers but with the help of RBFNN transformation into a polytope classifier and application of recursive rule extraction algorithm.

A two-stage hybrid model for data classification and rule extraction is proposed in [16]. The first stage uses a Fuzzy ARTMAP (FAM) classifier with Q-learning (known as QFAM) for incremental learning of data samples, while the second stage uses a Genetic Algorithm (GA) for rule extraction from QFAM. Given a new data sample, the resulting hybrid model, known as QFAM-GA, can provide prediction pertaining to the target class of the data sample as well as to give a fuzzy IF-THEN rule to explain the prediction. To reduce the network complexity, a pruning scheme using Q-values is applied to reduce the number of prototypes generated by QFAM. A 'don't care' technique is employed to minimize the number of input features using the GA. The main significance of their research is a usable and useful intelligent model (i.e., QFAM-GA) for data classification in noisy conditions with the capability of yielding a set of explanatory rules with minimum antecedents. Also, QFAM-GA can maximize accuracy and minimize model complexity simultaneously. Therefore it allows being used as useful decision support tool in assisting decision-making processes.

In [17] is presented a neuro-fuzzy classification scheme that can create proper linguistic features and simultaneously select informative features for a high dimensional dataset and applied to the diffuse large B-cell lymphomas (DLBCL) microarray classification problem. The classification scheme is the combination of embedded linguistic feature creation and tuning algorithm, feature selection, and rule-based classification in one neural network framework. The adjustable linguistic features are embedded in the network structure via fuzzy membership functions. The network performs the classification task on the high dimensional DLBCL microarray dataset either by the direct calculation or by the rule-based approach. The results show that the network can select a small set of informative features in this high dimensional dataset.

In [6], neural network rule extraction techniques are used for analyzing three real-life credit-risk data set. Clarifying the neural network decisions by explanatory rules that capture the learned knowledge embedded in the networks can help the credit-risk manager in explaining why a particular applicant is classified as either bad or good. As a neural network, well-known Multilayer Perceptron was used. Three neural network rule extraction techniques were evaluated and contrasted, namely Neurorule, Trepan and Nefclass for credit-risk evaluation and compared to the popular C4.5 algorithm. The experiments were conducted on three real-life financial credit-risk evaluation data sets: *German credit*, which is publicly available from the UCI repository, *Bene 1* and *Bene 2* that were obtained from two major Benelux financial institutions. In addition, authors described how Decision Tables could be used to represent the extracted rules. Decision Tables represent the rules in an intuitive graphical format that can be easily verified by a human expert. Furthermore, they allow for easy and user-friendly consultation in everyday business practice. They proved that neural network rule extraction and DTs are effective and powerful management tools which allow building advanced and user-friendly decision-support systems for credit-risk evaluation.

A different approach of classification rule extraction directly from data instead of ANN or SVM that uses Artificial Immune System (AIS) was presented in [18]. AIS is a computational technique inspired from the natural immune system, which is used to solve different problems such as clustering/classification, numeric function optimization, robotics, control, etc. The AIS has focused on three main immunological theories: clonal selection, immune networks, and negative selection. For rule extraction, they used CLONALG, which is an abbreviation of the clonal algorithm that was inspired by some elements of the clonal selection theory. The idea behind their approach is to use AIS for optimization of the classification accuracy function. The fitness function was defined as classification accuracy of the extracted rules. The rule mining algorithm is as follows:

1. Code the data
2. Create the population randomly
3. Execute CLONALG
4. Decode the rules

V. State of the Work

The goal of our future work is to extract semantic information from data using classifiers that we considered as a "white-boxes." We decided to use Membership Function (MF) ARTMAP neural network [19]. MF ARTMAP assumes that data in feature space are organized in fuzzy clusters. Each fuzzy cluster has a class label. The fuzzy cluster is considered as a fuzzy set in multidimensional feature space. For unknown input vector *x,* it computes membership to all fuzzy clusters. For each class, it finds a fuzzy cluster with a maximum value of membership for vector *x.* Therefore, the final output of MF ARTMAP for unknown vector *x* is a vector of memberships to all classes. This multivalued output may be used for creating *THEN* part of the *IF-THEN* rule. For instance, if the membership values of vector *x* to a class *A* and a class *B* is very similar, then extracted rule can be as follows:

$$\text{IF } x \text{ THEN } A \text{ or } B \tag{6}$$

Organizing the data in feature space to fuzzy clusters also leads to creating decision surface over data in *n+1* dimension, which is shown in Fig. 1 as an example for data "Circle in Square." The shape of decision surface for each class and also the structure of clusters in the feature space and classes distribution for each cluster are the bases for high-level processing, giving auxiliary output about the clusters, classes, their structures or similarities and dissimilarities between classes. The post-processing can offer information about one particular class (Intra-class knowledge) as well as the relation between several classes (Inter-class knowledge). Intra-class knowledge usually expresses a dispersion of clusters, which

belong to one class in the feature space. Contrariwise, Inter-class knowledge extracts relation between clusters by using a computation of coverage between clusters. A suitable method for computing coverage is a Jeffries-Matsushita distance. This way, it is possible to obtain information about class independence and similarity. The difference between them is that class independence investigates independence of one class from all others classes while class similarity examines every time the similarity between two classes [20].

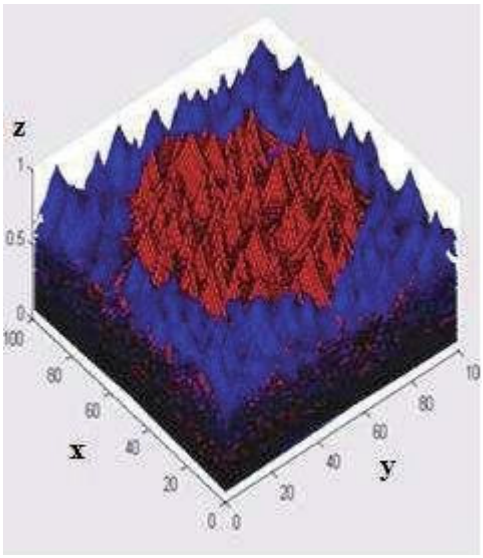

Fig. 1 Visualization of decision surface over data of "circle in a squre." Two axes (x and y) are coordinates of the pixels, and the third axis (z) denotes the number of membership. The blue color represents the object of the square, and the red color represents the pixels of the circle (from [20]).

In our research, up to now, we created new classifier with the similar characteristic as MF ARTMAP. It creates similar but much more complex decision surface over data as MF ARTMAP. Results showed that this fact led to higher classification accuracy, which, as we assume, should lead to more accurate extracted rules from this classifier.

VI. Conclusion

The main goal of this paper was providing a basic overview of Ph.D. thesis and give appropriate theoretical background. We explained needs of rule extraction and described new methods for rule extraction from Artificial Neural Networks and Support Vector Machine from recent years and their real-life applications in medicine or financial management. We concluded this paper with a discussion of a method that we will use in the task of rule extraction from data and mentioned new classifier, which will be presented in an upcoming paper.

Acknowledgment

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Deep Neural Network based on Voice Activity Detector

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***Abstract*—Proposed paper presents a Feed-forward neural network (FFNN) used for Voice Activity Detector (VAD). Four-layers model of FFNN works with different training algorithms. All parameters were set to default values. The dataset was constituted by more than 100 speech records which were divided into train and test database. The result section compares different algorithms accuracy.**

***Keywords*—neuron, Feed-forward, deep structure, Voice Activity Detector**

I. Introduction

Speech is the basic medium for changing information in human or animal life. The process of Speech transcription to the text form is called Automatic Speech Recognition (ASR). The ASR used Mel-Frequency Cepstral Coefficients (MFCC) has been described in [1].

This paper is oriented for distinguishing between speech and noise. The Voice Activity Detector (VAD) tries to separate an important (speech) signal and a background (non-speech) signal. Nowadays, the research around ASR and VAD is very popular [2]. The several VAD-based techniques have been used in machine learning algorithms [3], [4]. We were using a Feed-forward neural network described below in Section 1. Section IV deal with a neural net which was used.

The main goal focused on different training algorithms using. As a principal parameter was used Accuracy.

II. Feedforward Neural Network

This section shortly characterizes the Feedforward Neural Network (FFNN).

The FFNN is a type of NN contains input, hidden and output layer [5], [6]. Each layer can have many units (axons) and their amount may be different. The number of hidden layers specifies the deep architecture of the network [7], [8].

The FF network uses one-way information flow. It means that the input data have an influence only on the input neurons, input neurons send a signal to the first hidden layer, etc. The NN with at least two hidden layers is called Deep Neural Network (DNN) [9], [10]. The DNN was successfully used in many machine learning tasks such as pattern recognition, image or speech recognition, and many others [11].

III. Related Works

Works focus on NN based Voice Activity Detection (VAD) are listed below in this section.

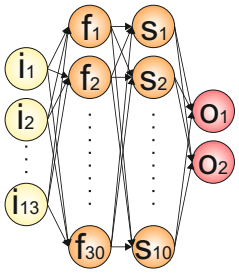

Fig. 1. Feedforward Neural Network

The VAD system used for Deep Neural Networks have been published in several papers [12], [13].

The authors in [14] joined their previous ASR-DNN model with other (output) layer, which distinguished speech/ no-speech signal. The speech corpus had around 100 hours of speech. They were using a Bayesian treatment which contributes to models with noisy data. The VAD-DNN results have shown better than the energy-VAD.

DNN-based work focused on Speech Activity Detection on Youtube outperforms the Gaussian mixture model baseline according to [15].

IV. Experimental Setup

This part of paper represents used dataset. The network architecture is described below.

The input data were provided by Laboratory of Speech Technologies from the Technical University of Kosice. We used 100 speech records (620s) for training process and 30 speech records (40,4s) for testing process. This data was obtained from the previous VAD system. This paper deals with creating a NN for our next research.

Network architecture consists of 4 layers is depicted on Fig. 1. Input layer had 13 nodes i_i, for $i = 1, 2, ...13$ which were represented with 13 Mel-frequency Cepstral Coefficients (MFCC). 30 hidden neurons f_i, for $i = 1, 2, ...30$ was chosen for first hidden layer. Second hidden layer had 10 hidden neurons s_i, for $i = 1, 2, ...10$. Output layer o_i, for $i = 1, 2$ had two nodes.

After creating a Feed-forward network, program continues with training. The number of input vectors hat to be same as the number of target vectors. As we mentioned above each input vector has 13 coefficients (see Fig. 2). Target vector contains of two different values (0 and 1). This values divide

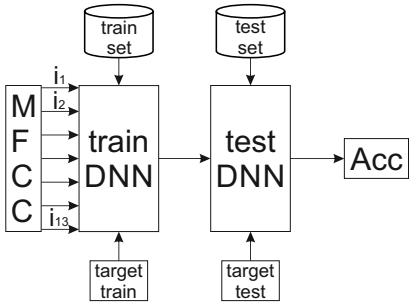

Fig. 2. Block diagram of Deep Neural Network- based VAD

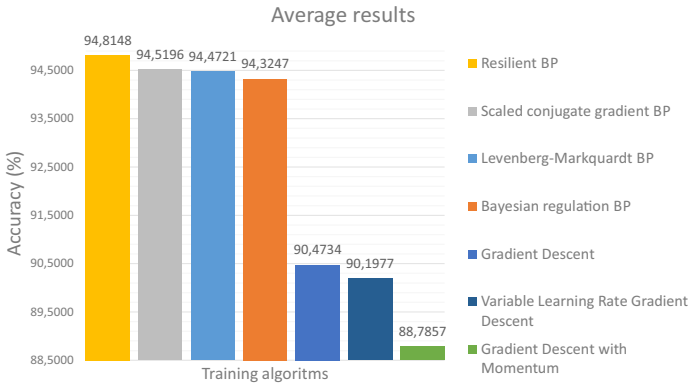

Fig. 3. Average results of different training algoritms

between speech and no-speech frames, thus neural network learns from this labels.

For the training we used different training algoritms. Resilient backpropagation, Scaled conjugate gradient, Levenberg-Marquardt, Bayesian regularization, Gradient descent, Variable learning rate gradient descent whether Gradient descent with momentum. All algorithms were used and compared. Time of training depended on algorithms. Some of them was very slow therefore our data had approximately 11 minutes. For example: when we run the program with more than 3 hours of speech with using Resilient backpropagation algorithm, the average Acc was 93,5848%.

On the end of training, the network is able to distinguish speech and no-speech signal. Now, the network can be considered as a trained network.

Next step is testing. Unknown data come to the input of trained network. Number of testing targets correspond with number of testing inputs also. After simulation follows smoothing process which repairs some deviations. The Output vector had real values in the range of -1 to 1.

The threshold was set on 0,55. It means that the upper value was rewritten to 1 and lower value was changed to 0. Output already contained of the same values as a target vector.

The Accuracy (Acc) was chosen as a resulting parameter. The Output vector which we got at the end of the testing process was compared with target vector. When the program found some differencies, it increased an error number. After comparison of all vectors was computed the Accuracy of the right detected vectors. This process and whole program have been running 100 times. At the end of each program, Acc was saved. The average results are depicted in Fig. 3.

V. Conclusion and Future Work

In this paper, we have proposed a Deep neural network-based Voice Activity Detector. We used feedforward network with 4 layers, where the input contained 13 MFCC coefficients and on the output was a 1-D vector. The script ran 100 times so we got 100 different Accuracies.

We can conclude that the best algorithm for our dataset has shown Resilient Backpropagation (RB) according to (Fig. 3). The RB was one of the fastest algorithms what we trained (because of Maximum validation fails [default=6]). Some algorithms had no limit in Maximum validation checks so their training time was much longer than in RB. In bigger dataset, RB can works worse than other. Each algorithm has specific parameters.

In these days we are trying to work with Convolutional neural networks (CNN). The CNN is a huge network with many different layers such as convolution, max-pooling, softmax, etc.. Future work will be oriented on CNN. The aim is creating a network with 5-7 layers. Our site will detect the speech frames, at the beginning.

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Design of backup line for FSO/RF system

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***Abstract*—Nowadays optical communication systems reach notable success. They impact in building topologies for Ethernets applications is dominant. Very high speeds of transmission it was possible reach only using optical fiber applied as transmission medium. Using of optical fiber offers stable conditions of transmission however is need trade-off with price. It was need develop new type of communication with maintaining required parameters of transmission and speed of transmission, reliability and availability of this system. Such system is FSO (Free Space Optics). FSO system is available for applications in areas where not possible usage of physical optical fiber communication is or it is more expensive. FSO systems have one drawback. It is sensitive to weather changes. Due this knowledge need secure stabile connection in every case. One of these possibilities is using RF backup line in case, when optical communication is not working.**

***Keywords*—availability, FSO, reliability**

I. Introduction

Many applications at present need stable connection with possibility of high speed transmission. Nowadays are usually used of optical fiber to transmission data, video streaming and other types of information contents. At present infrastructure of transmission network contains many optical devices, which reach dominantly position at design new topologies. Growth of optical devices reach significantly size. It is possible use optical switches, routers which are possible work on fully optical layer. However all of these devices used to transmission medium optical fiber created from silica or plastic. Usage of optical fiber is widely in range for many applications. Expansion of this technology come across a problem in areas, where is usage of optical fiber not effective. Application of physical optical infrastructure in areas where is heavy building physical optical network leaded to developing new technologies. These technologies can be able transmit optical signal in free space without physical medium. One of these systems is FSO.

II. FSO System

FSO used to transmission of optical signal in form optical beams in free space. Range of wavelength for FSO communication system is in unlicensed band. Usage of free space as transmission medium brings many complications for application FSO systems. Free space or atmosphere is fill with many particles which can be able interfere with optical beams. These non-linear effects are only few drawbacks which complicate possibilities for application these systems in real conditions. The next drawback of these systems is sensitivity of FSO systems to changes of weather conditions. It is very sensitive to weather changes. In case when outside is very bad weather this system is not able work. Nevertheless it is application more effective in case where application of physical optical fibers reached most of her possibilities. FSO system is working on wavelength near to wavelength of visible light. Range of these wavelengths is chosen on base of need reach to distance of communication points. Technology of transmission data in form optical beams in free space is significant with high level of security. Direction light emitted beam with a wavelength of about 785nm have narrow directivity to achieve a high level of safety. Detection of these optical beams is complicated, because the optical beams are spreaded in free space area while must be condition line of sight. Placing of optical receivers and transceivers must be in line of sight. If optical receiver and transceiver is not in line (one of these is placed under or over other device) beams of sun cause attenuation. This effect is show in Fig.1 [1-6].

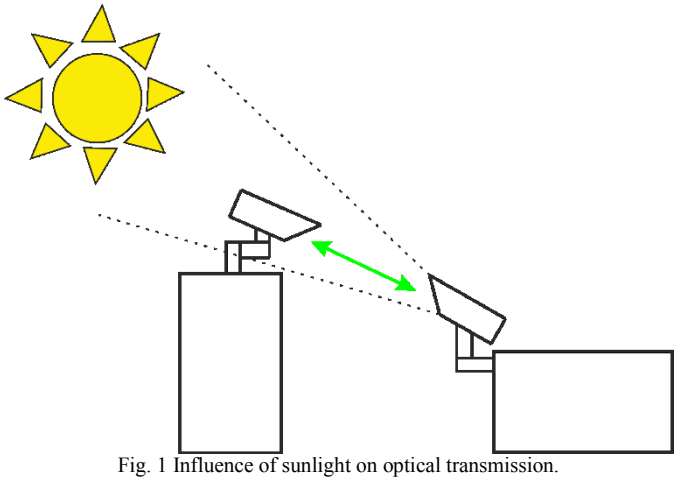

Fig. 1 Influence of sunlight on optical transmission.

FSO systems allow full duplex communication over atmosphere. In the Fig. 2 is show example of one direction transmission over atmospheric channel. Input electrical signal is bought to the transmitter and transferred to the optical spectra by using modulation an optical beam. Input signal guided to optical device can be optical signal. If this input signal is optical must be applied opto-electrical convertor. Radiated optical beam express by optical power $P_{m,\,TX}$. Optical power received on receiver is represent $P_{m,\,RX}$ and is affected by total losses along the path represent α_{tot}. Total gains along the path are summarized in γ_{tot}. Optical received power is express by equation (1) [5-9].

$$P_{m,RX} = P_{m,TX} - \alpha_{tot} + \gamma_{tot} \tag{1}$$

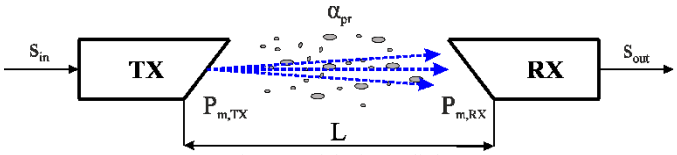

Fig. 2 Model of FSO link.

FSO communication system is wireless optical system communicate using multiple beams of infrared light. It is invisible to the human eyes. Basic condition is line of sight between two points which want communicate. Optical device transmits four optical beams which carry data from transceiver to receiver. Optical device on receive side receives optical beams over four receivers. Receivers contains filters of optical signals. FSO communication system working in full duplex mode. This regime allows use each optical device as transmitter and receiver. Each of devices allows streaming data in both directions [8-12].

FSO system is possible construct with using optical devices as FlightStrata 155E. This optical device was design for FSO system. It is working on wavelength 850nm and for communication using four optical beams. Usage of four optical beams secure redundancy sufficient to reach required quality of transmission. Each of optical beams carries same optical content. This avoid outages on communication link because in atmospheric channel are many possibilities which would affect quality of transmitted and received signals. Both receiver and transmitter contains optical lens. In Fig.4 is show block diagram of FSO system with four beams [12-13].

Input digital optical signal is converted to electrical signal before transmitting. These ensure splitting of data stream to four signals with the same data content. Following are electrical signals converted to optical signals. These optical signal are radiated each from own optical laser. Optical beams are spread in atmosphere channel and are exposed to all nonlinear effects. On receive side are placed four optical lens which receive attenuated optical beams. Received optical signals are directed to converter which provide optical to electrical conversion of optical signals. These signals are combined on electrical signal which will converted back to optical signal. Application this process gain one optical signal created from combining transmitted optical signals. Received optical output signal is sending in to optical network or to end user [12-15].

Optical device for FSO system is possible split three categories:

- Transmission components. This part include optical signals from data network are received at the data transceiver. Subsequently are converted to identical data streams. Four VCSEL lasers create radiation part of this device. Main role of these lasers is emitting four infrared beams into atmospheric channel.
- Receiver components. Optical device contain optical amplifier which converts the infrared signal received from the atmospheric channel an electrical signal. This signal is subsequently processing and sending to network. Electrical signal can be converted back to optical form and send to optical network or to end user.

Optical device which is able used for FSO system FlightStrata 155E contains four receive lens (large notes as RX) and four transmit lens (small notes as TX). Diameters of these optical lens is for transmit lens equal 2.5cm and for receive lens equal 8cm. Illustration front side of FlightStrata 155E is show in Fig.3 [16].

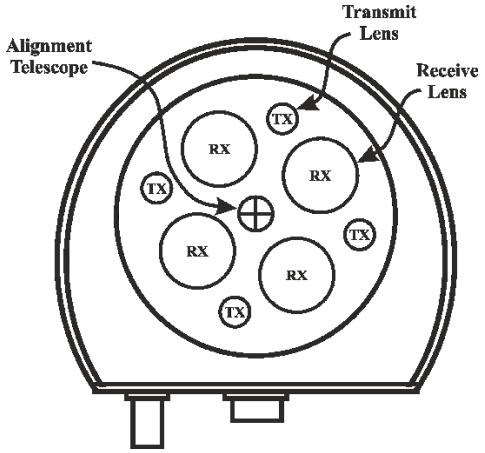

Fig. 3 Front side of FlightStrata 155E

III. Experimental Model of FSO System

Free space optic through wireless channel offers full duplex communication. Nowadays FSO systems are very popular because they enable connections of many points between which the connections based on physical optical fibers are not possible or they are more expensive. Distance between points which could communicate is in range from few meters to several kilometers. Communication with using wireless channel as optical transmission path offers many advantages which make FSO a very attractive system. Speed of transmission, using non-licensed transmission band, no need for expensive optical components and fibers are a few from the many advantages which this system offers. With raising trend of FSO development and it allows reaching bitrates higher than 10Gbps on distance of few kilometers without usage of physical optical fibers [15-19].

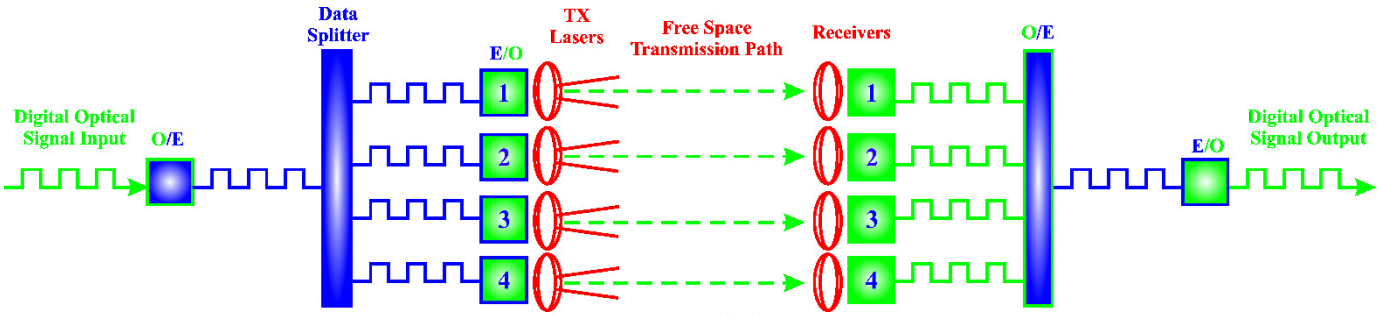

Fig. 4 FSO system with four beams.

The next advantage is installation which is very easy compared with standard optical communication system. FSO could be applied as backbone connection however it has to have backup line which would be used during very bad weather conditions when attenuation rises to critical values. Value of BER (Bit Error Rate) must be BER=10^{-9} or better and then the system can be considered as stable system with good error probability. FSO system is based on two optical terminals which allow receiving, transmission of optical signal through wireless channel. The optical terminals work on different wavelengths. Used wavelength is selected by type of used laser. In one area can be used more FSO systems working on same wavelength without errors. In several cases independent systems working on different wavelengths are chosen. The possible wavelengths are in optical transmission windows near 850nm, 1310nm and 1550nm. Each optical system is can work on one of these wavelengths [16-19].

Function of electro-optical convertor and reverse optical-electro convertor is conversion of signal to form which is supported by device on the next point.

Type of used optical terminal installed on buildings is Flightstrata 155E. Terminal Flightstrata 155E contains four optical lasers working on 850nm wavelength. The number of used lasers increases reliability compared to optical system which uses one optical laser [18-20].

TABLE I
PARAMETERS OF LIGHTPOINTE FLIGHTSTRATA 155E

Parameters	Values
wavelength	850nm
TX Power	160mW
RX Power (Sensitivity)	-30dBm
diameter of receiving lens	8cm
directivity	2mrad

TABLE I shows parameters of terminal used in experimental model of FSO system. Design of experimental FSO model installed on TUKE is shown on Fig.5.

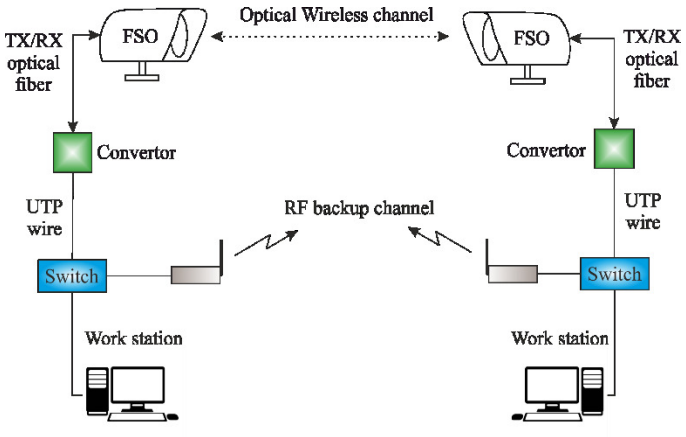

Fig. 5 Experimental model of FSO system.

Fig. 6 Flightstrata 155E.

FSO terminal Lightpointe Flightstrata 155E is shown on Fig.6.

IV. THE IMPACT OF WEATHER ON FSO TRANSMISSION QUALITY

The prime types of weather which significantly affect quality of FSO system transmission are haze, fog and dense fog. These weather conditions have other dominant effects for used different wavelengths. Interactions of atmospheric particles with optical beam take effect by increase of attenuation which causes extinction of this beam. By extinction of optical beam occurs when weather conditions are very bad and attenuation on transmission path is significant. Transmittance is defined by relation (2) [20-22]..

$$T_v(s) = \frac{I_v(s)}{I_{v,0}} = e^{-\beta_v s} \tag{2}$$

In relation (2) β_v corresponds with total extinction coefficients of aerosol absorption, molecular absorption and molecular scattering.

TABLE II
VALUES OF TOTAL EXTINCTION COEFFICIENT

Air condition	β_{vs} [km^{-1}]
clear	0.1
haze	1.0
fog	>10
dense fog	391

With using values of extinction coefficient from TABLE II is possible to determine examined value of attenuation. Channel loss in the transmission path is represented through attenuation in dB units. Attenuation was calculated for each type of air conditions are calculated by equations (3-6). In case of very good weather conditions during transmission the value of attenuation L_a is equal to -0.22dB. By very good conditions we understand clear sky. Attenuation is calculated for distance between communication points of 500m [20-22].

$$L_a = 10\log_{10}(e^{-0.1*0.5}) = -0.22dB \tag{3}$$

For haze the value of attenuation is calculated by equation (3) for the same distance.

$$L_a = 10\log_{10}(e^{-1*0.5}) = -2.17dB \tag{4}$$

The attenuations for fog and dense fog are calculated with usage of (4) and (5), respectively. The distance stays the same as in previous cases.

$$L_a = 10\log_{10}(e^{-10*0.5}) = -21.71dB \tag{5}$$

$$L_a = 10\log_{10}(e^{-391*0.5}) = -849.05dB \tag{6}$$

These results show sensitivity to atmospheric particles which interact with optical beam which is then attenuated and in several cases it is extinct. The most important is Mie scattering for FSO system because impact of this phenomena to SNR (Signal to Noise Ratio) does not depend of used wavelength of optical beam. Hence the creation of this effect cannot be avoided [22].

V. Conclusion

FSO systems offer many advantages such as was wrote before in this paper. Main application in areas where is more expensive usage of physical fiber was shown as very effective. Experimental model FSO is realized on Technical university of Kosice between buildings Vysokoškolska 4 and Letná 9 A. Optical transmission channel is atmospheric channel with all nonlinear effects which affect transmission beams. On quality of transmitted and received signal have dominant impact weather conditions. Bad weather conditions affect transmission significantly in some case can cause shutdown of communication link. Impact of these weather conditions was wrote before in this paper.

It is available the most possibilities for secure stabile connection in every case. Appropriate choose backup system with speed switching allow increase reliability and availability for FSO system. Possibility for backup system is widely for example usage of physically connection through metallic links or exist Ethernet infrastructure. In this case is backup system limited of maximal reach speed of transmission using metallic lines. Nowadays communication with using metallic lines offer speed of transmission something about 1Gbps with one drawback. It is need to build physically metallic infrastructure between communication points. This offers speed of transmission is which is possible reach is less than possible speed of transmission reached using FSO communication system.

Alternative for backup system is usage of radio-frequency transmission channel. Radio-frequency transmission channel used to communication frequency for range in 3kHz to 300GHz. Many frequency from this range are choose for license application. For usage these frequency you must pay to national organizations. For school applications are available unlicensed frequency ranges, for usage one of this frequency from range is not need to pay. Appropriate solution for design and construction backup line is usage frequency 60GHz.

VI. Future Works

The need of construction backup line for FSO system is shown in this paper. Effect of weather on quality of transmitted signal is significantly. When weather conditions are very bad in several cases is not possible communicate through atmospheric channel with using FSO. We need design appropriate backup line. One possible solution is usage of microstrip antenna working in 60GHz area. Design of type used microstrip antenna and their parameters is one of points of my work on PhD study.

Acknowledgment

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Design of the UWB antennas and the measurement of their parameters for the purpose of their usage with UWB radar systems

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***Abstract*—This article presents the summarization of the achieved results during post gradual study solved in previous year. The main field of my work is dedicated to the antennas suitable for UWB radar systems used in through-wall measurements. A brief overview of the state-of-the art literature showing the importance of the selected topic is provided. The paper also describes the new antenna design, the achieved results from simulations, and the antenna usage in the UWB radar system.**

***Keywords*—Sinuous slot antenna. Through-wall measurements. UWB Radar. Vivaldi antenna.**

I. INTRODUCTION

Ultra-wideband (UWB) radar systems are progressive systems for the motion sensing and imaging. They can be used for the through-wall measurements of the human being detection, localization and tracking [1], in impedance spectroscopy for the detection of the presence of impurities in the liquid (lactose in milk, wet granular materials, etc.) [2]. Also, UWB radar systems are used in medicine to non-invasively detect movements of the heart wall [3], in ground penetrating radar systems for the detecting and estimating buried pipes and cables [4], and more.

The antenna or antenna system – depending on the application, are very important element of every UWB radar system. Each of these UWB systems will not work with arbitrary antenna. The antennas of the UWB radar systems used in through-wall measurements (our department primary used UWB radars for this case) should satisfy the following requirements: cover the largest frequency bandwidth, linear polarization, low-profile, simple manufacturing, small dimensions while maintaining $f_{min} \leq 1$ GHz etc.

This article presents a brand new design of the antenna suitable for UWB radar systems, our antenna implementation to the UWB radar system, some experimental results of measurements and future work which is planned to do.

II. SOLVED TASKS IN PREVIOUS YEAR

A. Antennas comparison and antennas implementation in the UWB radar system

Two similar measurements were used in order to compare the performance of the commercial and self-made antennas. The first was double ridged waveguide horn RFspin DRH-10 commercial antenna. The second antenna was planar antipodal Vivaldi antenna designed in cooperation with the Brno University of technology. More information about antipodal Vivaldi antenna design was published in [5, 6].

For antenna performance comparison a simple scenario of measurement of static person detection and localization based on their respiratory motion with the using of the UWB radar system were used. The scenario was as follows: a single static person was situated in front of the antennas behind a solid obstacle. The only observable movement was uplift and descent of his chest. The obtained results from these measurements published in [7] indicate that low-cost compact antipodal Vivaldi antennas can be used for static person localization in conditions similar to laboratory.

B. Brand new antenna design suitable for UWB radar sensor network

Sinuous slot antenna was chosen for this case. This antenna compared with the Vivaldi antenna radiates in a direction perpendicular to the surface. Sinuous slot antenna provides frequency bandwidth more than 7:1 and retains the compact physical dimensions.

Antenna design is based on sinuous curve structure and also is from category of logarithmic periodic antennas. Sinuous slot antenna was first drawn than optimized and at the end simulated in CST Microwave Studio (CST MWS) – Student Edition.

According to the DuHamel equation [8] in analytical expression sinuous curve was drawn. From sinuous curves the antenna was designed. The impedance of the antenna was obtained from the simulations for the impedance matchmaking of the antenna feeding. Microstrip coupled feed was used for retaining planar structure of the antenna. Dimensions of the antenna feeding and antenna was optimized and simulated by CST MWS separately. Afterwards both elements were aggregated to one unit. Sinuous slot antenna is depicted in Fig. 1.

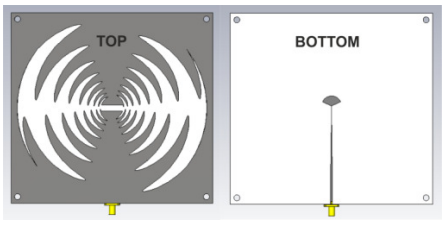

Fig. 1 Sinuous slot antenna - top and bottom layer

C. Experimental results

Proposed sinuous slot antenna (Fig. 1) was simulated by CST MWS and the results of s11 parameter are depicted in figure (Fig. 2). From figure is obvious, that the antenna operates in frequency band from 0.640 GHz to 4.5 GHz with few variations.

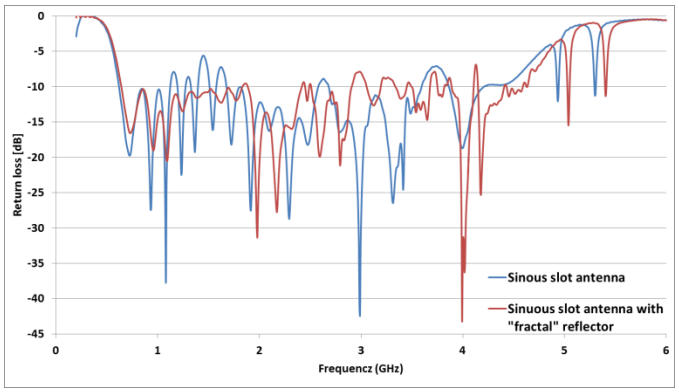

Fig. 2 S11 parameter of sinuous slot antenna and sinuous slot antenna with "fractal" reflector

Also, can be seen from Fig. 2 some variations are from 1 GHz to 2 GHz. For this mismatch we apply reflector with "fractal" elements which were placed a few centimeters behind the antenna. Reflector suppresses undesirable variations and also improved antenna radiation pattern. Fig. 3 shows the sinuous slot antenna with "fractal" reflector.

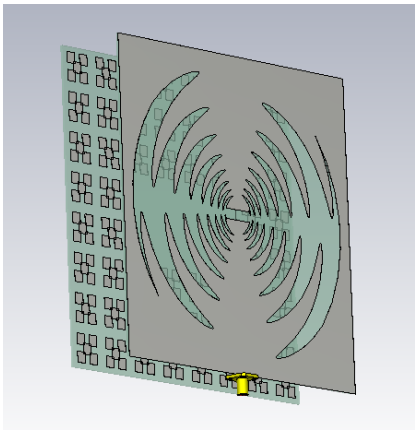

Fig. 3 Sinuous slot antenna with "fractal" reflector

III. Future work

In the near future I would like to improve the characteristics of proposed sinuous slot antenna with another type of the antenna feeding. Coplanar waveguide (CPW) feeding line is considered. CPW feed compared to the microstrip coupled feed (now used in the antenna) is more compact – only one side of antenna substrate are used and does not significantly affect to the radiation pattern and to higher frequencies. Also we would like to use special geometrics elements for the antenna arms. These elements can be extending the antenna frequency bandwidth etc. Another goal is compare the own manufactured sinuous slot antennas with commercial antennas for the through-wall person detection and localization. Many of the future work discussed above are already done but do not publish yet.

IV. Conclusion

Suitable antennas for UWB radar systems have been presented in this paper. From the experimental measurements is obvious that a commercial double ridged waveguide horn antenna with frequency range 0.74−10.5 GHz, dimensions (width x length x depth) 148 mm x 204 mm x 242 mm and weight ≈1.24 kg could be replaced with self-made antipodal Vivaldi antenna. Second antenna operates in the frequency band from 0.81 GHz to more than 10 GHz with few small acceptable variations at the beginning. It satisfies the requirements of the UWB technology [9]. Antenna dimension are (width x length x height) 128 mm x 190 mm x 1.575 mm and weight only 0.108 kg. Furthermore, the use of sinuous slot antenna for the through-wall measurements has been considered. Antenna operate in frequency band from 0.64 to 4.5 GHz with dimension (width x length x height) 170 mm x 160 mm x 1.27 mm and weight ≈0.10 kg. Besides, a described shape of sinuous slot antenna with this kind of feeding was not yet published in open literature. It can be say that a usage of compact antennas in real-life applications is considerably better because of their compact dimensions, low weight and easy manipulation.

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Digital signal processor and its application to control of stepper motor

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***Abstract*— Thanks to microprocessor and microcontroller versatility, accuracy and performance, they introduce one of the most important electronic devices and smart devices nowadays. They are factored in any digital devices, which primary objectives are analog to digital conversion, processing of data, communication and a lot of other operations. The STM32F446RE is high-performance microcontroller for quick signal processing. The goal of this paper is STM32F446RE describe and its application in the practice electrical connection with controlling of stepper motor. The results of this paper are to familiarize the reader with the DSP microcontrollers and visual precision of their implementation in practice.**

***Keywords*—microcontroller, STM32F446RE, Digital signal processor, DSP**

I. INTRODUCTION

Microprocessors are the most used electronic components of devices nowadays. It is primary control and performance unit in the electronic device. The goals of microprocessors are processing data and their evaluation. They make all mathematical and arithmetical operations, they control peripherals, etc. While microprocessor is the only chip consists of CPU, which doesn't include any memory or peripherals, the microcontroller removes these disadvantages. Microcontroller is device including CPU, peripherals, and memory storage. We can tell that it is a self-contained electronic device that can be used for a lot of applications – special purpose or generally purpose. In practice, we know a lot of various developers of microcontrollers. For example processor's giant Intel, Texas Instruments, Motorola, Atmel, etc. I would like focus on the STMicroelectronics Company in this topic, where I want presented 32-bit high-performance microcontroller STM32F446RE.

II. DIGITAL SIGNAL PROCESSOR

Digital signal processor or shortly DSP is microcontroller with architecture optimized for digital signal processing. DSP microcontrollers are the best devices for signal processing because they are very fast and reliable. One of more features of DSP is data processing in real-time. DSP operates with little or no delay. They are ideal devices for audio processing, image processing and signal processing with rapid change of intensity. Processed signal can be shown on the LCD display, we can earn it, or it can be converted to the other signal [1]

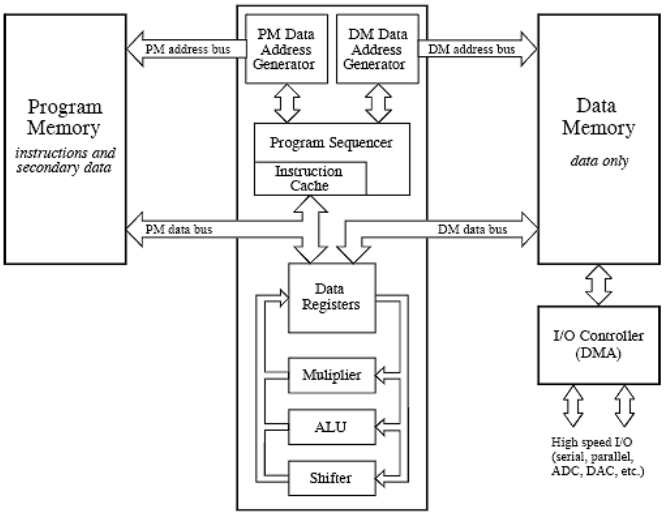

Fig. 1 Typical DSP architecture. Digital Signal Processors are designed to implement task in parallel. This simplified diagram is of the Analog Device SHARC DSP.

The architecture of DSP systems is the similar on a fundamental base. There can have some little differences between families of DSP. Primary parts of the DSP are: program memory which typically consists of SRAM memory, the other type is data memory which consists of Flash or EEPROM.

The second part of DSP consists of peripherals – A/D and D/A converters, timers, counters, communication interface, etc.

The last part of the microcontroller is processor unit (CPU – central processor unit). It makes all operations, numerical and arithmetical calculations. The CPU consists of data register, ALU (arithmetic-logic unit), instruction set and other blocks illustrated in Fig. 1.

As previously mentioned, the primary function of the DSP is digital signal processing. For example, they can be used for audio signal processing, for biomedical signal evaluation, radar or digital communication, etc. A special usage of DSP is in the mobile phones, where they are processed and sent to the other party of speaking caller signal communication. Of course, it can be used also in many other sectors where fast

processing data is necessary.

III. MICROCONTROLLER STM32F446RE

Microcontroller STM32F446RE is a member of ARM family (Acorn RISC machine). We consider that it is the family name of the microcontroller operating with reduced instruction set (RISC), what is more efficiently than complete instruction set (CISC). CISC process a large number of instructions in a single step, but it needs more time. Architecture based on RISC process less number of instructions in a single step, but they work faster than CISC.

Microcontroller is based on high-performance 32-bit processor Cortex-M4, which operating frequency is 180 MHz [2]

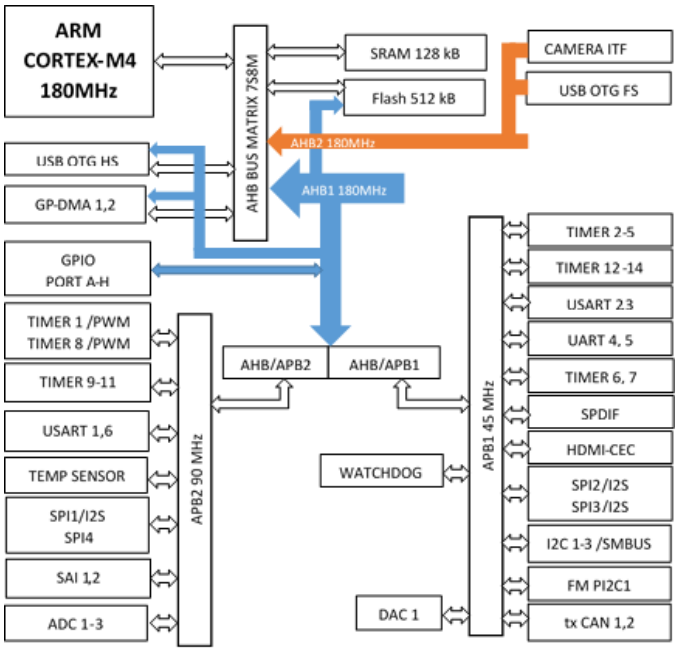

Fig. 2 Architecture of microcontroller STM32F446RE

STM32F446RE include full DSP (digital signal processing) set which provide efficiently signal processing opposite universal microcontrollers. Its architecture includes also FPU (float point unit), which is specially designed to carry out operations on floating point number.

We can see a number of blocks forming microcontroller STM32F446RE in Fig.2. As previously mentioned, processor Cortex-M4 is primary performance and control unit. This microcontroller includes two memory types – Flash memory with the size of 512 kB and SRAM memory 128 kB in size. Memory and peripherals are connected to the fast AHB BUS Matrix 756M. There can be used internal or external oscillator as source of clock frequency. Internal oscillator works at 16 MHz and external oscillator works with frequency in the range of 4 up to 26 MHz. Because not all peripherals work at the same frequency, it is divided and multiplied so that the resulting frequency coincides at the operating frequency of peripherals. Dividing and multiplying provides dividers and multipliers. All GPIOs, USB and DMA controller works at full frequency – 180 MHz. The other devices work at considerably less frequency. It provides low-speed APB1 bus operating at 45MHz and high-speed APB2 bus operating at 90 MHz. However, this applies to all peripherals except for timers because they operate at a frequency of 90 and 180 MHz. In this case, APB1 and APB2 are doubled.

Microcontroller's peripherals:

The peripherals are an important part of the microcontroller which performs a variety of operations. Each microcontroller include a lot of peripherals – input/output subsystem for general purpose, timers and counters, analog to digital and digital to analog converters. Communication interface and other peripherals described in the next part.

GPIO:

General-purpose input/output or abbreviated GPIO pins are presented as pins for general purpose. Each GPIO pin can be configured into four different modes – input mode, output mode, but it can be configured as alternative function or analog mode. Alternative functions means functions such as timer/counter, external interrupts, communication interface USART/UART or SPI, etc. which are shared with GPIO on the same pin. Microcontroller STM32F446RE includes 50 I/O pins for general purpose [2].

Timer/Counter:

The *timer/counter* is a microcontroller circuit which primary objective generates signals of the different frequencies, the generation of pulse-width modulation (PWM), input capture, output compare, etc. In general, we know a lot of types of timers – 8-bit, 16-bit and 32-bit timers, which can be used for different usage. Microcontroller STM32F446RE includes 14 timers divided into the three groups. The first group consists of advanced-control timers. This group includes two 16-bit, auto-reload up/down, counters with 16-bit prescaler - timers TIM1 and TIM8. These timers can be seen as three-phase PWM generators multiplexed on 6 channels. They have complementary PWM outputs with programmable inserted dead times. They can also be considered as complete general-purpose timers. This group work at 180MHz frequency and it can be used for input capture, output capture, one-pulse mode output etc.

The second group consists of *general-purpose* timers. Timers TIM2 and TIM5 are based on a 32-bit auto-reload up/down counter and 16-bit prescaler. TIM3 and TIM4 are based on 16-bit auto-reload up/down counter with 16-bit prescaler. These timers can operate together, or with the other general-purpose timers or advanced-control timers via the timer link feature. Timers TIM9 to TIM14 are based on a 16-bit auto-reload up counter and 16-bit prescaler. Timers TIM10, TIM11, TIM13 and TIM14 include one independent channel for input capture, output compare, PWM or one-pulse mode output. These timers can be synchronized with TIM2-TIM5 full-featured general-purpose timers, or they can be used as a simple time base.

The last timers group consists of *basic timers*. There are two timers TIM6 and TIM7. They are based on 16-bit auto-reload up counter with 16-bit prescaler. They are primarily used for DAC trigger or waveform generation. Their operating frequency is 90 MHz [2].

Communication interface

The term computer communication means the exchange of data between two or more devices. The data are encoded to the binary form and then sends via communication line to the processor or other device (microcontroller and PC, microcontroller and sensors, etc.). Microcontroller includes a lot of types of communication interfaces for various specification operations.

The STM32F446RE contains the number of communication interface – USART/UART, SPI, I2C, etc.

USART/UART

Communication interface use synchronous or asynchronous mode. It uses RX pin for reading received data and TX pin for transmitting data to the other device. STM32F446RE contain four USART interfaces and two UART interfaces. USART1 and USART6 interfaces are connected to the high-speed APB2 Bus which communicates with frequency 90 MHz. The USART2, USART3, UART4 and UART5 are connected to the low-speed APB1 Bus and frequency 45 MHz [3].

SPI

The *Serial peripheral interface* or abbreviated SPI is a synchronous communication interface primarily used for short distance communication. We can tell that SPI and USART are more similar devices. The SPI device operates in full-duplex mode. It means that it receives and sends data at the same time. The SPI device is based on master-slave architecture, with single master. The master device originates the frame for reading and writing and multiple slave devices are supported through selection with individual slave select lines. It consists of four signals:

- SCLK – serial clock (output from master)
- MOI – Master output, Slave input (output from master)
- MISO – Mater input, Slave output (output from slave)
- SS – Slave select (active low level, output from master)

To begin communication, the bus master configures the clock, using a frequency supported by the slave device – it is typically up to a few MHz. The master device, than select the slave device with a logic level 0 on the SS line. The master sends a bit on MOSI line and the slave reads it, while the slave sends a bit on the MISO line and the master reads it.

The STM32F446RE includes 4 SPI devices where SPI1 and SPI4 operate with 90 MHz and SPI2 and SPI3 operate with 45 MHZ frequency [4].

I^{2}C

The I^{2}C communication interface operates with only two signals: SDA-serial data and SCL-serial clock. This interface uses two-way communication. It is the same such as SPI interface because it works with Master-Slave architecture. I2C provides several Master devices (multi-master). The STM32F446RE microcontroller includes four I^{2}C interfaces connected to the low-speed APB1 bus. It operates with 45 MHz frequency.

The microcontroller include also the other interfaces such as HDMI, CAN bus, SMBUS or audio interface I^{2}S and SAI.

A/D a D/A converters

The A/D and D/A converters are more important devices in each microcontroller. These devices provide conversion from analog value to the digital value and digital to analog value. The STM32F446RE contains three 12-bit A/D converters shared up to 16 channels. A/D converters can be configured as 12-bit, 10-bit, 8-bit or 6-bit converters. It operates in single, continuous, scan or discontinuous mode.

Microcontroller includes also one D/A converter applied to the two channels. The D/A converter can be configured as a 12-bit, 10-bit or 8-bit converter. [2]

IV. STEPPER MOTOR CONTROLLED BY DSP SYSTEM

The DSP systems are suitable to work with quick changes of value and with difficult mathematical calculations. Therefore, in this case we applied DSP microcontroller, due to its speed and stability. These facts are more important in this project.

The design of stepper motor control is shown in the following scheme.

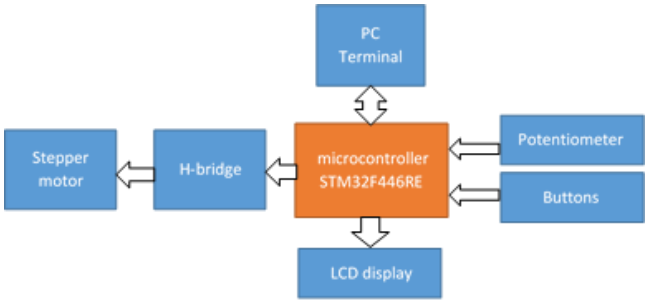

Fig. 3 Block scheme of stepper motor control by DSP system. Basic part of device is DSP – STM32F446RE

The main target is tried to apply the microcontroller STM32F446RE in the practical circuit. Therefore, the stepper motor control was chosen. Basic block diagram is shown in the scheme in Fig. 3. Microcontroller is applied in the middle of Nucleo board (see Fig.4). It communicates with the PC via UART link – asynchronous transmit data (block "PC terminal" in scheme).

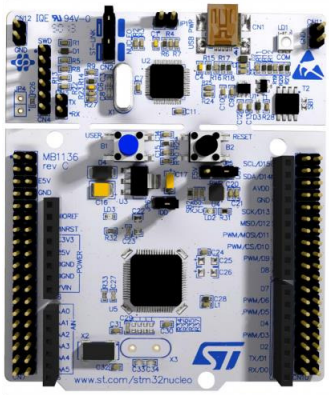

Fig. 4 Board Nucleo 64 with microcontroller STM32F446RE [5]

As the LCD display block in the scheme the character LCD display QC2004A with HD44780 driver was used (Fig.5). It serves for overview of the actual state of rotation or for

overview of the configured data in the case of for manual mode controlling. Manual mode means configuring of rotation number, rotation speed and direction of rotation by using the buttons and potentiometer contained in blocks "Buttons" and "Potentiometer" of scheme.

Fig. 5 LCD display QC2004A with HD44780 controller [6]

The last two blocks are the H-bridge and stepper motor. As the stepper motor the RH7-1319 type was used. We need to energize each coil of stepper motor with positive and negative voltage (because it is bipolar motor). This capability provides H-bridge integrated circuit identified as L298N.

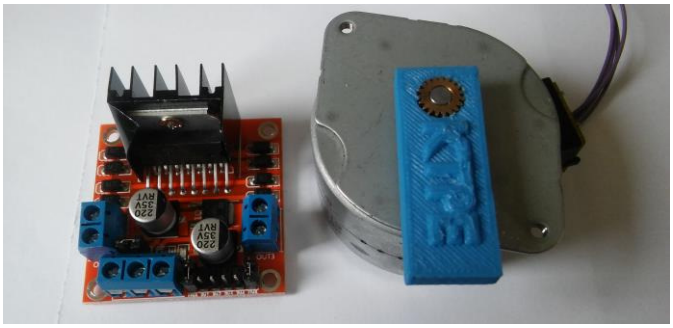

Fig. 6 Stepper motor RH7-1319 and H-bridge L298N

The principles of functionality of used blocks will be described in the following sections in detail.

In the default state, the user sets the parameters using the remote control. It provides application program developed in Microsoft Visual Studio 2012 environment (see Fig.7).

In the first step user retrieves the available ports and select the port where is device (microcontroller) connected. In the second step the user has to configure communication speed. It is usually 9600 baud.

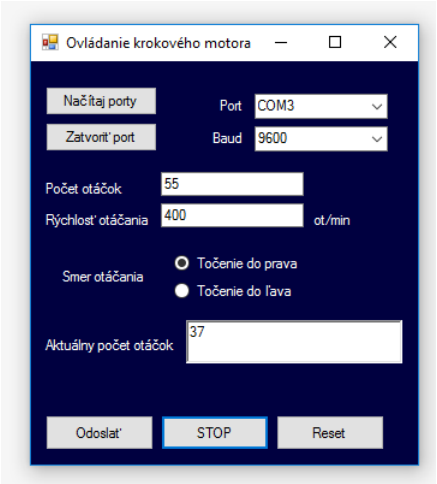

Fig. 7 Application for stepper motor control designed in Microsoft Visual Studio 2012

If the configuration is finished the port is needed to open by clicked on "*Otvoriť port*" button. At the moment when the port is open, the name of the button is changed to "*Zatvoriť port*". After the click on it, communication will be closed.

When application and device are synchronized, the user writes parameters to the text blocks for turning of stepper motor – rotation number, rotation speed and direction of rotation. The user sends the data when he clicks on "*Odoslat*" button. The application sends a data in the form:

```
ComPort.Write(data_na_odoslanie[0]+";"+data_na_odoslanie
[1]+"/"+data_na_odoslanie[2]);
```

It means that data are saved to the *string* variable, whereas *data_na_odoslanie[0]* includes number of rotation values, *data_na_odoslanie[1]* includes speed of rotation value and the last parameter *data_na_odoslanie[2]* contains the direction of rotation. *STOP* button is used for stop the rotation and *Reset* button is used for reset all stored data.

Data are sent via the serial line USART2. Microcontroller processes the data and received string divide into three parts. Numbers to the character " ; " are stored in the variable *pocet_otacok*, the next numbers to the character " / " are saved in variable *rychlost_otacania* and the last characters are saved as the *smer_otacania* variable. This variable includes also values "*parvo"* or "*lavo"*, which are also saved.

After the data process, the microcontroller sends pulses on each phase in required sequence and motor will rotate one step at a time.

The actual rotations number and steps number are viewed on the LCD display. These values are sent to the application via a serial link and the user can see it in the application too.

Manual mode consists of settings of the parameters by using the buttons. This mode is the secondary, because the default mode of control is the remote control.

V. Conclusion

Microcontrollers and DSP systems are the most used electronic devices nowadays, because they can be applied in various industries such as microelectronic, automation, electrical engineering or non-electronic sectors. Microcontroller STM32F446RE is a quick and reliable system for fast operations such as motor controller, regulation and the other operations where is needed digital signal processing.

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Employing Sketches and Information Retrieval Techniques to Improve Program Comprehension

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***Abstract*—There are many ways for improving program comprehension. Two approaches are considered in this paper. We can preserve the intent of code in informal sketches and diagrams embedded into that code. Also, information retrieval techniques can be utilized for establishing traceability links between user stories and source code. Experiments focused on measuring influence of the mentioned approaches on program comprehension are elaborated.**

***Keywords*—sketches, diagrams, information retrieval, intent, traceability, user stories, program comprehension**

I. Introduction

Because of collaboration of many developers who need to share knowledge about some software system and because of the need to maintain that system later in the future, we need software to be *comprehensible*. Two approaches to accomplish this are elaborated in this paper.

a) Preserving intent: Software can be more comprehensible by explicitly preserving a developer's intent [1], thus making it accessible to others. There is a plenty of ways of preserving intent. The paper will discuss a potential of informal sketches and diagrams.

b) Streamlining traceability among semantically similar artifacts: Another way to improve software comprehension is based on the fact that there are usually more than just one artifact (a source code file, documentation, a UML model, a user story, etc.) comprising some feature and we need to easily navigate among them. This is provided by so-called *traceability links (TL)* and one of possible approaches for establishing these links is employing *information retrieval (IR)* techniques [2].

The paper is a continuation of the author's written thesis for dissertation examination. Based on the proposed thesis and goals, a set-up of planned experiments is described here. Their conducting may lead to improving relevancy of retrieved traceability links and also may validate a deeper inclusion of sketches into the software development process.

II. Informal Sketches and Diagrams

Many developers spontaneously write or create notes, lists, tables, ER/class diagrams, drawings or other sketches [3] "to understand, to design and to communicate" [4]. Many important design decisions are made on whiteboards [4]. These sketches may resemble UML but do not strictly adhere to it [3], they are spontaneous, ad-hoc and informal. I believe this spontaneity and informality is great to capture *immediate* thoughts. These sketches can be later changed, refined, even formalized (if necessary) – usually such sketches also have a longer lifespan and are more likely to be archived (when compared to sketches into which not such a big effort was put) [5]. An interesting fact is what medium developers use for sketching: almost two thirds are on some analog medium (mainly paper and whiteboards), whereas modern means such as *interactive* whiteboards, tablets and smartphones are almost never used [5]. It is not sufficient to just *archive* those sketches – some *organization* must be brought in. Not to forget about the time dimension – as mentioned, the sketches *evolve* and we need means for handling this. Baltes et al. [6] created a tool for managing these sketches, especially for linking them to relevant parts of source code. There is still room for improvement and for studying usability and influence of sketches on program comprehension when embedded to corresponding code fragment.

III. Information Retrieval Techniques

It is possible to utilize IR techniques to tackle the *traceability problem*. There are many possibilities: probabilistic models such as Latent Dirichlet Allocation (LDA); or Vector Space Model (VSM), Latent Semantic Indexing (LSI), which are based on the idea that a document is represented by a vector of weights assigned to individual words [7]. Links are created based on the computed similarity between those documents (e.g. cosine of the angle between corresponding vectors) [7]. By *a document*, in the context of IR, we mean some software artifact at a particular granularity level after being preprocessed so that only relevant textual information is left [8]. In this preprocessing and "weighting" phase, improvements can be made, e.g. taking a structural information about a given artifact [9] into account.

IV. Experiments

A. Research Questions and Expected Contributions

Experiments are being set up to answer the following research questions:

- *RQ1:* Does embedding of informal *sketches and diagrams* into source code improve code *comprehension*?
- *RQ2:* Does weighting of terms in specific artifacts (source code files, user stories & issues) based on *structural information* improve relevance of retrieved *TLs*?

The expected contribution is at the end of the Introduction section. A setup of proposed experiments is described in the rest of the paper (basically describing a further research).

B. Experimental Codebase

All experiments will be conducted on the system well-known to the author – it is advantageous mainly regarding the *RQ2* because in order to evaluate the accuracy of retrieved links, the proper (correct, expected) links must be established first and this has to be done manually and requires a deep knowledge and understanding of the given system.

The system is a company internal system for managing their customers. It is a web application consisting of a server side created in Grails (a Groovy-based framework for the Java Virtual Machine) and a client side created in AngularJS (a JavaScript framework). Source files have ca. 150 KLOC[1] and following programming languages are used[2]: Groovy (48%), JavaScript (28%), HTML (14%), Java (7%) and some others.

C. Measuring Program Comprehension

We want to measure the influence of embedding (or linking) sketches in (to) source code on *program comprehension*. However, "program comprehension is an internal cognitive process that inherently eludes measurement" [10]. Measuring program comprehension (or understanding) is hard and only *indirect*. Siegmund [10] enumerates the following approaches for measuring:

1) *software measures* measuring the code itself: based on the assumptions that the more complex code, the harder it is to comprehend – e.g. lines of code, cyclomatic complexity;
2) *subjective rating* of developer's understanding;
3) *performacne of developers*: based on the assumed correlation between ease of understanding and speed of fulfilling a given task;
4) *think-aloud protocols*: allow observing a process of comprehending by verbalizing subject's thoughts.

Considering these standard approaches, software measures (1) are not applicable for obvious reasons: our experiment does not affect existing code. In (2) and (4), measurements would be hardly comparable and obviously biased. The approach (3) – measuring performance of developers – seems like the most appropriate choice for the given experiment.

D. Experiments to Answer RQ1 About Sketches

Programmers, participants of a controlled experiment, will be given a task and source code of the relevant part of the project. A task may be oriented on programming (altering a functionality) or deriving some knowledge from the code. Both approaches require *comprehending* and can be measured – by measuring a time to fulfill the task. Participants of the experimental group will also be given a relevant sketch or diagram. Hence the impact of these extra artifacts on program comprehension can be (indirectly) measured.

E. Experiments to Answer RQ2 About Traceability Links

Traceability links will be retrieved between source code files and so-called *user stories* and *issues* from an issue tracking system. User stories describe a desired functionality at business (end-user) level. Issues describe features or bugs on lower level with more technical details. These data will be dumped from the project's Jira/GitLab. Also some preprocessing will be necessary because of the Slovak language used in these artifacts (identifiers in source code are named in English). Experiments will be focused on measuring the impact of including *structural information* from artifacts (when computing term weights) on relevancy of retrieved links. An IR method such as LSI may be utilized, some existing implementation of the method will be used.[3]

F. Metrics for Information Retrieval

To measure success rate in recovering traceability links, well known metrics as *recall* and *precision* [7], [8] can be used. Recall is the ratio of correct and also retrieved links (true positives) to all correct links, thus the best value of 1 means that all correct links were retrieved, even though there may also be retrieved links that are incorrect (false positives). Similarly, precision is the ratio of correct and also retrieved links to all retrieved links, thus the best value of 1 expresses that all retrieved links are correct, even though there may also be correct links that were not retrieved (false negatives). To combine these metrics, a harmonic mean (*F-measure*) can be computed: $F = 2\frac{r \cdot p}{r+p}$.

[1] Kilo Lines of Code (no blank or comment lines), based on the output of `cloc` tool applied to files stored in a Git repository (`git ls-files`)

[2] As reported by *GitLab* in Graphs–Languages section

[3] Example of LSI implementation: https://github.com/aliabbasrizvi/LatentSemanticIndexing/blob/master/lsi/LSI.java.

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Evaluation of natural user interfaces

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***Abstract*—Natural user interfaces are an evolution of traditional user interfaces. Human-computer interaction in them is executed through devices that observe the user. The NUI reacts on actions and movements of the user and creates responsible reaction. Difficulty in creating a NUI withstands from the need to evaluate, if the user interface does not bother the user and if it truly feels natural. Our aim is to create measures for evaluation of NUI-s by adapting existing metrics of traditional user interfaces. We also list up devices that are used in NUI-s and their possible applications.**

***Keywords*—Natural user interfaces, human-computer interaction, observation of the user, evaluation of user interfaces**

I. Introduction

Natural user interface (NUI) is a user interface (UI), which reacts to the user in a way that corresponds with the users' understanding of the world [1]. This means that a NUI needs to offer unobtrusive means for human-computer interaction that are intuitive for the user through the use of sensors, which observe the user.

When evaluating traditional UI-s we focus on the usability attributes: *learnability*, *effectiveness*, *memorability*, *error rate* and *satisfaction* defined by Jakob Nielsen [2]. Aside from this, a NUI should also be *aware of the context*, *personalized*, *anticipatory*, *adaptive*, *ubiquitous* and *transparent* [3].

This many different aspects that need to be evaluated for every NUI create the need for measures, which would allow comprehensive evaluation of NUI. Ideally, these measures should be objective, carried out with sensors embodied in the NUI. Subjective measures that use questionnaires for collecting personal opinions of users, should be kept at a minimum as collection and evaluation of subjective data is time-consuming.

The problem of evaluating traditional UI-s is that since we need to use special devices to observe data for identification of these factors, the normal use of the UI is separated from its evaluation [4]. These sensors are already present in a NUI, which means that the gap between usage of the UI and the evaluation is diminishing.

Multiple users can be in a NUI at the same time. Since one user can obscure another one in the view of a sensor, additional sensors should be used in cooperation to identify areas that can't be viewed by the first one and vice versa [5].

Our goal is to create and validate metrics for evaluation of NUI-s by adaption of existing metrics used in evaluation of traditional UI-s.

II. Evaluation of user interfaces

The first step for evaluation of NUI-s is to analyze existing metrics and means for evaluation of UI-s. For evaluation of UI we collect data about the look of the user, his position and movement in space and sounds that the user makes. We use this data to identify the *attractiveness of the interface*, *pragmatic quality*, *hedonic quality-identity* and *hedonic quality-stimulation* [6]. These qualities are same for the NUI-s.

Through collected data we can determine the users emotions. The positive emotions correspond with *satisfaction* with the interface, while negative ones are associated with *error rate* of the interface. The emotions could be evaluated with *Pleasure, Arousal and Dominance* - PAD [7] method, circumplex model of affect [8] or through observed behavior patterns [9]. In a NUI there is the given benefit that the interface already employs sensors for observing data needed by these methods.

Evaluation of user attention and focus is executed through eye tracking [10], position tracking [11] and with electroencephalography [12]. These attributes are connected with *learnability* and *memorability* of the UI.

The *effectiveness* of a UI is set as the time needed by an expert user of the interface to accomplish a certain goal. It is affected by the order of steps, which the expert makes. *Effectiveness* is the only exact metrics, since the lower task execution time indicates better efficiency.

A. Our research in evaluation of user interfaces

For use of a standard UI we developed a system that uses kinect sensor in multi-display work environment [13]. In this setting we examined that the user satisfaction and task efficiency is increased when the system executes desired reactions on the observable user actions. One of the examined reactions was activation of a program window on a display, when the user looks at it. Since the user needs to look at a screen with a window (s)he wants to use, we could associate this action with appropriate reaction. The efficiency of the task in this case was measured by the time needed to execute a simple text editing task and the satisfaction was evaluated through a questionnaire.

Secondly we evaluated the effect of a multi-display setting in a pharmacy domain, where we connected additional display to a computer station used by a pharmacist to give out medicines with prescriptions [14]. We used a questionnaire to evaluate the satisfaction of the pharmacist. The overall performance of the pharmacist was evaluated objectively by measuring the time, during which certain categories of programs (work, leisure etc.) were active. However, the efficiency of giving out medicine with prescriptions was not analyzed in this setting. We plan to further analyze this efficiency through observation of the usage of certain key-shortcuts that are associated with the task.

We also created method for *automated evaluation of the domain usability* called ADUE [15], as the domain usability is related to the attributes of usability of user interfaces. *Domain content and specificity* is automatically evaluated for two cases. In the first case a new version of an application is created and we want to compare it with the previous version. We compare the terminology of those versions using ontologies to check, if the UI-s are consistent. In case that only one version of application UI is available, we use a reference ontology represented as the model of the domain language for the content comparison. Other option is to use ontological dictionaries or web search. *Language barriers and errors* in ADUE method are evaluated through the use of open-source OpenOffice dictionaries. The presence of *tooltips* on functional components was evaluated in application UI as the last part of the automated evaluation.

We evaluated sensors and devices used in a NUI and proposed options, which combinations of these devices could be used in unison in a NUI [16]. The devices that we analyzed were: a *widescreen multi-touch display*, a *kinect one*, an *eye-tracker* and a *wireless EEG headset*. When touch is used for interaction with multi-touch display, the kinect one and the eye-tracker are unable to observe the user. The EEG headset on the other hand can be used in combination with any of these devices, however its use is a hindrance to the user and headset placed on the head of the user does not fulfill the *transparency* requirement of a NUI.

The possible combinations of use of these devices is as follows:

- *An eye-tracker with a kinect device.*
- *A wireless EEG headset with a kinect device.*
- *An eye-tracker with a wireless EEG headset.*
- *An eye-tracker with a wireless EEG headset and a kinect device.*
- *A wireless EEG headset with touch interaction.*

All these devices should be present in a NUI so these combinations are designed for simultaneous evaluation of NUI. Although the user should use all of them at some point when interacting with the NUI. The use of displays to show computer generated elements of the user interface additionally allows the adjustment of the NUI for different domains.

III. Further research

In the further research we are going to create a scheme of a modular NUI for an interactive hall in the main building of the Technical University of Košice. This NUI would be part of an open laboratory. In this area multiple students and researchers would move during day and would be able to interact with the system. This would allow execution of experiments with evaluation of NUI on a large continuous scale. For this however, existing afore-mentioned metrics need to be adapted for the use in NUI.

Since the use of NUI would be directly connected with its evaluation, we could determine the effects of the Hawthorne effect on the evaluation of NUI [17]. Hawthorne effect states that the behaviour of the experiment participants changes as a consequence to the participants awareness of being studied. Evaluation of UI consists of a task presented to the user by researcher. However in a traditional use of a UI the user alone decides what task he wants to do. In a NUI it is important to analyze how the user can discover the means to fulfill his/her goal.

For the NUI we intend to examine following research areas:

1) How to attract the user attention with attention being evaluated by the distance of the user from the screen and his facing towards certain parts of the screen.
2) Observe multiple users pursuing the same goal in the NUI and evaluate them simultaneously.
3) Analyze the effect of the brain-computer interface on user's capabilities in a NUI.

We plan to execute these experiments with multiple different groups of users, from which some groups would be aware of the testing, while others would be observed when they enter the NUI and start doing the desired activity of the experiment.

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Experimental observation of living parasite interaction with electromagnetic field

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***Abstract*— Studies show that interaction between biological systems and electromagnetic fields produced by wireless transfer of information (mobile phones, TV broadcast, wireless internet, etc.) can lead to health problems and interaction between technical systems and electromagnetic fields can lead to improper function of technical systems. The interaction of biological and technical systems to radiofrequency electromagnetic radiation is increasing with rapid development of wireless transfer of information. This paper is focused on the current research of impact of the interaction between electromagnetic field and biological and technical systems and it describes the aim of future work and research.**

***Keywords*— radiofrequency electromagnetic field, tick, interaction, exposure, biological samples**

I. Introduction

Scientist are trying to find answer for question whether this electromagnetic exposure is or is not dangerous for our health. Electromagnetic pollution is responsible for interference between electrical devices, but it also affects the human body. The organism reacts to the electrical, magnetic and electromagnetic fields around it. The biological effects depend on the type, frequency and strength of these fields. The boom in the use of the cellular phone has led to a very evident increase of electromagnetic pollution [1].

The number of mobile phone users has increased exponentially recently and it has become an important device in human daily life. In 2014, there were more than seven billion mobile phone subscribers worldwide, a number that is expected to keep growing [2]. Radio frequency used in mobile communication has the ability to penetrate through the semi-solid substances like meat and living tissue [3]. Researches conducted show that the electromagnetic wave produced by the mobile phone might cause adverse effect to human especially at place near the ear region [4].

II. Recent research

Great emphasis is given to the effects of EM radiation on the brain and nervous system. Therefore, several studies focus their attention on this very issue [5],[6],[7]. They use sources of radio-frequency (RF) radiation in the form of propagating waveguide, but also pulse radiation with high specific absorption rate (SAR). They are trying to demonstrate the impact of mobile phones, antennas or high-frequency emitters on the nervous system of animals and mostly on human.

There are concerns that radiation from mobile phones has a negative impact on brain activity, specifically on memory and learning disorders. A group of scientists [8] in order to protect the population and preventing possible negative effects on the human brain, tried to demonstrate the effect of radiation on the brain in male mouse. They used RF EM radiation in three different frequency levels (400, 900, and 2200 MHz) and the power absorption in the range from 2.05 to 35.7 W/kg. It was found that although this radiation irritated nervous system, it has lasting effect on the physiology and function [7],[8]. The current state of the problem suggests that mobile phones do not have a major impact on the functioning of the nervous system, because mobile phone manufacturers are trying to reduce the level of SAR at unchanged frequency.

Our preliminary works are based on exposing several biological tissues for different time periods to non-ionizing electromagnetic field. We have chosen the frequency and power similar as it is with telecommunication devices. The very first experiences revealed that research methodology, laboratory procedures, analytical methods and sample logistics are suitable for designing of future research [9],[10],[11],[12].

The decision on realizing this experiment was influenced by the fact that this area of science is relatively poorly mapped, and the chances are high of obtaining new and especially beneficial results.

III. Current Research

Current research is aimed on exposing ticks (Fig. 1) to electromagnetic field. There are concerns that ticks reacts to applied electromagnetic field. This research is done in partnership with scientists from Institute of Parasitology of the Slovak Academy of Science.

The aim is to expose the ticks to non-ionizing electromagnetic field with four different frequencies and observe their behaviour. The frequencies were chosen to be 900 MHz, 1800 MHz, 2400 MHz and 5000 MHz, two from mobile broadband and two from Wi-Fi broadband. The electric field intensity was chosen to be constant 0,61 V/m at distance one meter from antenna. The output power was calculated for different frequencies according to (1).

$$P = E + 20\log(\mathrm{r}) - G_i - 107.78 - b \qquad (1)$$

where P [dBm] is output power, E [dBμV/m] is electric field intensity, r [m] is the distance between antenna and object, G_i [dBi] is gain of antenna and b [dBm] is cable attenuation.

The exposure is performed in anechoic EMC chamber (Fig. 2, Fig. 3) for different frequencies, different time periods, different number and gender of ticks and different exposing methods. The behaviour of the ticks exposed and not exposed to electromagnetic field is observed and statistically analysed.

Fig. 1 Lurking tick

Fig. 2 Exposure set-up

Fig. 3 Exposed ticks

IV. Future research

Subsequent analysis and consultation is concluded in an agreement with an expert on electromagnetic fields in practice for measurement of non-ionizing electromagnetic fields in various locations of the Slovak Republic and evaluating the effects on technical systems. A spatial simulation in ANSYS software will be created for a better idea of penetration, distribution and impact of non-ionizing radiation on biological tissue.

V. Conclusion

According to statistics the trend in various types of wireless communication is rising. It rises electromagnetic pollution in populated areas. On one side this calls for better bands management and on the other for deeper studies of possible negative effects from ecological and health risk standpoints.

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Facilitating Program Comprehension with Source Code Labeling: A Progress Report

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***Abstract*—This article summarizes our research, which is focused on labeling source code with metadata to facilitate program comprehension. We also describe future research directions.**

***Keywords*—program comprehension, source code labeling, annotations, dynamic analysis**

I. Introduction

Developers often have trouble understanding the source code of existing programs written by others, or even by themselves. The main goal of our research is to improve program comprehension correctness and efficiency.

II. Program Comprehension

First, we will briefly review our work related to program comprehension in general. We performed an ad-hoc review of existing literature in the area of program understanding [1]. Next, the most rising and falling trends were recognized by analyzing the titles, keywords and abstracts of program comprehension articles [2]. When researchers try to design program comprehension experiments or practitioners try to understand existing programs, they often encounter build failures which prevent further analysis of the systems. We quantified the severity and investigated the reasons behind this practical problem in our article [3]. The most important findings were that more than 38% of open source Java programs fail to be build from source code; and that most build problems are dependency-related.

In the following sections, we will focus specifically on the area of source code labeling.

III. Source Code Labeling

Understanding the program just by looking at its source code alone is difficult. Therefore, many approaches of labeling parts of source code with metadata have been devised. Traditional source code comments are the most primitive example of a form of metadata aiming to facilitate program comprehension. A more sophisticated example is Senseo [4]. It is an IDE (integrated development environment) plugin showing methods' callers, overridden argument and return types, execution frequencies, and other information obtained using dynamic analysis, above source code elements.

A. Systematic Mapping Study

In [5] and [6], we performed a systematic mapping study of source code labeling approaches and tools. From more than 2,000 articles, 25 were reviewed and a taxonomy was formed. The taxonomy consists of four dimensions: source, target, presentation and persistence. Every approach/tool was assigned one or more attributes of each dimension. The "source" dimension represents the origin of a piece of metadata – whether it is manually entered, obtained by static or dynamic analysis, or mined from IDE or version control history. The "target" is the granularity of a piece of code to which the metadata is bound: e.g., a whole file or a one-line element. A piece of metadata can be presented directly in the source code view of an IDE, another view (like a package explorer), or completely visually separated. Finally, the metadata can be persisted directly in the source code file, using external storage, or not at all.

B. Concern Annotations

Concerns are intentions behind a piece of code – what a developer had in mind when (s)he was writing the code. Concern annotations [7] are a source code labeling approach with human source, code-view presentation and internal storage. In [8], we examined the relation of developers' mental models and annotations using multiple empirical studies. We also performed two controlled experiments assessing the effect of presence of concern annotations on program comprehension correctness, time and confidence. The first controlled experiment was performed on students. The group which had concern annotations available in their code performed 34% faster than the control group. In the replication performed with industrial developers, the treatment group had 33% more correct answers than the group without concern annotations.

Although concern annotations are useful, they must be manually inserted and updated in the code. Therefore, we designed a semi-automated method of concern annotation [9]. It uses differential code coverage [10] – it executes the program twice and computes a difference of sets of executed methods to obtain a set of feature-relevant methods. The results are written as source code annotation above corresponding methods. Regarding our taxonomy, this approach has runtime source (dynamic analysis), method-level granularity (target) and internal persistence.

C. Internal Metadata Persistence

Many program comprehension tools either present metadata related to code elements as separate textual or graphical artifacts, or are implemented as plugins of a specific IDE. In [11], we outlined a method of IDE-independent program comprehension tools via internal metadata persistence. Using our approach, a tool directly modifies the source code by writing annotations above corresponding elements. For example, a list of callers of a method can be presented as an annotation `@Callers({"Class1.method1", "Class2.method2"})` above a method definition. This way, the programmer can read the metadata in any IDE or text editor, without using and IDE-dependent plugin (often forcing him to use a particular IDE). After the work is finished, the tool can either remove the generated metadata from the source file, or they can be left there and committed into a version control system.

D. Static and Dynamic Source

We also examined the relationship between static (code) and dynamic (runtime) source of metadata. In [12], we performed an empirical study aiming to find what portion of strings displayed in a GUI (graphical user interface) of a running program (e.g., menu items, button labels) is literally present in its source code. The study was performed on four open-source Java applications. More than 11% of strings were not found at all and a large portion of strings had too many occurrences to be practical. Furthermore, many occurrences are located in various domain-specific configuration files, not directly in the Java source code. These results and our personal experience motivate us to further explore the binding between runtime values and source code.

IV. Labeling Code with Runtime Data

There exist many source code summarization approaches trying to automatically describe a class or method with natural language sentences. They use static analysis and version control information to construct the documentation [13]. Our goal is to generate documentation using dynamic analysis.

In [14], we generate Javadoc for methods using concrete examples of argument and return values. We will now briefly summarize the approach described in [14]. First, the program is run – either manually by executing some use case or automatically by running tests. During this execution, called methods along with their argument and return values are collected, transformed to string representations, and saved into a trace file. For each method, a few executions are selected and documentation sentences are generated. E.g., for the method `Math.abs(number)`, the documentation could be: "When number is -1, the method returns 1. When number is 0, the method returns 0. When number is 1, the method returns 1." Such sentences are then written into Javadoc documentation, using a special `@examples` tag. The generated Javadoc can be then viewed as usual – in a browser or an IDE. The specific examples of values and their relationships in the documentation should help developers to more efficiently comprehend unknown methods.

V. Future Work

Although the approach of generating documentation containing runtime value examples seems promising, it has several shortcomings in its current version. Now we will mention some of them, as described in [14].

First, the set of examples is selected based on very simple criteria. For instance, the most frequent executions are selected for presentation. Exploring what attributes an ideal example should have is a promising research question.

Second, in the case of primitive types like integers or floats, the rendering of string representations is trivial. However, more complicated objects with many member variables are not easy to describe using a short text. We would like to investigate this problem in future research.

Finally, overwriting Javadoc is not always practical. Integrating the approach with IDEs is another future work direction.

Overall, we would like to achieve tighter integration between run-time data and the source code to make the process of program understanding easier.

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Fundamental concepts in the theory of oscillation

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***Abstract*—Mathematics is a necessary language for doing science and differential equations form one of the most important parts in this language. Their application in almost any scientific field has motivated generations of mathematicians to study properties of their solutions from a theoretical point of view. Research on qualitative behavior of ordinary differential equations dates back to Sturm's work in 1836. Since then, an immense body of obtained results by many researchers have formed a well-developed, full and concise theory turning more towards functional differential equations that depend on the past history rather than only the current state. This paper aims to introduce the basic concepts and results keen to the oscillatory nature of solutions. Also, we list the main topics of our interest together with open problems which have appeared and the results so far achieved.**

***Keywords*—mathematical modeling, functional differential equation, oscillation, nonoscillation.**

I. Introduction

The development and analysis of mathematical models of physical processes have been of great importance in bettering our understanding of nature and the world around us. Since the invention of differential and integral calculus by Sir Isaac Newton (1642–1727) and Gottfried Wilhelm Leibniz (1646–1716), differential equations have arisen in almost any area of human knowledge, whenever a deterministic relationship involving some continuously varying qualities (modeled by functions) and their rates of change in time and/or space (expressed as derivatives) is known or postulated.

The mathematical theory of differential equations developed as a result of a significant demand coming from various sciences, which had found the equations as an accurate language to determine and to advance their knowledge further. However, diverse problems, sometimes originating in quite distinct fields, may be described by identical mathematical expressions. Whenever this happens, the study of differential equations as a subject of mathematical theory does not aim to provide a concrete physical interpretation, but to offer an unifying principle behind diverse phenomena.

Since 1820, the only question taken up in the theory of differential equations has been: "Given a differential equation, *find its solution as an analytic expression.*"

However, Liouville's successive approximation formula allowing to express the general solution of the differential equation by means of elementary functions was shown to be unsuited for some cases.

This gave rise to a new stream of the theory of differential equations (qualitative theory) characterized by a question: "Given a differential equation, determine the geometric properties of solutions *without finding their analytic expressions*."

At present, it is well-known that most differential equations, such as those used in modeling of real-life processes, may not admit explicit (closed-form) solution. In those cases, one approach is to approximate the solution numerically. In fact, it has became quite common to take advantage of the computer technology to make the numerical approximations. However, in most applications, these approximations are only made to visualize some properties of the corresponding system of equations. The aim of the qualitative theory is to analyze these properties (such as existence and uniqueness of solutions, systems dynamics, phase-portraits analysis, parametric stability, boundedness of solutions, bifurcations, periodicity, oscillations, ...) without solving them *analytically* or *numerically*.

II. Oscillation theory

A. Fundamental aspects

Many people regard the work of Henri Poincaré on the three-body problem in celestial mechanics and Alexander Lyapunov's theory on the stability of motion as main foundation stones of the qualitative theory [1]. In 1836, when investigating the thermal conductivity, Jacques Charles Sturm posed oscillation problems of the second-order differential equation

$$x''(t) + q(t)x(t) = 0 \tag{1}$$

in the real domain, which initiated a whole new direction in the qualitative theory of differential equations. His innovative idea was to deduce oscillatory properties of unknown solutions of a given differential equation from known ones of an another, see [2]. For convenience, we shall indicate what is meant under the oscillation of solutions.

Definition 1: A nontrivial function $y(t) \in \mathcal{C}([t_0, \infty), \mathbb{R})$ which is not eventually zero for t large enough is said to be oscillatory if it has arbitrarily large zeros. Otherwise, $y(t)$ is called nonoscillatory, i.e., $y(t)$ is nonoscillatory if there exists $t_1 \geq t_0$ such that $y(t) \neq 0$ for $t \geq t_1$.

The essence of the oscillation theory lies in establishing conditions for the existence of oscillatory (nonoscillatory) solutions and/or the convergence to zero, in studying the laws of distribution of the zeros, in obtaining the lower bounds for the distance between consecutive zeros, in studying the number of zeros in a given interval, as well as in examining the relationship between the oscillatory properties of solutions and corresponding oscillatory processes in systems of diversified physical nature. Since Sturm's pioneering work, the oscillation theory has become an indispensable mathematical tool for many sciences and high technologies.

Although the ordinary differential equations (ODEs) have been the preferred language for describing and understanding various physical phenomena, they are often inadequate to serve as models due to the inherited principle of causality, that is, the future state of the system depends *exclusively on the present state* and not on past and/or future states.

In other words, since a result of any change of the system state does not occur instantaneously, it is meaningless to assume that the causality principle applies to the system. The dependence on the past (or future) naturally appears in many processes including biological, physical, chemical, physiological, economic or control systems, which can be modeled more appropriately by using functional differential equations, also known as differential equations with deviating arguments.

B. Classification of functional differential equations

Functional differential equation (FDE) is an equation concerning the unknown function and some of its derivatives, for, in general, different argument values (present, past, future). Recall the essential notions from study of ODEs that are used to describe several specific classes of equations such as order, degree, linearity, etc. In classifying of functional differential equations these notions also occur, but the key-notion of our interest, firstly introduced in [3] is the relation between the argument of the highest-order derivative and arguments of remaining derivatives contained in a FDE.

For this purpose, consider a following equation:

$$\begin{aligned} x^{(m)}(t) = f(t, x(t), x'(t), \dots, x^{(m-1)}(t); x(t-\tau_1(t)), \\ \dots, x(t-\tau_p(t)); x'(t-\tau_1(t)), \dots, x'(t-\tau_p(t)); \\ x^{(n)}(t-\tau_1(t)), \dots, x^{(n)}(t-\tau_p(t))), \\ \tau_i(t) \geq 0, \quad i = 1, 2, \dots, p. \end{aligned} \tag{2}$$

The equation (2) is called a *delay differential equation* if $n < m$. Therefore, the equation is limited by condition that the highest (m-th) order derivative contained in the equation *cannot be* delayed, i.e. it must only have one value of the argument and the argument of an unknown function and of all its lower derivatives must not be greater than that of the highest-one.

Similarly, the equation (2) is called an *advanced differential equation* if $n > m$, i.e., the argument of the highest-order derivative is not greater then the argument of an unknown function and of all its lower derivatives. Finally, the equation (2) is called a *neutral functional differential equation* if $n = m$.

Delay differential equations as a subclass of functional differential equations take into account the dependence on the systems past history, which results in predicting the future in a more reliable and efficient way, explaining at the same time many qualitative phenomena such as periodicity, oscillation or instability. The concept of the delay incorporation into systems is now proposed to play an essential role in modeling when representing time taken to complete some hidden processes.

A wide and diverse range of particular applications such as transport phenomena, distributed networks, interaction of species, epidemiology, etc., can be found in the literature [4], [5], [6], [7].

Conversely, *advanced differential equations* can be used in many applied problems whose rate of change of state at any moment of time is determined not only by the present state, but also by future state. Hence, an advance could be introduced into the equation to highlight the influence of potential future actions, which are available at the presence and should be beneficial in the process of decision making. For instance, population dynamics, economical problems or mechanical control engineering are typical fields where such equations find applications [8].

Finally, *neutral delay differential equations* arise in various phenomena including problems concerning electric networks containing lossless transmission lines (as in high speed computers where such lines are used to interconnect switching circuits), in the study of vibrating masses attached to an elastic bar or in the solution of variational problems with time delays, or in the theory of automatic control and in neuro-mechanical systems in which inertia plays a major role, see [5], [9].

The related theoretical framework of functional differential equations has received a great deal of attention since the first half of the 1950s with the pioneering work of Bellman and Cooke [10], Hale [5] and Kolmanovskii and Myshkis [6], to name a few.

The oscillation theory of differential equations with deviating arguments was initiated in a pioneering paper [11] of W. B. Fite, which appeared in the first quarter of twentieth century. Since then, there has been much research activity concerning the oscillation of solutions of various classes of differential equations with deviating argument. The interest on this subject has been reflected, e.g., in the well-known monographs by G.S. Ladde, V. Lakshmikantham, and B.G. Zhang [12], I. Gyori and G. Ladas [8], L.H. Erbe, Q. Kong, and B.G. Zhang [13], R.P. Agarwal, M. Bohner, and W. T. Li [14], R.P. Agarwal, S.R. Grace, and D. O'Regan [15], U. Elias [16] and D.D. Bainov and D.P. Mishev [9].

It is worth mentioning that already Fite paid attention to the great differences between the oscillatory properties of the solutions of differential equations with deviating argument and of the correspoding ordinary differential equations. For instance, it is well known (see, e.g., [8]) that if the solution of the initial value problem

$$y'(t) = f(t, y(t)), \quad f(t, 0) = 0 \tag{3}$$

exists and is unique, then (3) does not possess oscillatory solutions. For example, the solutions of the first order differential equation $y'(t) + q(t)y(t) = 0$ are of constant sign, while both the delay equation $y'(t) + \frac{\pi}{2}y(t-1) = 0$ or the advanced equation $y'(t) - \frac{\pi}{2}y(t+1) = 0$ have oscillatory solutions $\sin(\frac{\pi}{2}(t+\frac{1}{2}))$ and $\cos(\frac{\pi}{2}(t+\frac{1}{2}))$, which are completely caused by the delayed/advanced argument deviation.

C. General approach for the investigation of oscillatory behavior of functional differential equations

This section aims to review the process of the investigation of oscillatory behavior ofeliska two-term functional differential equations appealing to the classical framework of ordinary equations. The main subject of our interest is to obtain sufficient conditions for all solutions to be oscillatory. As is common, it suffices to focus on the task of deriving conditions ensuring to the studied equation nonexistence of any type of nonoscillatory solutions. It is, therefore, of utmost importance to provide as detailed information as possible about the structure of nonoscillatory solutions. The Kiguradze's lemma and Kiguradze's classes of solutions are well

known to researchers working in the field of oscillation theory and are extensively used to advance the knowledge further.

Lemma 1 (Kiguradze's lemma, [17]): Let $u(t) \in C^n([t_0,\infty),\mathbb{R}^+)$. If $u^{(n)}(t)$ is eventually of one sign and not identically zero for all large t, then there exist a $t_x \geq t_0$ and an integer m, $0 \leq m \leq n$ with $m+n$ even for $u^{(n)}(t) \geq 0$, or $m+n$ odd for $u^{(n)}(t) \leq 0$ such that for every $t \geq t_x$,

$$\begin{aligned} m > 0 \quad &\text{implies} \quad u^{(k)}(t) > 0, \quad k = 0,1,\ldots,m-1, \\ m \leq n-1 \quad &\text{implies} \quad (-1)^{m+k} u^{(k)}(t) > 0, \\ &k = m, m+1, \ldots, n-1. \end{aligned}$$

The above lemma is a consequence of the simple fact: if $u'(t) > 0$ and $u''(t) > 0$ for $t \geq t_0$ then there exists a $t_1 \geq t_0$ such that $u(t) > 0$. We say that for a given m, $u(t)$ belongs to the class $\mathcal{N}_m$.

Hence, if we consider the functional differential equation

$$y^{(n)}(t) + q(t)y(g(t)) = 0, \quad n \geq 2, \tag{4}$$

where $q(t)$ is of one sign, Kiguradze's lemma allows us to classify the set of all possible nonoscillatory solutions of (4) according to their asymptotic behavior as $t \to \infty$. In other words, if we denote by $\mathcal{N}$ the set of all nonoscillatory solutions of (4), then if follows from Lemma 1 that $\mathcal{N}$ has the following decomposition:

$$\mathcal{N} = \mathcal{N}_1 \cup \mathcal{N}_3 \cup \ldots \cup \mathcal{N}_{n-1} \quad n \text{ even}, \ q(t) > 0, \tag{5}$$
$$\mathcal{N} = \mathcal{N}_0 \cup \mathcal{N}_2 \cup \ldots \cup \mathcal{N}_{n-1} \quad n \text{ odd}, \ q(t) > 0, \tag{6}$$
$$\mathcal{N} = \mathcal{N}_0 \cup \mathcal{N}_2 \cup \ldots \cup \mathcal{N}_{n} \quad n \text{ even}, \ q(t) < 0, \tag{7}$$
$$\mathcal{N} = \mathcal{N}_1 \cup \mathcal{N}_3 \cup \ldots \cup \mathcal{N}_{n} \quad n \text{ odd}, \ q(t) < 0, \tag{8}$$

In case when $g(t) = t$, that is, (4) is an ordinary differential equation, it is known that the classes $\mathcal{N}_0$ in (6), (7) and $\mathcal{N}_n$ in (8) are not empty. Therefore, the classical literature on qualitative behavior of higher order differential equations of type (4) introduced the following definitions, see [18].

Definition 2: A solution of equation (4) is said to be a *Kneser solution* (of $\mathcal{N}_0$ type) if it satisfies for all large t

$$y^{(k)}(t)y^{(k+1)}(t) < 0, \quad k = 0,1,\ldots,n-1.$$

A solution of (4) is said to be a *strongly monotone solution* (of $\mathcal{N}_n$ type) if it satisfies for all large t

$$y^{(k)}(t)y^{(k+1)}(t) > 0, \quad k = 0,1,\ldots,n-1.$$

Definition 3: Let $q(t)$ be positive. Equation (4) is said to have *Property A* if, for n even, any solution is oscillatory and, for n odd, it is either oscillatory or Kneser solution satisfying

$$\lim_{t\to\infty} y^{(i)}(t) = 0, \quad i = 0,1,\ldots,n-1. \tag{9}$$

Let $q(t)$ be negative. Equation (4) is said to have *Property B*, if, for n even, any solution of is oscillatory or Kneser solution satisfying (9) or strongly monotone solution satisfying

$$\lim_{t\to\infty} \left|y^{(i)}(t)\right| = \infty, \quad i = 0,1,\ldots,n-1, \tag{10}$$

and, for n odd, any solution is either oscillatory or strongly monotone solution satisfying (10).

Several authors observed in [12], [19], [20] that it may happen that $\mathcal{N}_0$ or $\mathcal{N}_n$ or both are empty, and more strongly that all intermediate classes $\mathcal{N}_m$, $0 < m < n$ disappear if $g(t) < t$ and the deviation is sufficiently large.

Following the above classification, many authors contributed to the subject studying different classes of equations and applying various techniques.

In the rich literature related to the subject (see any cited monograph and vast references therein), there have appeared two main techniques in the study of oscillation of differential equation with deviation: one of them involves the Riccati type transformation which has been used to reduce the studied equation to a first order Riccati inequality. Another widely used technique has been based on a reduction of order and the comparison with another differential equation of the same or lower order, in the sense that a desired property of the studied equation is deduced from properties of these equations. Other important and frequently used methods include applications of mathematical analysis, fixed point theorems along with delicate analysis or so-called integral averaging methods.

The difference among above-mentioned techniques is mainly in the form of resulting oscillation criteria. Their effectiveness strongly depends on obtaining and the appropriate use of certain functional inequalities, which would most accurately estimate relations between the unknown function and its derivatives in a studied equation.

D. Recent advances, open problems

In general, oscillation theory flows along two main streams [16]. First of them focuses on the study of qualitative properties, which are common for as general as possible differential equations (linear, nonlinear, functional, abstract, etc.). The second stream of research is centered around selected classes of differential equations, studying in a great detail qualitative phenomena that are characteristic just for these equations.

In this sense, the subject treated in our research fits into the second type. In what follows, we list the main topics of our interest together with open problems which have appeared and the results so far achieved. Since, because of the generality of the context, almost all the references in the paper are monographes only, the reader can find a survey of related recent papers in, e.g., the introductory sections of author's own contributions [21], [22], [23], [24], [25], [26], [27], [28], [29].

Oscillation of differential equations with a middle term

It is well-known that the problem of beam deflection in linear theory of elasticity is represented by the classical linear fourth order equation

$$y^{(4)}(t) + q(t)y(t) = 0,$$

where $y(t)$ approximates the shape of a beam, deflected from the equilibrium due to some external forces.

Following [30], let the motion of a (sufficiently) long beam be governed by the following delay differential equation

$$y^{(4)}(t) + p(t)y'(t) + q(t)y(\tau(t)) = 0, \quad \tau(t) \leq t, \tag{E}$$

where the middle term is incorporated to control the slope of the beam. As the beam undergoes horizontal oscillations, the studied motion is described more accurately due to presence of delay. In view of the above, one of our subjects of interest has been to study the middle term influence on the qualitative behavior of the equations with the middle term:

$$y^{(n)}(t) + p(t)y^{(n-k)}(t) + q(t)y(\tau(t)) = 0. \tag{11}$$

These classes of equations enjoy a very rich structure which makes their study difficult and less studied. Our aim here has been to partially fill the gap in oscillation theory by proposing a novel approach depending on the order of the middle term, which causes that the solution structure of such equations is unclear and direct application of existing techniques is generally disabled. To get over difficulties, one of our most important tools was to employ Trench's factorization theory of disconjugate canonical operators and special properties of related principal systems of solutions. In particular, special attention has been devoted to the oscillation theory of (11) with $\{n, k\} = \{3, 1\}$ or $\{n, k\} = \{4, 1\}$. For related results, see [21], [22], [23], [24], [25], [26], [28].

Refinements of known techniques

Many oscillation results appearing in the literature for FDEs are generalizations of some results known for ODEs. The method of proof of the generalized result often remains the same as that of the original one, but it requires certain severe restrictions on the deviating argument. There have been constant efforts to improve resulting criteria, that is, to reduce number of conditions, to simplify their form, to generalize or extend them on wider class of equations, etc.; by refining existing techniques. In addition to the aforementioned objectives, we especially pay attention to the development of the novel computer-assisted method of proofs, which would significantly simplify the investigation process, by achieving qualitatively stronger results at the same time.

Oscillation of second (and higher)-order differential equations with advanced argument

So far, most of the literature has been devoted to the investigation of differential equations with delay argument, and very less is known up to now about their advanced counterparts. Especially, in case of the advanced equations of second-order, all the impact of the advanced argument has been completely neglected. Our aim is to provide a concise theory for such equations supported by applications in real-life modeling.

Generalization on an arbitrary time scale

From a modeling point of view, it is more realistic to model a physical phenomenon by a system which incorporates both continuous and discrete times. The study of dynamic equations on time scales, which goes back to its founder S. Hilger [31], is an area of mathematics that has recently received a lot of attention. It was partly created in order to unify the study of differential, difference, quantum equations and others. The general idea is to prove a result for a dynamic equation where the domain of the unknown function is a so-called time scale (or measure chain), which is an arbitrary closed subset of the reals. Oscillation theory for dynamic equations on times scales has been developed rapidly in the past ten years. We plan also to generalize the aforementioned ideas to be applicable on arbitrary time scale.

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Grammar method for 3D object description

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***Abstract*—The object recognition and special 3D object recognition is a very discuss topic in several scientific papers. We can see the impact of this research area in many sectors of human life. Our research was focused on the 3D object recognition in the last year. We decided to use a grammar method for this aim. This paper describes the essential grammar method for the 3D object description.**

***Keywords*—3D object symbolization, grammar, symbolization, 3D object recognition**

I. Introduction

Since the computer's performance is increasing, the communication between humans and computers might be more complex as well. Current state allows us to process a lot of data, but abstraction is still low. High data abstraction, or data understanding, is the essential in better human-computer communication. The problem of these process has origins in the object description. Real objects (3D objects) are consisted of a lot of vertices and edges in generally. These attributes create the objects a very complex for a simple recognition. The three dimensional object mapping methods are improving. This improvement of methods allows to simplify the recognition process. A lot of recognition problems arise in the image processing process. This is a big weakness, because we aren't able to apply the recognition method. We need to solve limitation of the image processing at first. And then we might apply the recognition method. The recognition method often gets limitations that are inherited from the image processing process. The improvements of 3D objects mapping[1], [2] allow us to replace the image processing process by the 3D object mapping. Of course, this process has limitation as well, but these limitations aren't so problematic like in the case of image processing.

Many recognition approaches are based on either neural networks(NNs) or their derivatives in present. These methods achieve good results in generally. The mainly problem with neural networks approaches is hidden. The neural network methods use relative simply equations to simulate processes in a brain. The problem arise when the system is filled with a lot of data. The exactly state of system is very hardly predictable. We can say it is impossible to predict the state in real conditions. It is obvious the NNs are the chaotic system we therefore cannot exactly predict future systems states. We suppose methods based on grammar approaches might be better predictable over time. Because of this, we decided to investigate the possibilities of grammar based on method for the 3D object recognition. In this paper we present our method for the 3D object symbolization.

II. Related work

Our related work is from different sectors. Our research has started with investigation of the biological processes in a human brain. One of most useful work for us is Klein's[3] work. The work is focused on the brain healing after a brain damage. Second relevant area for us is 3D symbolization, Thiemann 's work[4] in this area presents a new method for the 3D symbolization method using templates. Further who it works in this area is Nagel et al[5]. He introduced his method for an automated 3D building reconstruction. The works of Izadi et al[1] and Battiato et al[2] are focused on creating 3d objects by depth map.

III. Symbolization method

As we mentioned in previous section, our research was started with investigation of biological processes in human brain. Based on this, we suppose the human brain stores information to different parts in brain. And information between parts are joined by synopsis connections. This model ensures data non-redundancy. Because we want to approximate this model we use context free grammar to approximate brain parts. And references to create connections between parts. It is very unusual joins different grammars by this way. In such a case, it is very useful. It allows us to create grammar structures. Each grammar might contain different structures. If we realize we can see this diversity in the human brain as well. The brain is able to process different signal types such as: a sound or an image. Physical implementation is the same for each signal type. This is seen in both cases. Here it arises a very interesting question: How can we teach computer the meaning of words? We find the answer in relations between different grammars. For example: We suppose, we have a grammar describing 3D models as well as we have an another grammar describing a natural language. Both grammars are context free. And now, we create connections between grammar structures each other. The relations create an abstract layer above the context free grammars. The layer can be called: the meaning. It is a non-abstract meaning. It is similar to the child learning process. At first, children learn how objects around them are called. Over time they are able to recognize them.

In our case, we can say to computer what means the meaning. The meaning is the relation between 2 or more context free grammar. If we want to perform practical implementation we need to perform a symbolization process at first. The symbolization results are used like fundamental grammar structures. We then can create relations between these structures. Moreover the symbolization process ensures a

fundamental data abstraction. Further, the process is be able to process raw data(e.g.: 3D model) and then create an symbolic description of these data. We should describe objects the most universal as possible. This fact allows us to create a system with a good data compressibility. Therefore, the symbolization process is an ideal for us.

Our symbolization method is based on our previous research[6], [7] in the object recognition area. We use a grammar based on the chain code[8]. Grammar is called: Direction Vector Grammar(DVG). The grammar was primarily developed for the symbolization of 2D object on image. To adapt for 3D objects, we add a new process - the layering process. This process divides an 3D object to several 2D layers. These layers are subsequently used like input arguments of DVG. The layering process might be implemented by several ways. We used an approach that we divided the z-axes to the fix number of layer at first. Number of layer we can set up on the start. Tests showed the main weakness of approach: if we use a part of object, in the recognition process for instance, the object gets the same number of layers. This attribute causes wrong object recognition in real conditions. It is obvious this is unacceptable for us. The second approach what we tested is based on the dynamic number of layers. The layers are created based on distance between the first and the last point in layer. It is defined a constant that defines this value. The layering process is processed from left to right as well as in the reverse direction. In this case, tests showed satisfying results.

The input arguments of layering process consist of 3D models. We use the wavefront model format. It is relatively simple format, but our requirements are satisfied. Before the layering process application we apply the vertices reduction process at models. The aim of this process is reducing of vertices number. It is unnecessary to preform the layering and the symbolization process at the extremely detailed model. We want to catch the specific characters of models. We therefore don‘t need to preform the symbolization process at the detailed model. The reduction process contains a constant that defines minimum distance to another vertex. If a vertex is closer than constant value defines it is removed from the model. After this we get a new model with lower number of vertices, but model characters are still there. The modified models is used as the input argument of the layering model.

As we mentioned above the symbolization process using the DVG grammar. The DVG uses the chain code. And the chain code uses object edges. However 3D objects don’t contain edges like 2D objects. Methods based on the chain code pass around object edges pixel by pixel. If we use the process on the 2D object we get several direction vectors(each direction vector specifies direction in certain part of object). We can change the level of robustness and this changes the number of direction vectors, but the minimal value is one pixel. When we try to apply this process at the 3D models a new problem arises. Although, the method creates direction vector, a relative ratio between these points is lost. We try to reconstruct object to the original form. The object is be deformed. The solution is add additional information about the object ratio. We apply the symbolization process on each dimension. It is needed, because in the recognition process we don’t know how the input object is rotated. This fact should ensure a better recognition results. The Fig1 shows the visual representation of processes in our method.

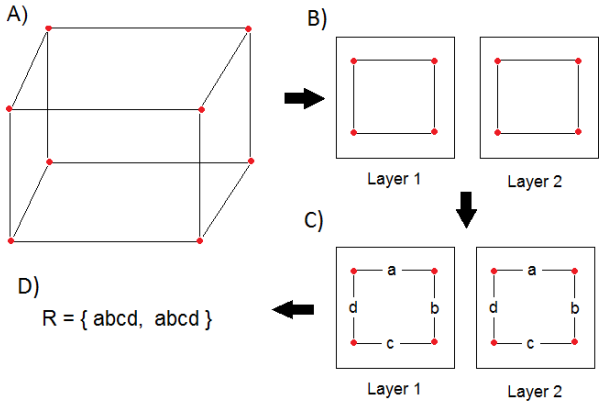

Fig. 1. Our method is divided to four steps: a) Loading objects b) The layering process c) The symbolization process d) A result

IV. Conclusion

We present our 3D objects symbolization method in this paper. The grammar approach shows in this research area interesting results. During experimental testing of our symbolization method we didn’t observe any decrease of objects probability in test set. Even if we added new symbols the object probability was still the same. This fact is very interesting, because it confirms our supposition in this area: object symbols are independents each other. We didn’t observe phenomenons like an underlearning or an overlearning. The present research shows potential in the fractal learning - data are stored into multi-level system where each level represents a different level of detail. This allows us to create a better recognition method. However this is a matter of further research.

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Haiku Generation for Human-Robot Interaction

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***Abstract*— This article presents authors' research in the field of computational creativity and its possible use in human-robot interaction. Approach for haiku poetry generation is presented.**

***Keywords*— creativity, haiku, human-robot interaction, poem, robot**

I. INTRODUCTION

Many researchers aim to find answers to thought-provoking questions as in [1]: „Is computer capable of exhibiting creative behavior? Can a computer produce artefacts that can be evaluated in a similar context as human artworks?"

Certainly, creative software can be used for autonomous creative tasks and current research and applications prove that. Some computer programs are able to create pictures [2], compose music [3] or write poetry [4-6].

Computational creativity in language (creating prose and poetry) can help in human-robot interaction by improving robots' natural language generation and thus making the interaction between human and robot more natural.

Author's research focuses on specialized task of creative natural language generation – creating haiku poems. It is traditional Japanese genre of poetry specified by formal and content rules. Haiku has 3 lines, the first and third verse must contain 5 syllables and second verse always has 7 syllables. The inspiration for haiku comes from nature.

The algorithm creates poems by combining words into a poem model. These models are extracted from poems created by human authors. They represent a formula on how to create a haiku poem. Essentially, they encapsulate content and formal rules for writing proper haiku poem.

II. POEM GENERATION IMPROVEMENTS IN ACADEMIC YEAR 2016/2017

Poem model is a list of word specifications extracted from haiku corpus. This specification consists of part of speech and syllable count for each word. Then, the model is filled with words from dictionary.

Haiku corpus is not saved in database, only models and dictionary are saved. Both are extracted from haiku corpus and are used to create poems.

Example of haiku evaluated as good:
each January
in frozen sunshine brightness
cutting pine branches
Example of haiku evaluated as bad:
rhododendron down
rain storms electricity
invisible weed

A. Metadata Determination

At first, online dictionary and syllable counter were used to determine word metadata. This approach required custom application that searched for the word, parsed HTML of the webpage in order to find the required information and saved it to database.

Acquisition of metadata was long and not very reliable. From 9 117 words, only 5 471 were successfully found in the online dictionary (≈ 60 %). Thus, metadata determination was implemented using Words API [7].

Main advantage of Words API is that it provides complex information about searched word at one place and using it is much quicker. It contains 150,000 words and besides part of speech and syllable count it also provides more features that can be used in the future work:

- word definitions and example sentences
- list of rhyming words
- usage frequency
- list of synonyms
- list of antonyms

Basic subscription offers 2 500 requests per day for free.

B. Words in Dictionary

From 8 107 haikus [8, 9], total of 73 309 words were extracted, from which 9 117 were unique. For each unique word, number of occurrences in haiku corpus was counted.

Different thresholds were used for dictionary creation. Original dictionary and 4 of its subsets (with threshold of 3, 5, 10 and 15 occurrences) were used in poetry generation in order to determine the right threshold that would create haiku-specific dictionary. With each dictionary, 30 poems were created and evaluated by 3 participants.

The results of the experiment:

- when too low occurrence threshold is set, dictionary contains too many words thematically not consistent with haiku genre in dictionary – e.g. microwave
- when too high threshold is used, all haiku-specific words are removed and only general vocabulary remains

The most thematically balanced poems were produced by dictionary created with threshold of 5 occurrences.

C. New Functionality

Currently, web application provides only introductory tab and tab for creating a new poem.

Following several new tabs on the haiku generator website are ongoing work:

- Best haikus - showing list of haikus that gained the best evaluation
- Worst haikus - with list of poems that have the lowest evaluation
- Newest haikus - with poems that were generated most recently

III. Future Goals

Following tasks are set to be implemented in near future.

A. Haiku Generation Improvements

One of the main characteristics of haiku is a seasonal word (kigo, can be expressed directly as "winter" or indirectly using e. g. "snow"). Traditional Japanese haikus are about the changes of a season and kigo helps to express it. [10] The next goal is to implement thematic generation of haikus – based on user-selected season. There are multiple kigo databases available online, e. g. [11] or [12].

Japanese haiku is an emotional genre of poetry. It is undeniably an art to express strong feelings and emotions in such short text form. [10] Thus, another goal is to allow user to select what emotion should be expressed in haiku. Multiple sentiment analysis methods will be researched and several algorithms will be compared.

Apart from the above objectives, possibility to generate haiku from keywords chosen by user will be implemented as well.

B. Haiku To Speech Transformation

Last goal of the research is to enrich the poems with recitation performed by a robot. Apart from technical challenges to create human-like recitation – speech with appropriate speed and voice pitch followed by non-verbal expression such as posture, hand and head movements – it also has to be artistically pleasing.

IV. Conclusion

Creative software can be used to „boost" human creativity because of thinking outside the box. Computers are not limited by social background (such as conventions, customs, attitudes, etc.) and can explore areas in art that people would not think of.

Also, computational creativity can be used as a means to optimize human-robot interaction and make robots' appearance more natural and human-like.

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Hierarchical Text Classification with Machine Learning

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***Abstract*—This paper consolidates latest research, findings and implications of hierarchical text classification by machine learning. We outline 3 most efficient machine learning approaches tailored for text classification, with regards to hierarchical and non-structured categorization. Further, we investigate and explore classification task as a learning process, which formal representation is defined in terms of computational learning theory. We introduce a concept of perceptron, which forms a neural network – a principal of a learning machine. Finally, we summarize key aspects of fundamental principals of computational learning theory and its implications on design and implementation of novel solutions, applied for text classification problems.**

***Keywords*—hierarchical classification, machine learning, neural networks, learning theory.**

I. Introduction

Learning machine is so long awaiting revolution in developing abilities to train computer machine so it can learn presented concepts. The discovery and establishment a formal representation of learning process was a breakthrough event. Been able to present and describe this process mathematically has enabled to conduct more intensive and detailed research by theoretical computer scientists in this area.

Conceptually, it was proven that it should be possible to design such learning algorithm, which is capable of acquiring conceptual knowledge base by learning from provided training data sets. After learning is completed, the perceptron, represented as neural network, is capable to classify new unseen concepts according learned hypothesis [3].

Generally speaking, categorization divides the world of experience into groups or categories whose members share some perceptible similarity within a given context. And, it worth to noticed, that this context may vary and with it the composition of the category. We define classification as process that performs the orderly and systematic assignment of each entity to one and only one class within a system of mutually exclusive and non-overlapping classes [5]. This process is lawful and systematic: lawful because it is carried out in accordance with an established set of principles that governs the structure of classes and class relationships; and systematic because it mandates consistent application of these principles within the framework of a prescribed ordering of reality [2].

The focus of our research is on hierarchical classification and its implications on efficiency, accuracy, generalization and reusability. And, we seek answer for a following question: "How hierarchical classification approach should be designed in order to outperform non-hierarchical one?"

II. Computational Learning Theory

Computational Learning Theory is relatively new science field that established a foundation for a formal representation of the learning process. Based on the fundamental principals of computational learning theory, the goal of the learning process is to construct a hypothesis that would correlates to the concept. The set of all concepts, which is determined by a machine M (see Fig. 1), is called a hypothesis space.

Fig. 1. Learning Framework Design

In Fig.1 W represents learning concept example and P encodes and formalizes the input concepts into some formal machine representation such as matrix or string of bits. We define M as a machine that is capable of recognizing of certain examples on its input [3].

Generally speaking, let's assume two sets of concepts, C (the concept space) and H (the hypothesis space), and the problem is to find, for each $c \in C$, some $h \in H$ which is a good enough approximation to c [1].

Text classification problem is formulated as following [2]; let $C = \{c_1, c_n\}$ be a set of classes and $D = \{d_1, d_n\}$ be a set of files. Given a set of case of the form d_i, y_j where $d_i \in D$ and if $d_i \in C_j$ then $y_j = 1$, otherwise $y_j = 0$, the goal is to take in a function f such that $f(x) = 1$ if $x \in c_j$ and $f(x) = 0$ if $x \in c_j$.

Further, the concept of VC dimension is introduced and the bound for the Growth function is defined, such as the value of $N^{\Lambda}(l)$ is either 2^l or polynomially bounded [1],

$$N^{\Lambda}(z_1, \dots, z_l) \leq \left(\frac{el}{h}\right)^h \quad (1)$$

The h is one free parameter of polynomial bound and this bound, which depends on one capacity parameter, which cannot be improved. If we would be able to find more than one parameter that describes some property of capacity, to

increase the bounds, then it will be having direct impact on the bound of the generalization ability of learning machines.

Suppose that some set of N points in the feature space is shattered by rules in C such as, for any possible classification of those points, some rule in C perfectly fits the points so categorized. Then the VC dimension of the set of rules C is at least N. Thus the VC dimension of the set of all linear separations in $D - dimensional\ space$ is $D + 1$. If the rules in C have VC dimension V, there is a function $m\ (V, \epsilon, \delta)$ that indicates maximum amount of data needed to ensure that the probability is less than δ and expected error rate exceeds the minimum by more than ϵ. Where there is such a function $m\ (V, \epsilon, \delta)$ there is "probably approximately correct" learning or PAC learning. One of the implications is that smaller ϵ indicates a better approximation to the minimum expected error for rules in C and a smaller δ indicates a higher probability of desired approximation to that minimum expected error [1].

III. Machine Learning Solutions

In this section we present 3 most popular and commonly used approaches for text classification purposes. Each of the approaches conveys it's own paradigm derived from theoretical computational learning theory. The popularity of these techniques is based on the following aspects: simplicity of implementation, learning process convergence in relatively acceptable time, potential for reusability and generalization, scalability of learned model, and relative complexity of the solution that is considered acceptable [4].

A. Linear Classifier

This classifier requires a vector to represent a category in the same space and a linear function $f\ (d)$ to evaluate similarities between the document and the category. Those documents with higher value of $f\ (d)$ are likely to belong to the category. The linear function can be represented such as:

$$f\ (d) = \ w * d = \ f\ (\sum_j w_j * d_j) \qquad (2)$$

there $j = 1, \dots, m$ and $d = (x_1, \dots, x_m)$ represents a document vector, $w = (w_1, \dots, w_m)$ represents a vector of classifiers, and m is a number of features that represent a document. Because linear classifiers extract an explicit profile from training data to represent a category, they are also called Profile Based Classifiers. The performance of linear classifier is fairly good, and ranging between 0.44 – 0.55 BEP [4].

B. Neural Networks

Perceptron model consists of neural networks, singles neurons that are interconnected into a network, has been successfully applicable for pattern recognition and text categorization. Each neuron described by McCulloch-Pitts model according to which the neuron has n inputs $y = (y^1, \dots, y^n) \in X \subset R^n$ and one output $Y \in \{-1, +1\}$ [3].

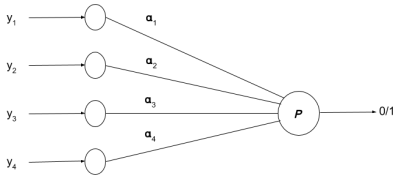

Fig. 2. Perceptron with 4 inputs

The output is connected with the inputs by the functional dependence as following

$$y = sign\ \{(w * x) - b\} \qquad (3)$$

Neuron divides the space X into two regions: region of those output that takes the value 1 and the second region that takes the value -1. These two regions are separated by the hyper plane $(w * x) - b = 0$. Neural networks perform fairly well, with registered 0.82 BEP measured on Reuter's collection [4].

C. Support Vector Machine

A truly hierarchical classification algorithm is the Big Bang and Top-Down approaches, both using Support Vector Machine. According to the Big-Bang approach, a categorization model can be created in a single category of the specific algorithm through classification of the hierarchy of orders as a whole and therefore, representing the higher algorithmic complexity. The Big-Bang approach cannot use an entirely flat classification method because it must be adopted and considered in the whole hierarchy. In Top-Down approach, number of classifiers is trained for every level in the hierarchy and thus producing tree classifiers. In this scenario, the root classifier is trained on all the instances at every level in the hierarchy after which the next class level is also trained with just a subset of instances that belong to a particular class. This process of training the classifiers in the SVM is done from top-bottom until the classifiers reach the leaf node. Reported performance of SVM classification on Reuter's collection is 0.864 BEP [4].

IV. Conclusion

Based on presented findings regarding the effectiveness of different Machine Learning Approaches expressed in BEP units, we may conclude that SVM approach produced the highest BEP index of the classification performed on Reuter's collection. However, the complexity of the representation of training data for SVM algorithms is much more complex than Linear Classification and Neural Networks algorithms. On other side, SVM enables hierarchical classification at scale and can obtain better bounds, which impacts generalization abilities of this solution [4].

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Hierarchical Topic Modeling on Streams of Social Media Data

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***Abstract*—Textual data represent important source of information which can be used in decision making process. Especially contributions from social networks contains significant information which can be useful for analysis in case of crisis situations, elections, launching a new product on the market, etc. Topic modeling represent one of the ways to analysis such textual data. It tries to uncover the hidden thematic structures from input data collection. The main aim of this paper is to describe a new way for topic modeling. In difference to standard topic modeling methods our method is able to extract topic hierarchy from input data collection. Also some approaches for visualization and reduction of topic are presented.**

***Keywords*—topic modeling, formal concept analysis, singular value decomposition.**

I. Introduction

In recent years, the resources on the Internet and especially social networks are produced rapidly. There is daily published a large amount of contributions, which usually reflect user opinions, attitudes on worldwide events, products, persons, etc. This can be useful mainly in marketing. Marketing has been always dependent on the data, because proper understanding and using information can bring the company competitive advantage.

Data from social networks can be useful in different types of tasks or analysis, e. g. crisis analysis (for example at time of some war conflict it is possible to monitor how users perceive current situation), launching new product on the market (monitor if users like new product, which bugs it has, etc.), protection of reputation (monitoring social networks to catch contributions with negative opinions on company), etc.

Problem of contributions from social networks is their large amount. Because of that their manual processing and analysis is difficult and time consuming, so there is need to use some methods for automatic analysis of this contributions. One of such methods is topic modeling. It shows us a new way to browse, search and summarize data from different sources using methods which try to uncover hidden thematic structure in data collections. In recent years, several methods have been proposed. One of the most popular and used method is Latent Dirichlet Allocation (LDA, [1]). which was also extended to other variants, e.g., in [2] authors extend LDA to explicitly allow word distributions encoding in order to improve topic alignment quality and synchronization of topics over different languages, Zhai and Graber in [3] proposed the online version of LDA. Also, other methods have been proposed like moving average stochastic variation inference [4] or stochastic variational inference[5]. While these methods produce standard topic modeling output, we are more interested in approaches which can create not only flat topic classes, but create hierarchical model of particular subtopics. This leads to hierarchical variation of topic modeling, where also some methods were already proposed. We can mention here work of Blei et al based on nested processes[6], cluster-based abstraction model architecture by Hoffman [7], or hierarchical extension of Dirichlet processes in [8].

Our focus in this paper is to study other approaches which are able to create hierarchical topic models from streams of textual data.

II. Achieved results

In this section, we present achieved results in domain of topic modeling.

In paper [9] we propose method for classical topic modeling, which is able to extract topics from streams of social media contributions. This method use different way for topic modeling compared to other proposed approaches, first we use methods of community detection to obtain clusters of similar contributions and after that we extract the most informativeness words for each of the clusters.

In paper [10] we propose different approach for topic modeling which is able to extract topic hierarchy from input data collection. It is based on combination of formal concept analysis (FCA) [11], [12] and singular value decomposition [14]. The basic idea is to combine FCA-based method (GOSCL [13]) with singular value decomposition (SVD) i.e., SVD is used to uncover hidden thematic structures and FCA is used to create hierarchical topic model from them. The procedure of our proposed approach is shown in Figure 1. First step in our procedure is to preprocess input collection of documents (contributions) and the creation of document-term matrix. Next step is the usage of SVD on input document-term matrix to find hidden thematic structure in input data collection. Next step is application of GOSCL algorithm to extract hierarchical structure of topics. After that we use simple threshold based method to reduce number of output topics. This method remove topic which contains less documents than threshold. Obtained result for this method are shown at Tab 1. As you can see our approach can reach the results of comparable quality LDA and k-means.

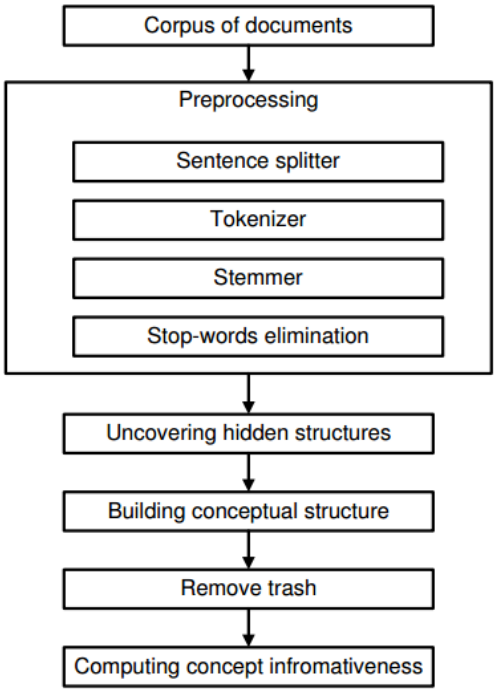

Figure 1 Process of topic hierarchy extraction by proposed method

Problem of FCA based topic modeling is number of generated concepts (topics). For that reason, we presented some reduction methods in paper [15], which reduce output concept hierarchy from FCA by removing edges between concepts such that every concept has only one parent. Also some dynamic visualization techniques were proposed in paper [16], which are able to visualize large hierarchical structures.

Tab 1 Comparison of Purity metric achieved by the standard methods (k-means and LDA) with (k-means and LDA) with our proposed approach (FCA-SVD) for different settings of trash elimination (removing concepts which cover less % of documents than this threshold) and K (best K singular values from SVD reduction step before topic modeling using FCA).

Method	Trash(v %)	K(SVD)	Purity	Number of Concepts
LDA	-	-	0,699	4
k-means	-	-	0,766	4
FCA-SVD	5	4	0,73	91
FCA-SVD	5	8	0,69	750
FCA-SVD	5	20	0,55	2942
FCA-SVD	10	4	0,72	68
FCA-SVD	10	8	0,67	455
FCA-SVD	10	20	0,49	784
FCA-SVD	0	4	0,74	185
FCA-SVD	0	8	0,72	1669
FCA-SVD	0	20	0,64	25383

III. Conclusion

In this paper we have presented our approaches for the topic modeling. First method for classic topic modeling was proposed and also method for creation of hierarchical topic model based on the combination of Formal Concept Analysis and Singular Value Decomposition was proposed. Our methods were tested on selected contributions from Twitter network and showed comparable results with the standard non-hierachical method. In the feature we would like to aim to problem of number of generated topics by better visualization and better reduction methods.

Acknowledgment

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High Availability and Reliability in Wireless Optics Using Data Analytics Techniques

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***Abstract*—Free Space Optics (FSO) - often called Wireless optics is high speed mean of communication which can take place in some fields of nowadays industry. The state of art of FSO devices can easily reach 1.25GBps data bit rate with sufficient availability and reliability most of the time. The fact that FSO system's operation is significantly deteriorated because of negative weather effects still makes this communication technique not used as often as it could. This drawback is often compensated by employing RF link as a secondary communication channel in a system. Assuming that FSO links operate within infrared range of electromagnetic spectrum it is obvious that particles as fog, heavy raining, snowing will eventually lower the quality of received optical signal at the receiver end. When overall atmospheric conditions make received optical signal converging to critically low values the signal fade occurs. Considering described scenario will employ a subordinate RF link during the time of such an event so the communication is persistent. The crucial question arises when it comes to defining the received optical power threshold. However, settling the proper threshold level for particular FSO link with its unique specification and switch timing is a rather complex task. This paper deals with the designing of hardware and software proposal to bring new way to set up a measuring device essential for FSO/RF high availability and reliability.**

***Keywords*—FSO, reliability, availability, atmosphere, machine learning.**

I. Introduction

FSO signal is strongly influenced by atmospheric channel conditions along the transmission optical path between two transceivers. When considering reliability and availability of FSO links, it's evaluated in terms of the actual ratio between the time of overall operational link time and the link signal fade duration. Modulated optical beam carrying the information is influenced by numerous weather effects such as heavy fogs, rainfalls, snowing, dust, wind, etc. The result of all the mentioned phenomena the received optical signal detected on both sides of FSO link is lowered. This parameter is called RSSI (Received Signal Strength Indicator). This indicator in fact determines whether actual FSO link is still in operation mode on not. The critical level of received optical signal varies depending on the device configuration (light source, receiver sensitivity, the quality of lens, etc.). In general, this RSSI level splits the received optical power interval into two regions. The region above the critical RSSI level is called a positive one and the rest of the interval is unacceptable for FSO operation. In the first phase, we have decided to design a device to measure some weather effect indicators to understand their influence at the received optical signal (RSSI) [1-7].

II. Design Of The Device To Characterize Atmospheric Channel Conditions

In the first phase the device for measuring weather effects has been designed and assembled as it has been already discussed. This device can measure the following weather parameters: temperature [C], humidity [%], pressure [hPa], visibility [m], wind speed [m/s] and particle density concentration [mg/m^3]. The FSO link operates at 850nm wavelength and the distance between two transceivers is about 300m.

Fig. 1. FSO link – FlightStrata 155E (Technical University of Košice campus, Vysokoškolská 4).

The proposed measuring device is encapsulated in a white box right next to the FSO transceiver. Collected data characterizing atmospheric channel conditions are managed by numerous scripts and stored in the database which is directly integrated within a device (an actual minicomputer). Instantaneous data can be also visualized and accessible from the internet. The following Fig. 2 demonstrates such an achievement by referring to the received optical power [dBm] besides the rest of the parameters. It's important to note that the operational wavelengths of all employed optical sensors such as visibility sensor and the sensor for measuring the particle concentration in the air are aligned, so it means that all of them use 850nm. These sensors are basically based on so called back scattering principle which is in some way the analogy to the RSSI parameter in terms of FSO

communication. Sensors are triggered to receive required data perpetually and all the records are processed in database.

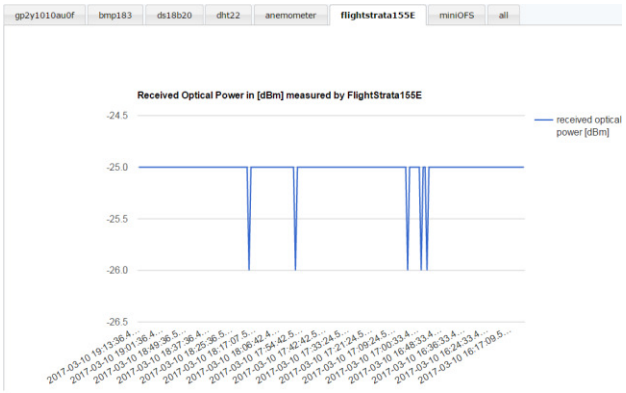

Fig. 2. Web interface to visualize instantaneous measurements of collected data (temperature [C], humidity [%], pressure [hPa], visibility [m], wind speed [m/s] and particle density concentration [mg/m3] and received optical power [dBm]).

III. Free Space Optics

As it has been already mentioned FSO laser beam suffers from negative weather effect which in fact cause signal loss in two forms: absorption and scattering. The negative effects which contribute to RSSI loss has been studied. However, when trying to relate any of the measured parameter to RSSI the results are less than promising. The goal is to predict whether the RSSI level decreases under the critical interval threshold or not. Blue color horizontal line represents a critical RSSI threshold for FSO link. In case that the probability such an event is getting certain it's also important to estimate the actual time when RSSI remains in this state. These tasks are rather complicated and can be split into two approaches.

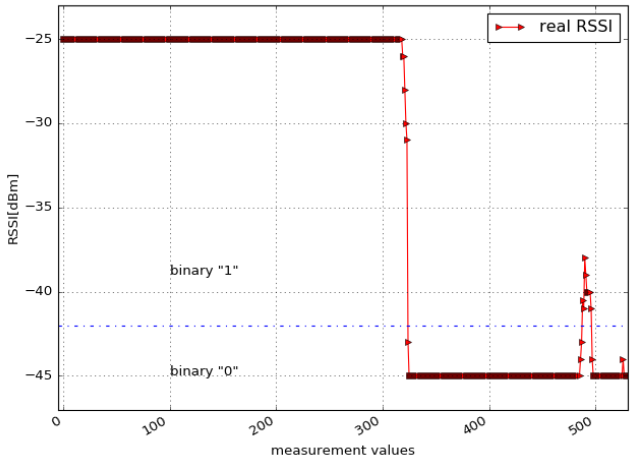

Fig. 3. Received optical power RSSI [dBm] interval split into binary regions.

The first approach to estimate RSSI based on weather characteristics influencing the optical beam is regression which more or less predicts an exact RSSI value. This can be achieved by using machine learning algorithms like DecisionTreeRegression and many others. The second approach is employing so called classification methods. Both of mentioned approaches provide vast choice of configuration of the actual models which requires deep analysis. The most complicated part in deep data analysis is the way to compose the matrix of input parameters (features). The following Fig. 4 demonstrates comparison of three methods with the same input parameter matrix (GradientBoostingRegressor, RandomForest and DecisionTreeRegressor with AdaBoostRegression).

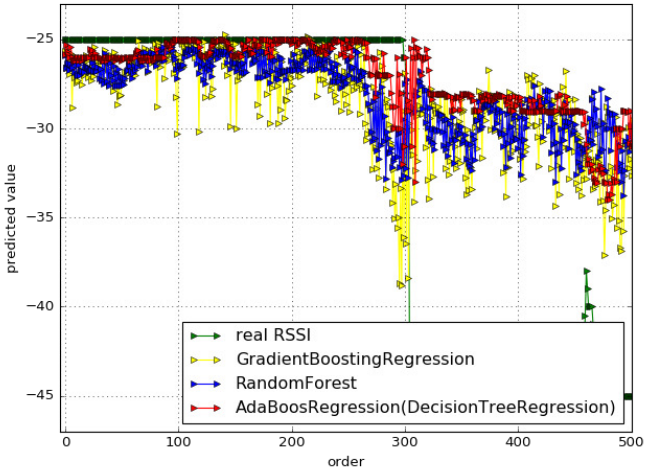

Fig. 4. Comparison of three prediction models for determination of received optical power RSSI [dBm].

IV. Conclusion

This paper presents employing of data mining methods in estimation of RSSI parameter which is essential when FSO link must be switched to backup RF link. It turns out that by using one of sufficient data mining methods the received optical power can be predicted with higher precise so the overall FSO availability and reliability can be improved. The communication can be kept on optical link with higher confidence and this system prevents undesired switches when RSSI flapping.

Acknowledgment

This publication arose thanks to the support of the Operational Programme Research and development for the project "(Centre of Information and Communication Technologies for Knowledge Systems) (ITMS code 26220120020), co-financed by the European Regional Development Fund". This work was supported by research grant KEGA no. 023TUKE-4/2017.

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High-Level Malware Behavioural Patterns

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***Abstract*—Current trends in the research of malicious software emphasize analysis of behavioural aspects rather than only syntactic features. Still, the combination of both approaches seems to be the most useful. In accordance with this trend, our research progresses with seeking indicators of malware at the level of executable code, and also in the form of behavioural patterns on high level of abstraction, which are not directly bound to syntactic representation of analysed samples and so have potential to withstand code mutation.**

***Keywords*—Analytic services, high-level representation, malware analysis, malware behaviour pattern, syntax-independent.**

I. Introduction

Code obfuscation and program mutation on syntactic level still pose a problem, not only in detection of novel computer security threats, but also in analysis of well-known malicious infiltrations. The trend of behavioural malware analysis, which could combat defences of malware, persists among researchers. The approach used in obtaining behavioural information, however, did not change significantly - operations performed by malicious samples are often deduced from executable code by means of static analysis. Even if some high-level behavioural signatures appear in recent research papers, they are usually built from statically extracted data. As Miao et al. state in their work, "*behavior features of high-layer semantics*"[1] are needed for progress in malware detection.

II. Previous work

During previous years of research a hypothesis was tested, which suggests that features and behaviour notoriously known in malware are present also in non-malicious - benign software [2], [3]. The hypothesis was verified on harmless programs designed for operating system maintenance and the features observed in these samples were related to *packing* - a combination of compression and encryption with the purpose of obscuring suspicious fragments of program's code.

The next steps of research were aimed at more notable features of behaviour. Our attention was drawn to 4 major groups of behaviour - *file actions*, *process actions*, *network actions* and *registry actions*. These have already been given particular attention in earlier doctoral paper [4] at the beginning of the research.

III. Progress in the research area

Research in behaviour of harmless programs has been extended with additional significant feature related to program packing, specifically the feature of *entropy*. Entropy, in the context of programs' static analysis, can be simply explained as a measure of unpredictability of operational code comprising a program. A source code written in any programming language and compiled into binary code contains repeating patterns, which form e.g. conditional statements, jumps and arithmetic operations. This causes distribution of bytes in programs to be non-random and relatively predictable (low values of entropy). Compressing and encrypting a program disrupts its natural distribution of bytes (very high, limit values of entropy), which is in fact an effect of packing. Program's code modified in such way is not possible to decompile - no symbolic instructions are recognisable and the code seems like meaningless sequence of bytes.

We analysed program sections of 100 malicious samples and 100 harmless samples, all of them selected specifically in the domain of system maintenance utilities. In the context of entropy described above, we state in our paper [5] that analysed harmless programs show symptoms of programs created with malicious intents. Majority of samples contain a lot of program code out of usual sections (so-called `.rest` section) and with high entropy. Comparison between malicious and harmless samples showed, that in case of malicious set, fewer samples were detected for unusual code sectioning, but the correlation between relative size of `.rest` section and entropy of this code is preserved in both sets of samples.

According to plans from previous year, a large amount of behavioural characteristics from thousands of malicious and harmless samples was assembled by utilising online malware analytic service *Totalhash* [6]. To facilitate obtaining required data, sorting and storing it into a database, a utility application was developed. Its implementation and features are delineated in our paper [7].

A part of last year's work with great significance is contained in a paper [8], which was presented on international conference SOFSEM 2017 in Ireland. It builds upon analytic data obtained by the utility application [7] with a goal to address the problem of malware's behavioural characteristics on high level of abstraction. Inspired by categorisation of malware operations, addressed in earlier paper [4], we observed quantity of these actions executed per sample. In particular, our observations covered amount of *file creations*, *file deletions*, *mutex creations*, *process creations*, *service creations*, *services started*, *registry entries* manipulated, *DNS* and *Winsock DNS* operations, *HTTP get* and *post* requests, and *TCP flows*. There are several reasons for analysing software behaviour from this, quite untraditional, point of view:

- Behavioural patterns are often extracted statically from program's execution traces. The problem with this ap-

proach is that obfuscation techniques increase complexity of code and create numerous "dead" traces, which in fact never get executed. This significantly complicates pattern extraction or makes the resulting pattern unusable.
- Malware mutations on syntactic level reduce effectiveness of behavioural patterns, which are formed from sequences of operational code.
- Considering the issues above, behavioural patterns should be less dependent on programs' code or analytic technique, which is used for pattern extraction. Also, the pattern should not determine which detection technique can be employed.
- We considered a top-down approach - looking for patterns on the highest possible level first, decomposing the behavioural features into more detailed fragments later, when appropriate.

Our goal in this part of research was to verify a hypothesis that even coarse-grained information about malware behaviour are useful in detection or differentiation between malware types.

Overall 34 099 reports of behavioural analysis were available for our research. These reports contained valuable information about operations performed by each sample. By analysing quantity of these operations, we figured out that there are distinct samples, belonging to the same infiltration type (malware signature), which activity corresponds to a pattern. An example of this pattern is given in Fig. 1.

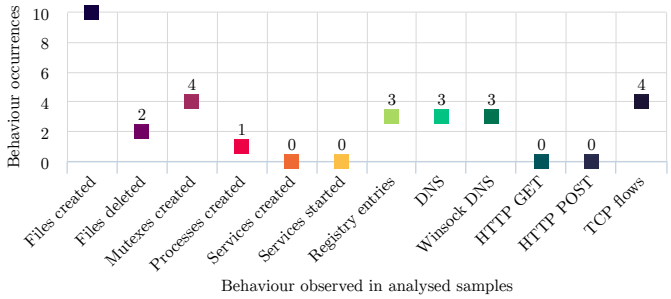

Fig. 1. Behavioural pattern discovered among malicious samples with signature labelled internally as *A*. All the samples belonging to the signature performed exactly the same amount of actions as presented in the chart. Figure originally published in [8].

No other samples, harmless or malicious, corresponded to the pattern from Fig. 1. In other words, a unique pattern was found which defines behaviour of malware signature on high level of abstraction.

Among behavioural patterns some non-random variabilities occurred, as shown in Fig. 2. In fact, behaviours which showed variability were often related, so considering sub-groups of behaviour in the pattern was appropriate. For illustration, in pattern from Fig. 2, the first sub-group showed 11 *files created*, 3 *DNS* operations, 3 *Winsock DNS* operations and 4 *TCP flows*. The second sub-group showed 12 *files created*, 8 *DNS* and 6 *Winsock DNS* operations, and either 7 or 5 *TCP flows*.

To describe high-level behavioural pattern of malicious samples corresponding to some signature, a formal notation was outlined. Further details and also examples employing the notation for defining behavioural patterns are available in the original research paper [8].

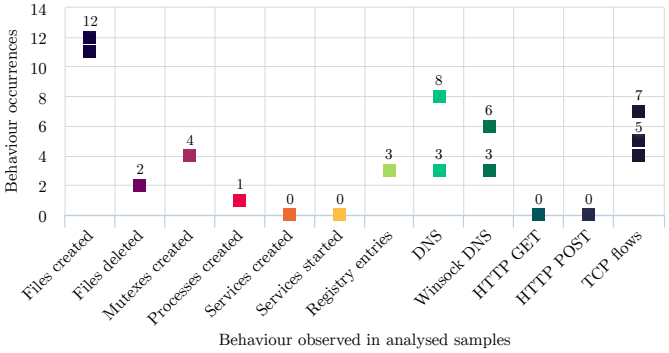

Fig. 2. Behavioural pattern discovered among malicious samples with signature labelled internally as *C*. The pattern demonstrates slight variability of samples' behaviour regarding actions *Files created*, *DNS*, *Winsock DNS* and *TCP flows*. Figure originally published in [8].

IV. Next Steps in the Research

Since quantity of samples corresponding to one malware signature varied greatly, behavioural patterns which were discovered are not equivalent in accuracy. Therefore, the next steps will cover the issue by proposing *behavioural pattern evaluation system*. Not only number of samples which contribute to pattern formation will be considered, but also structure of the pattern - amount of variations among types of observed behaviour and groups of related behaviour which are formed as a consequence of variations.

Improvements of high-level behavioural patterns could be made by including information about specific system calls which realise program's behaviour. This type of information is still considered high-level, but provides much more details about program's behaviour.

Limitations of analytic service *Totalhash*, which was used to obtain data for our research, are the weaknesses of our approach. They could be alleviated by adding another resource of behavioural information, e.g. service VirusTotal[9] which provides more details in analytic reports.

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Hybrid RF/FSO Communication System and Puncturing Technique

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***Abstract*—Spectrum of radio frequency (RF) communications is limited and expensive to install new applications. Free space optical (FSO) communication is a viable technology which offers enormous bandwidth, license free installation, inexpensive deployment and error prone links. The FSO links degrade significantly due to the varying atmospheric and weather conditions. A hybrid FSO/RF communication system adapts the varying nature of atmosphere and weather. For the adaption of varying atmosphere and weather scenarios, was developed a novel optimization algorithm. The proposed algorithm is based on the well-known puncturing technique. The proposed algorithm is computationally less expensive and provides better performance gains over varying atmosphere and weather conditions. The algorithm is suitable for fast speed applications [1].**

***Keywords*—FSO communication system, hybrid FSO/RF communication system, puncturing technique, RF communication system.**

I. Introduction

Communicating over FSO, with its nearly boundless bandwidth, has been proposed as viable candidate for "last mile connectivity" [2]. But the meteorological conditions and scintillation severely affect the FSO channel. FSO communication undergoes significant deterioration whenever the visibility of the laser beam is affected. It is mentioned in [3] that fog is the dominant parameter which significantly affects the visibility of the FSO laser beam. The atmospheric effects on the FSO beam propagation can be divided into power attenuation and laser power fluctuation usually called scintillation [3]. These channel variations can be improved by introducing the rate adapting technique.

Theory about study on punctured LDPC codes can be found in [4,5], considering the binary erasure (BEC) channels. Low density parity check (LDPC) code was first introduced by Gallager in 1962 and its performance is nearly close to the Shannon's limits. The LDPC codes of any rate and block length can also be created easily by just changing the shape of the parity check matrix. It means that the rate adaptability in the LDPC codes can be obtained easily compared to other codes. LDPC codes have the feature of parallelism for supporting different speeds, performances and memory consumption [1].

Recent research [2, 5] shows that the demerits of one communication links (FSO) can be overcome by introducing a parallel channel of other communication link (RF) named as hybrid FSO/RF communications system. But a true hybridization can be made possible only when both channels collaboratively compensate the disadvantages of each other and providing good performance improvements of the communication system. To cope with the channel variations, we propose puncturing LDPC codes which provides better performance improvement by making the system adaptive over the non-adaptive system [5]. The proposed algorithm shows a better flexibility over slowly fading channels [1].

II. Irregular LDPC Codes

Low density parity check codes have received attention by the research community because of their capacity approaching performance over a large range of data transmission and storage channels. The original Gallager codes are known to be regular LDPC codes. Another class of codes known as irregular LDPC codes can achieve better performance comparing to the regular ones.

An LDPC code can be well represented by a bipartite graph known as Tanner graph. The Tanner graph consists of two sets of component nodes decoders known as variable nodes decoder (VND) and check nodes decoder (CND). The number of edges which join the VND and CND are equal to the number of *1*s in the sparse parity check matrix *H*. The iterative decoding of the LDPC code is performed by passing messages between the neighboring VND and CND [1].

Irregular LDPC structures are those for which the degrees of each set of nodes are chosen according to some distribution. For a right regular also known as check-regular LDPC structure, it's all check nodes have the same degree. For irregular LDPC code structure, we can define a degree distribution ensemble (λ, ρ) from edge perspective way as

$$\lambda(x) = \sum_{i=d_v^{min}}^{d_v^{max}} \lambda_i x^{i-1} \qquad (1)$$

$$\rho(x) = \sum_{i=d_c^{min}}^{d_c^{max}} \rho_i x^{i-1} \qquad (2)$$

where d_v^{max} and d_v^{min} are the minimum and maximum variable node degrees respectively, d_c^{max} and d_c^{min} are the minimum and maximum check node degrees respectively and the fraction of edges which are connected to degree *i* variable nodes is denoted by λ_i and the fraction of edges which are connected to degree *i* check nodes, is denoted by ρ_i [1].

III. PUNCTURING PRELIMINARIES

An error correcting code can be considered to be the rate-adaptive codes when the information rate of the code is dynamically adapted to the communication channel requirement. We investigate the feature of rate-adaptability of the irregular LDPC codes by introducing the puncturing technique. Puncturing increases the rate of originally constructed code, (*C(n, k)*), by deleting a set of symbols from the codeword, where $p < n$. It then converts the code ensemble (*C(n, k)*) into a new code ensemble *C(n- p, k)*. The punctured coding rate R_p is then increased to

$$R_p = \frac{k}{n-p} \tag{3}$$

where (3) can be written in the context of puncturing fraction as

$$R_p = \frac{R_m}{1-p} \tag{4}$$

where p represent the puncturing fraction and can be calculated for a given code rate using (4). We can further defined it with new name "overall puncturing" [1].

Then the overall puncturing fraction P can be defined as

$$P = \frac{1}{\varrho}\sum_i p_i v_i \tag{5}$$

where ϱ is variable node population types in the irregular LDPC code structure. In order to find the optimum puncturing fractions, can be used an efficient puncturing algorithm [1].

IV. HYBRID RF/FSO CHANNEL

The puncturing technique was implemented in a hybrid channel (RF/FSO) [1]. System effectiveness were increased using a single pair of encoder and decoder. The goal was to decrease the computational complexity and cost of the communication system using single pair of encoder and decoder considering a slow varying channel with the additive white Gaussian noise (AWGN).

A. FSO Channel Model

The FSO link employs intensity modulation with direct detection using two level-pulse amplitude modulation (2-PAM) transmission schemes. The received signal (y) after the optical to electrical conversion is given by

$$y = \eta P x + z \tag{6}$$

where η is the photodetector efficiency which is assumed to be unity for simplicity, $x \in \{0, 1\}$ is the transmitted optical symbols after puncturing, P^2 is the optical received signal to noise ratio (y). Various noise models are possible including Poisson, signal dependent Gaussian and signal independent Gaussian noise [2].

B. RF Channel Model

There is consider a line of sight (LOS) RF channel which is modeled as a fading free AWGN channel. Let P be the transmit RF power on the RF link, then the received RF noisy signal y

$$y = \sqrt{P}x + z \tag{7}$$

where $x \in \{+1, -1\}$ is the transmitted RF symbols after puncturing using binary phase shift keying (BPSK), z is the AWGN with zero mean and unit variance [1].

C. Summary

In a hybrid FSO/RF communication system, we transmit data bits over two independent parallel channels. Previously researchers [6] have suggested a separate error-correcting code for each channel. Here, however, main goal is to design only one LDPC code. It is noted that the channel state information (CSI) is available at the transmitter so that the appropriate puncturing ratio can be selected. The ratio of the puncturing will be determined by the CSI. Puncturing will be suitable in order to incorporate different weather conditions. It will puncture the bits depending on weather condition and adapts the rate of transmission in a flexible fashion [1].

V. CONCLUSION

There is shown a novel puncturing optimization algorithm for rate adaptation and analyses its performance for the hybrid FSO/RF channel case. The propose algorithm well adapted the different weather scenarios by providing the best threshold and the corresponding puncturing patterns. It distributes the amount of channel bits in an efficient way under equal and unequal channel conditions in a flexible fashion. Verifying this algorithm is the subject of my next work.

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Hybrid system for malware detection

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***Abstract*—This article aims at malware analysis and possible options for its detection. Various methods for malware detection and antivirus software evolution are described along with their weaknesses. It is proven at work that modern malware cannot be detected by simple methods and usually it needs combination of various techniques. Next, some ways are described for bypassing malware detection by antivirus systems.**

***Keywords*—Behavioral analysis, Hybrid analysis, Malware, Virtualization.**

I. Introduction

Nowadays, almost every computer contains data which may be valuable to third parties. This is why malware may pose a serious risk. Usually, malware is aimed at generating profit (i.e.: credit card or account credentials theft), but the sole purpose of some malware may be damaging the data, or disabling some computer functionalities [1]. Detecting a malware before it can cause any harm is crucial, but not every malware can be easily detected. Modern antivirus software uses a various techniques in order to detect stealthy malware, but sometimes it needs to be manually reverse-engineered and patched, which may take some time. If an antivirus software could detect such malware, it can drastically lessen threat which the malware poses [2].

II. Malware and detection

A. The methods of malware concealment

Typical malware life cycle can be portrayed as follows [3]:

- The malware is created and published.
- Some computers are infected with unknown malware, which is then sent for an analysis.
- The malware is analyzed and a new signature is added to the antivirus database.
- Every computer protected with such antivirus can deal with the malware.

This way the malware cannot infect lots of computers, when it gets quickly detected and removed. The malware creators began fighting back with more sophisticated methods for avoiding detection. Most effective or used methods are [4]:

- Encryption
- Polymorphism
- Obfuscation
- Metamorphism

Most used method is an encryption, which is relatively easy to detect via behavioral analysis. Polymorphism is a more complex method which uses encryption. Another way to avoid detection is obfuscation which makes the code visually harmless while preserving original code functionality. Most sophisticated method is metamorphism, which uses obfuscation methods to avoid detection and also rebuilds with every iteration, so every copy of the malware is different, while it still perform the same functions [5], [6].

B. Malware detection

There are various methods aimed at malware detection. While simple methods consist of looking for string, which is like a malware signature, more complex methods utilize machine learning, reverse-engineering and virtualization. Modern antivirus software combine a variety of methods to maintain good detection rates. The detection mechanisms can be divided into four categories:

- First generation scanners [7]
- Second generation scanners [8]
- Algorithmic scanning methods [9]
- Code emulation [10]

Comparison of the methods by various aspects can be seen on the table I.

			Promise of perfect disinfection	Scanning speed-up	Generic virus detection	Detection of new or unknown viruses	Encrypted/polymorphic viruses	Metamorphic viruses	Macro viruses	Odds of false positive	Odds for false negative
First generation scanners	Simple string scanning		Yes	No	No	No	No	No	No	Low	Low
	Optimization methods	Wildcards	Yes	No	Yes	No	No	No	No	Low	Low
		Mismatches	Yes	No	Yes	No	No	No	No	Low	Low
		Gneric detection	Yes	No	Yes	No	No	No	No	Low	Low
	Bookmarks		Yes	No	No	No	No	No	No	Very low	Low
	Speed-up methods	Hashing	Yes	Yes	No	No	No	No	No	Low	Low
		Top and tail scanning	Yes	Yes	No	No	No	No	No	Low	High
		Entry/fixed point	Yes	Yes	No	No	No	No	No	Low	Low
Second generation scanners	Smart scanning		Yes	Yes	Yes	No	No	Yes	Yes	Low	Low
	Skeleton detection		Yes	No	No	No	No	No	Yes	Low	Low
	Nearly exact identification		Yes	No	No	No	No	No	No	Very low	Very low
	Exact identification		Yes	No	Yes	No	No	No	No	Null	Null
	Heuristic analysis		No	No	Yes	Yes	No	Yes	Yes	Very high	Low
Algorithmic scanning methods	Generally		Yes	No	Yes	No	Yes	Yes	Yes	Low	Low
	Optimization methods	Filltering	Yes	Yes	No	No	No	No	No	Low	Low
		Static decryptor detection	No	No	No	No	Yes	No	No	Very high	Very high
		X-ray scanning	Yes	No	No	No	Yes	No	No	Low	Low
Code emulation	Generic detection		Yes	No	No	No	Yes	No	No	Low	Low
	Dynamic decryptor detection		No	Yes	No	No	Yes	No	No	Low	Low

TABLE I: Comparison of AV detection methods

III. Methods for avoiding AV detection

The main role of AV systems is to detect malware. With the evolution of AV systems also malware began to evolve and to incorporate mechanisms to avoid detection. With more sophisticated static detection mechanisms, virus developers realized that a perfect way to mitigate the detection rate is to alter the code so it is almost impossible to make identification strings from it [11]. Some methods still provided a chance to

extract the identification strings from virus code, but it was getting more and more difficult.

Security specialists then started working with virtual sandboxes in order to analyze the behavior of a malware, which will remove the need for strings detection. It became a very powerful tool, but it still has some weaknesses resulting from the virtualization usage [12]. AV sandboxes also incorporate an incomplete OS versions in order to save resources needed for the test, so it is often exploited by malware to distinguish the testing environment from regular virtual machine, which can contain valuable data (some servers run on virtual machines) [13], [14].

Since this work is aimed at hybrid analysis, a practical experiment was established to prove this information. The experiment should prove the vulnerability of AV systems and it is based on avoiding static and dynamic detection. VirusTotal was used as a testing environment, because it incorporates most commonly used AV systems. As a payload, Meterpreter part from the framework was used, because it is a code recognized as a malware [15]. Methods used for testing can be divided into following categories:

- Exceeding AV limits
  - Allocate 100MB of memory
  - 100 millions of increments
- Detection of uncommon behavior
  - Trying to open system process
  - Open non-existent URL
- Using the information known about the target
  - Use the name of a local user
- Using the "unnecessary" parts of a system
  - Trying to use NUMA library
- Method for environment detection
  - Checking the process memory
  - Checking the file name

Some methods were FUD (Fully UnDetectable), while other methods were detected by some AV systems with heuristic detection, which was almost always false positive (detected different payload, which was non-existent in the code). Only few AV systems were able to detect the right payload when using some of the methods. The detection rates of various methods can be seen on the table II. This can prove that there are still fairly simple methods, which can be used to avoid AV detection. These methods are known, but they abuse the AV limits, so they cannot be easily patched.

Method	Detection rate
Allocate 100MB of memory	0/55
100 millions of increments	0/55
Trying to open system process	11/55
Open non-existent URL	2/55
Use the name of a local user	0/55
Trying to use NUMA library	0/55
Checking the process memory	1/55
Checking the file name	0/55

TABLE II: Detection rates of various AV avoiding methods

IV. Conclusion

There are numerous of ways for evading antivirus detection. Most of them include encryption or obfuscation in order to avoid detection based on the string identification. Some of them also try to avoid behavioral analysis by exploiting weaknesses based on the virtualization. Some methods were shown as examples to prove the fact that it is possible to conceal malware in the OS. While these methods do work, widespread malware can be patched manually to avoid additional spreading or damages. However this takes time, because the malicious code needs to be dissected and reverse-engineered. Consequently, future work will be aimed at these shortcomings, to provide better detection rates, even for less spread malware. In general, future work will include:

- Automatic quarantine for new files in OS.
- Virtualization analysis and customization in order to lessen its drawbacks.
- Malware concealment mechanisms analysis.
- Proposing an improved solution for better detection rates.
- Testing new solution and comparison of detection rates with popular approaches.

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Identification of appliances in smart homes based on their information profiles

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***Abstract*—By now, there is perhaps no area of human activity, which does not use information systems and their fragments. A good example are the households that are equipped with a variety of electronic devices with elements of intelligence, for example different sensors for gathering valuable information. This intelligence is being used in televisions, tablets, phones and the latest trend is to introduce intelligence into household appliances such as washing machines, dryers, dishwashers, refrigerators and the like. Also, every building with already established power connection is equipped with an electro meter which is capable of measuring how much power each household is consuming. Smart metering is bringing intelligence and efficiency into power measuring, providing better flexibility and additional services including energy savings, intelligence across the connected appliances and load forecasting for power distributors. The goal of this paper is to highlight the concept of smart metering and the approach we took in order to develop a smart meter for the purpose of providing services such as prediction of anomalies and mainly identification of appliances in based upon collected energy profiles of known household devices.**

***Keywords*—Disaggregation methods, information profiles, smart homes, smart metering.**

I. INTRODUCTION

One of the modern ways in which we can increase comfort and safety in our households is the use of an intelligent system. These systems not only allow the control of electronic devices and appliances in our homes but it can also provide valuable information about the status of various electronic devices which may have an important value for consumers. This may include information that the operation of an appliance just finished or another option is to obtain the status of the household like open garage doors or windows [1].

Home automation systems can also be used for the actual learning process of mapping the standard situations in the homes, including the behavior of ordinary people in everyday situations and subsequent evaluation of non-standard situations, like those conditions which are different from ordinary situations and that may mean that something happened which requires an emergency procedure.

Using sensors, that can monitor a situation , for example electricity appliances in your home, you can evaluate the energy consumed, how often the appliance is used, or what costs are associated with a particular appliance over time. For simple and inexpensive solution to monitoring activities a smart meter can be used. Smart metering is spreading quickly. The drivers for smart meter implementation are multiple. Its advantage is the reliability of data reading, accuracy and the ability to communicate via the built-in interface [2]. Many distribution system operators in western countries have installed, are installing or are planning to install smart meters.

Smart meters are essential components in smart micro-grids and smart grids [3]. Together they form a complex system which has become today an attractive area of research world-wide in view of enormous benefits of reliability and safety of power supply economically.

Several studies in smart meter applications have shown that in residential buildings, energy consumption can be reduced with better management. For this, a non-intrusive appliance load monitoring (NIALM) technique has been advocated which enables appliance identification to help better energy management [4].

II. SMART METERING

Since the inception of electricity deregulation and market-driven pricing throughout the world, utilities have been looking for a means to match consumption with generation. Traditional electrical and gas meters only measure total consumption, and so provide no information of when the energy was consumed at each metered site. Smart meters provide a way of measuring this site-specific information, allowing utility companies to introduce different prices for consumption based on the time of day and the season [5].

Smart meters enable two-way communication between the meter and the central system. Unlike home energy monitors, smart meters can gather data for remote reporting. Without knowing the essential parts of smart metering it is hard to understand what it is.

A. Smart Grid

An advanced energy network to which a two-way digital communication between the supplier and consumers was added along with smart metering, control systems and monitoring is called a smart grid. Electronic power conditioning and control of the production and distribution of electricity are important aspects of the smart grid.

Roll-out of smart grid technology also implies a fundamental re-engineering of the electricity services industry, although typical usage of the term is focused on the technical infrastructure [6]. The amount of data required to perform monitoring and switching one's off automatically is

very small compared with that already reaching even remote homes to support voice, security, Internet and TV services.

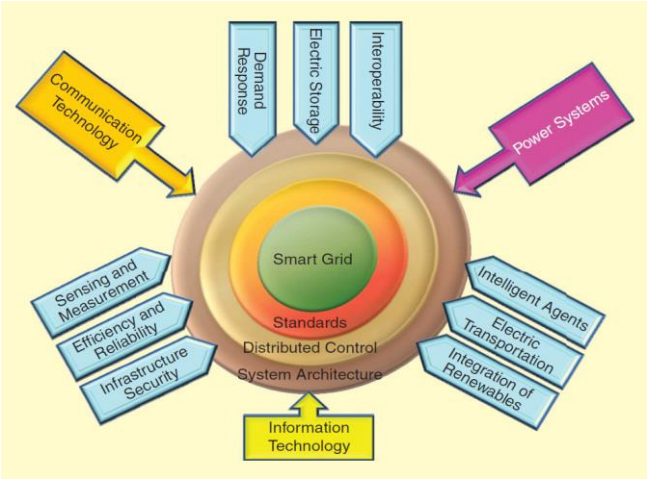

Fig.1 shows basic smart grid ingredients [5]

B. Smart Meter

A smart meter is an electronic device that records consumption of electric energy in intervals of an hour or less and communicates that information at least daily back to the utility for monitoring and billing.

Smart meters usually measure energy usage in increments of minutes, such as five minute intervals, 15 minute intervals or as mentioned hourly intervals [8]. Interval usage refers to the amount of energy measured by advanced meters for the specified interval. The term smart meter often refers to an electricity meter, but it also may mean a device measuring natural gas or water consumption.

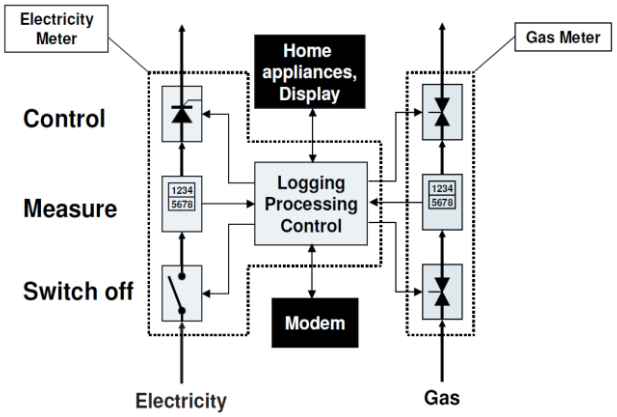

Fig. 2 Schematic overview of a typical smart meter configuration [9]

Smart metering is often referred to as automated meter reading (AMR), or in the case of real-time, two-way communications, as advanced metering infrastructure (AMI).

The concept of intelligent measurement system (IMS) is similar to advanced metering infrastructure. This device can measure current component of all commonly used energy and active power P, reactive power Q, distortion power D and asymmetry N [10]. The IMS is also able to send the recorded energy consumption data to a remote location.

IMS usually include real time or near real time measurement of several components of the electricity, monitoring the quality of notification during measurements etc. They become less expensive alternative to traditional electricity meters.

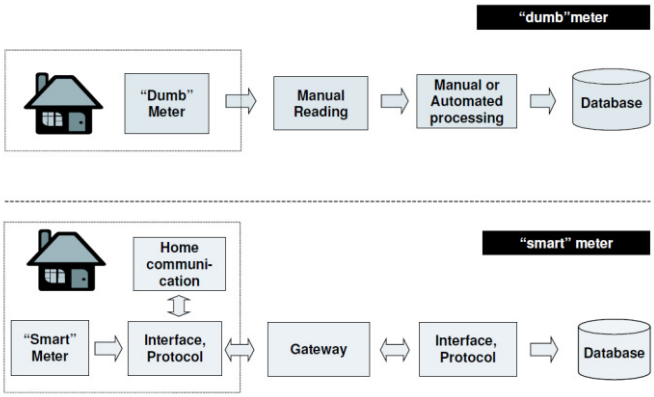

Fig. 3 Difference between the conventional and the smart meter data process [9]

There is a growing trend toward the use of TCP/IP technology as a common communication platform for smart meter applications, so that utilities can deploy multiple communication systems, while using IP technology as a common management platform.

A universal metering interface would allow for development and mass production of smart meters and smart grid devices prior to the communication standards being set, and then for the relevant communication modules to be easily added or switched when they are. This would lower the risk of investing in the wrong standard as well as permit single product to be used globally even if regional communication standards vary.

Some groups have expressed concerns regarding the cost, health, fire risk, security and privacy effects of smart meters and the remote controllable kill switch that is included with most of them [11].

Smart meters expose the power supply to cyber attacks that could lead to power outages. However many cyber security experts state that smart meters of UK and Germany have a relatively high cybersecurity and that any such attack there would thus require extraordinarily high efforts or financial resources.

Implementing security protocols that will protect these devices from malicious attacks and new exploits has been a problematic task due to their limited computational resources and long operational life spans.

III. APPLIANCE POWER MEASUREMENT

Through smart metering it is possible to measure the progress of the electrical appliances performance. Waveforms of current are different depending on the appliance. It can be said that each appliance is unique in its own way. Depending on the type of appliance and its load characteristics the course is always different when compared to other appliances.

It is possible to obtain a variety of information about the appliances. In particular, it is when they are turned on or when they are turned off. There is the challenge to build profile for each appliance and then evaluate whether the consumption of the appliance is not expensive to operate compared to a similar appliance.

Alert-notification systems for mobile devices are a potential, so for example washing machines, driers, dishwashers or any other equipment activity might be directly displayed at the user

interface of the smart phones or the TV screens [12]. Another useful benefit of this idea is to reduce household consumption – notice the abnormally long time that the light is turned on. Last but not least it is the added safety and convenience.

Fig. 4 An actual model of a smart meter [15]

IV. NONINTRUSIVE APPLIANCE LOAD MONITORING

Significant saving in energy consumption can be achieved by better energy management and control in residential building [13]. More advanced control approaches require real-time information on the appliances in use. A straightforward method to obtain this information uses a power sensor attached to each household appliance of interest. Unfortunately, this method is costly and requires significant installation and maintenance efforts.

A more sophisticated way to obtain appliance-specific data is by disaggregation of total power consumption data acquired at the main breaker level [14]. Such nonintrusive appliance load monitoring (NIALM) uses a single point of power measurement (e.g., of the electric feed for the whole house), combined with special signal processing techniques.

NIALM was developed at MIT in the 1980s. The MIT group suggested four categories of appliances [16].

- Permanent consumer devices,
- On-off appliances,
- Finite state machines,
- Continuously variable consumer devices.

Permanent consumer devices are devices that remain on for 24 hours a day, 7 days a week, with approximately constant active and reactive power draw. Examples of devices in this category include hard-wired smoke alarms and some external power supplies.

On-off appliances include most household appliances, such as a toaster, light bulb, or a water pump.

The third category includes consumer devices which pass through several definite switching states, whereby the complete switching cycle is repeated frequently in the daily or weakly cycles of events. Examples of finite state machines are a washing machine or a clothes dryer.

Continuously variable consumer devices are consumer devices with variable power draw, without any periodic pattern of changing the states of power. Examples of such appliances are dimmer lights and power tools.

Of these categories only on-off appliances and finite state machines could be detected and monitored using the changes of real/reactive power as the features [17].

A. MIT NIALM Algorithm

The established version of the MIT method [18] includes five steps.

First, an edge detector identifies changes in the steady-state power draw levels.

Second, a cluster analysis algorithm locates these changes in a two-dimensional signature space of real and reactive power. The signature space reduces the potentially complicated load transient data to a two-dimensional space of changes in power consumption with a simple graphical interpretation.

Third, positive and negative clusters of similar magnitude are paired or matched.

In the fourth step, known as anomaly resolution, unmatched clusters and events are paired or associated with existing or new clusters according to a best likelihood algorithm.

In the fifth and final step, pairs of clusters are associated with known load power consumption levels to determine the operating schedule of individual loads.

These steps uses information gathered either during a training procedure (which is actually an intrusive, though one-time procedure) or using historical data.

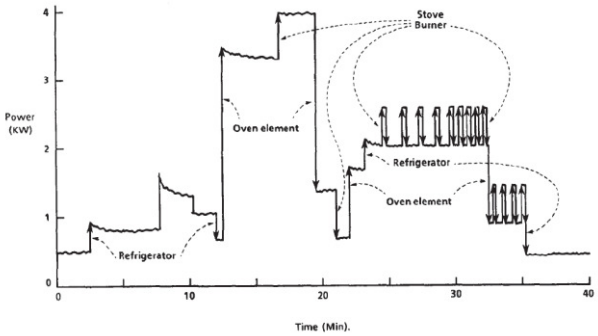

Fig. 4 Power vs. time plot shows step changes due to individual appliance events [18].

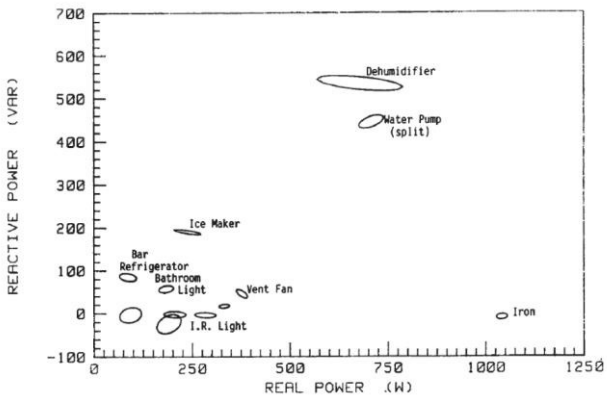

Fig. 5 Complex power space and appliance clusters [18].

Advantages of NIALM [19]:

- It easily distinguishes two-state devices,
- The accuracy of disaggregation is estimated at 80%.

Disadvantages of NIALM [19]:

- Not compatible with multi-state devices,
- Various devices with similar consumption may not be identified as different,
- The algorithm based on this method assumes a constant output in on and off states.

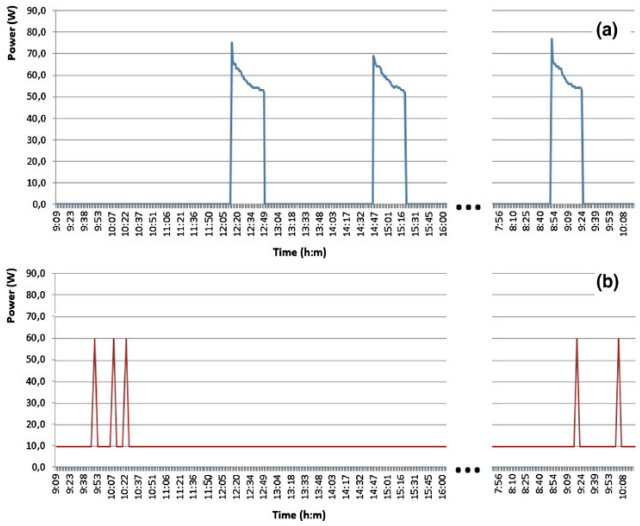

Fig. 6 Fridge and the LCD monitor consumption pattern repeated over 24 hours [20].

V. Conclusion

The main goal of this paper was to present the current state of smart metering problems, their future potential and actual conditions. In the near future it is expected that there will be large-scale expansion of services for households in this area. We believe that such services will be linked with smart solutions and will provide greater convenience to customers.

Prediction of abnormal behavior should be an integral part of every intelligent building. This would improve the safety of users in conjunction to injury prevention, especially for the older generation of people. Another important area is automated discovery of appliances in the smart home.

The conclusion of this paper is that no complete NIALM solution suitable for all types of household appliances is available. The available solutions are either unsuitable for some appliances or at still an early developmental stage.

Another important point is that no complete set of robust, widely accepted appliance features has been identified. The available features do not provide for unambiguous appliance detection and classification.

Acknowledgment

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Importance of MPPT control algorithm for photovoltaic purposes

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***Abstract*—Paper provides briefly description of how more efficiently the energy from photovoltaic panels can be obtained. The paper also briefly describes the basic parts of the photovoltaic system and give importance to a control algorithm, because the control algorithm ensure obtaining a maximum power from the photovoltaic panel.**

***Keywords*—DC-DC converter, maximum power point tracking, MPPT algorithm, photovoltaic panel**

I. INTRODUCTION

With increasing number of electrical appliances a large need for electricity is required. However the most part the electricity is still produced with the help of fossil fuels, which are firstly harmful to the nature, and secondly, these materials are not renewable. Thus, it is necessary to modify the methodology for obtaining electricity from renewable sources. As it is possible to look in the world, renewable energy source is becoming more and more popular in use. Renewable energy sources are producing electricity without creating pollution. Among clean power generators also called renewable energy sources include, for example energy obtained with aid of water, wind or sun. Even some countries around the world depend solely on renewable energy sources. Water and wind power for the average user are less available than generators producing electricity with the aid of sunlight, also called photovoltaic panels (PV). The PV panels in recent years undergone various developments that have given to the improvement of efficiency in generating electricity.

The overall process of obtaining energy from photovoltaic panels is composed of several parts as can be seen in figure Fig. 1.

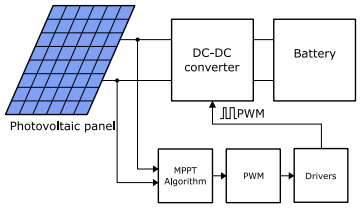

Fig. 1. Block diagram of obtaining energy from photovoltaic panel

The first part is the PV panel itself. The second part is formed by using a DC/DC converter. Further, the converter can be connected to the battery and to the inverter. The battery is then used to store excess energy from PV panel. The third, and no less significant part is the control algorithm which controls DC/DC converter to ensure of obtaining required amount of energy. From presented parts it is likely that the overall efficiency of energy transfer is determined by the three elements. The PV panel efficiency is given by the manufacturer, so it could not be influenced. The only things that can be influenced are the DC/DC and the control algorithm efficiency. The article is mostly devoted to improving the effectiveness of the control algorithm. While there is no less substantial DC/DC converters. Therefore, they are briefly described in the following chapter.

II. DC-DC CONVERTERS

DC/DC converters as the name implies are changing DC voltage from one DC voltage level to another DC voltage level. In general, there are three basic converters, namely: step down, step-up, step-down-step-up. The step down converter provides voltage level lower as the voltage level on its input. The step-up converter has the opposite effect. In case of step-down-step-up converters occurring situations that the converter provides an output voltage higher or lower which it is depending on the duty cycle. In practice, the step-down converters are most commonly used for photovoltaic purposes, see figure Fig. 2. Because, the most commonly used battery voltages are 12V or 24V wherein the voltage of the photovoltaic panels can move several times higher.

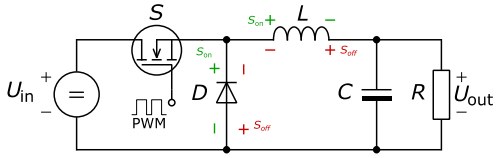

Fig. 2. Buck converter

Eye-catching novelty is that it came to be used so-called multiphase converters. This solution has several advantages. Among these advantages are smaller inductors, because the current is equally divided among phases. In case of interleaved mode the output current and voltage ripple are n times lower, where n is a number of used phases. Another advantage is that it is not necessary to use components that can handle higher current, because of current sharing. The goal of this paper is not to inform readers about the principles of operation of DC/DC converters, therefore in case of interests, references [1] and [2] provides further information. The DC/DC converter without control is practically useless. On the other hand the control without regulation which in case of photovoltaic purposes ensure obtaining maximum power is also useless. Before passing to the control algorithm, it is necessary to mention a few things about PV panels.

III. Photovoltaic Panels

The PV panel has a non-linear current-voltage characteristic see figure Fig. 3. The parameters placed on the PV panels are Open circuit voltage, short circuit current and maximum power point (MPP). The open circuit voltage is the voltage without load (open terminals). The short current indicates the current with shorted terminals. The MPP as can be seen in the figure Fig. 3 is at a certain load when the PV panel current multiplied by voltage are highest. For example the MPP at 10A and 100V. In that case a 10 ohm resistor is needed for obtaining the maximum power from the PV panel. As it is known the MPP is not static but dynamic. Therefore, it is ineffective to use series-connected batteries with a static resistance. Instead the DC/DC converters are used.

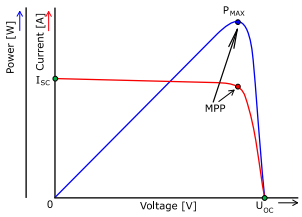

Fig. 3. Maximum power point of Photovoltaic panel

According to the equivalent circuit of the photovoltaic panel, can be assumed that the quality of the photovoltaic panel can be determined from Rsh and Rs resistors. In ideal case the value of resistance Rsh is infinite and value of resistance Rs is zero. Because the ideal case is not possible the volt-amps characteristic of photovoltaic panel is determined by resistors Rs and Rs as can be seen in figure Fig 5.

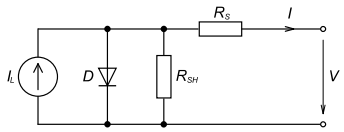

Fig. 4. Equivalent circuit of the photovoltaic panel

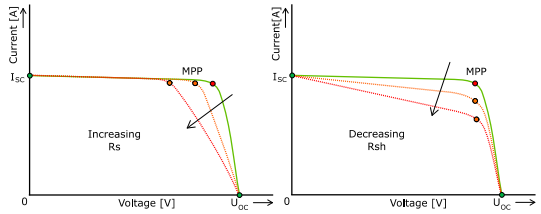

Fig. 5. Influence of Rsh and Rs parameters on MPP

The reference [3] provides further information about PV panels. So if it is already briefly known what the PV panels and DC/DC converters are it is possible to move to next chapter, which is dedicated to the proposed control algorithm.

IV. Proposed Control Algorithm

As it was mentioned in previous chapters the control algorithm for PV purposes is as important as DC/DC converter. Also the control algorithm change is much cheaper than electrical component change in the DC/DC converter. But before the proposed algorithm will be described the basic method of achieving the MPP needs to be known.

For example algorithm so-called Hill Climbing use follow method. First of all, current and voltage from PV panel are measured for a given duty cycle. From measured values of current and voltage the power is calculated and compared with previous one. In case of difference of actual power with previous one the control system does change of duty cycle. That it is mean, that the control algorithm provide duty cycle change to both directions and finds out, which direction is pointed to MPP. After achieving MPP the duty cycle is constantly changing around MPP to ensuring MPP position. This method is sufficient and easy to calculate. The problem occurs when the sun irradiance is changing fast. This change can occur in the event of coming clouds. In this case the Hill Climbing method is not sufficient enough, because the sun irradiance is changing faster than the method can handle. This happen because the small step of duty cycle is provided. But increasing value of step resolution will decrease accuracy. Due of that the proposed improved algorithm was created. The reference [4] showing different process of obtaining MPP.

The principle is to store the voltage and current values for a certain duty cycle. The proposed algorithm detects the load characteristics of photovoltaic panel for each specific situations. In time where the same situation occur (weather condition) the control algorithm change duty cycle to value which represents the MPP. For example if the proposed control algorithm does not have any saved data (current and voltage for specific duty cycle) it starts changing duty cycle from small value to larger towards to MPP. But in this case the control algorithm during the processes of MPP tracking the voltage and current for each duty cycle value change from photovoltaic panel will be stored into a memory card. This helps finding the MPP much quicker than without saved data. It is because the control algorithm for similar weather conditions already know where the MPP is. Because of that a right value for duty cycle can be set now. Same process is done for different weather conditions. Now this control algorithm can be applied in areas where the sunlight irradiance often change. Only requirement for this control algorithm is choosing right microprocessor.

V. Conclusion

Currently exist many control algorithms that can be used for obtaining maximum energy from PV panel. Each method can achieve or can be close to maximum power. The question is, how fast they can achieve the maximum power. Because the faster maximum power is obtained the more average power is achieved. Therefore improving the control algorithm is also important.

Acknowledgment

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Influence of Load Time Management on Sizing and Cost of the Hybrid System

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***Abstract*— This paper describes modelling, simulation and sizing of hybrid renewable system for pumping of soaking water from closed mine Bankov in Košice and different electrical power load time management strategies for using electricity. There will be analysed three different time management strategies of electrical load and how they affects to cost and sizing of hybrid renewable systems. Hybrid renewable systems are suitable in remote area where grid connection is unavailable or connection to grid is expensive but it can be also used at places where connection to the grid is.**

***Keywords*—hybrid system, simulation, modeling, load.**

I. INTRODUCTION

Hybrid renewables sources systems has been proposed by many different researchers as sufficient source of electricity distant sites where there are difficulties with connection to electrical grid. Demand for electricity in distant sites is covered with hybrid renewable sources by using available potential renewable sources on site where is realized system. This hybrid systems using more types of renewable energy sources like sun powered solar photovoltaic plants, wind turbines using wind energy, micro hydroelectric power sources etc. advantage of this sources is direct generation of electricity at the site. Hybrid renewable sources systems have the potential to combine advantages such as energy capability and energy management, results from the chosen mix of renewable energy sources. By using different renewable sources of energy is minimized requirements for storage of electricity and raises predictability of electric power delivery and quality of electricity, which is also important factor nowadays. For grid-off using, these structures are usually combined with repository devices to obtain the continuous supply from renewable energy sources like solar and wind. Controlling systems are the most important parts of hybrid renewable sources systems that maintains the information and communication between many devices from which system consist. Control system manages the output of renewable energy sources and also, produces the signs for planning of storing parts of system and using surpluses in energy generation. Such system helps to secure the storage system from overcharging and it help to operate the storage system in rated limits [1], [2], [3], [4], [5], [6].

Not all of distant areas have adequate renewable energy sources available, in this cases it is needed to adding some conventional choice as diesel/petrol/gasoline fuel generator with renewable energy sources to cover whole electrical supply [7], [8].

II. POWER MANAGEMENT STRATEGY

A. Modelling of hybrid system and simulation data

A hybrid renewable energy sources grid-off system is usually composed from a renewable sources as wind and photovoltaic connected with battery or other repository devices but in grid-off systems where is need to cover whole consumption of consumption of load can be used some conventional sources like diesel generator and so on.

Fig. 1. illustrates a small-scale hybrid configuration that will be used as the basis of the feasibility study simulations. System consist from sources like photovoltaic field, wind turbines, batteries and dc-ac converter.

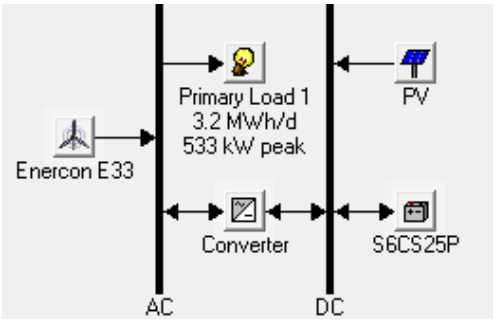

Fig. 1. Implementation of hybrid system

B. Solar irradiance data and wind data for Košice

Fig. 2. and Fig. 3. Shows solar irradiance and wind data for Košice.

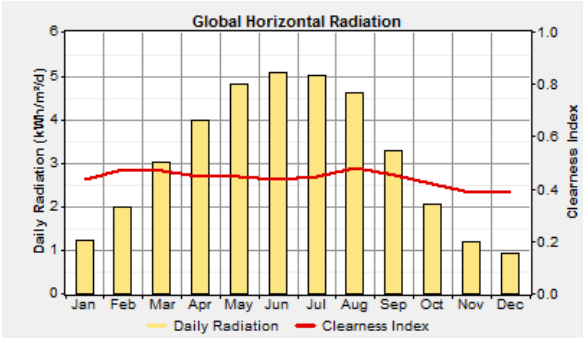

Fig. 2 Solar radiation data and clearness index for mine site in Košice from HOMER

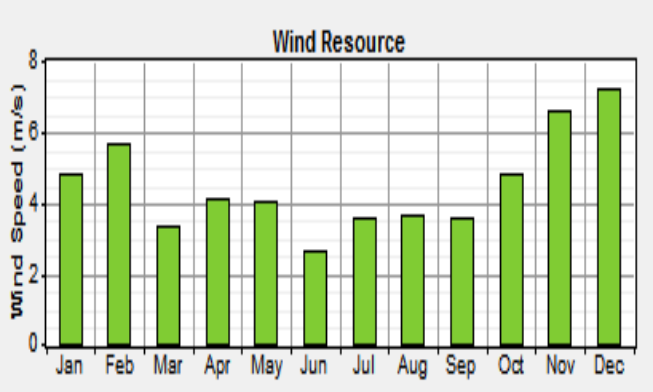

Fig. 3. Wind speed profile for site in Košice from HOMER

C. Electrical load scenarios

Modelled daily energy consumption times for mine pumping load could be seen on Fig. 4, Fig. 5 and Fig. 6. There is need to pumping soaking water from this mine to prevent damage and eliminate risk of rupture land somewhere deeply in main which can cause flood in city under the mine. For pumping are used two hydro pumps the first with power 300 kW and second with power 233 kW which pump 6 hour a day. There will be compared three different pumping time scenarios and their affect on hybrid system sizes and cost of such hybrid system.

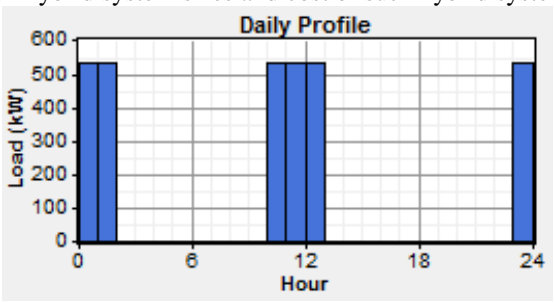

Fig. 4. First proposed daily pumping time scenario.

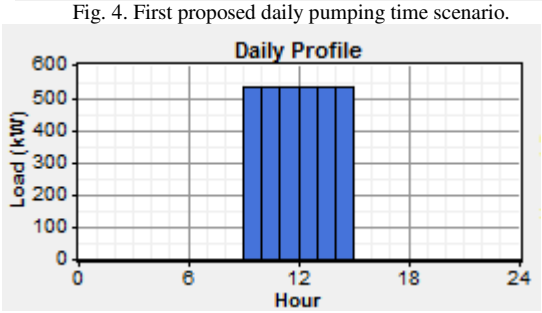

Fig. 5. Second proposed daily pumping time scenario.

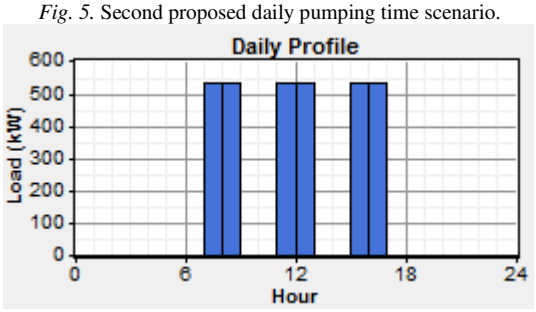

Fig. 6 Third proposed daily pumping time scenario.

III. Simulation Results

When system modelling is finished and each of componets were set properly simulation of hybrid system is able to execute. HOMER software model for optimization was used to simulate the hybrid renewable sources system. Sofware calculate many options which were set to search space and choose best option for size of all components. Large number of choices are considered and calculated for multiple component sizes used an the best choice is chosen for hybrid renewable grid-off system which optimally cover the load of hybrid system. This system is optimised by HOMER's algorithms and the best possibilities are evaluated as choice for the best configuration of hybrid renewable system configuration.
Results of simulated scenarios can be seen in Table 1. There was simulated three difffent load scenarios with different times of load and results are represented as table.

Table 1 Results of simulations with final sizes and costs of hybrid renewable systems

Scenario	PV Power (kW)	Quantity of wind turbines (pcs)	Converter (kW)	Quantity of batteries (pcs)	Cost of system ($)
1.	450	9	600	860	2 684 969
2.	525	7	550	650	2 343 978
3.	375	10	550	700	2 422 737

IV. Conclusion

As it can be seen in Table 1 as the most economic choice for such hybrid system is scenario with load 2 where consumption is mainly in times from 9 a. m. to 3 p.m. These times are also times with the biggest production of electricity from photovoltaic part of the hybrid system so the savings are mostly on batteries in hybrid system. With the right load time management is possible to have significant savings in initial capital of such hybrid renewable systems. This is the main aim to apply such load time management in consuption of electicity in hybrid renewable systems.

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Influence of Nonlinear Optical Phenomena in All-Optical Fiber Communication Systems

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***Abstract*—In these age is continual development a part of all sectors. Field of optical communication systems is not exception. At the beginning were copper wire and coaxial cables but number of limitations were bigger than benefits. Nowadays, we are working with optical transmission systems. Those systems offers many advantages, such as number of transmission path, lower electrical power, large bandwidth and many others. The growing demands result in compression of transmission channels, transmission speed, etc. It brings new challenges e.g. Four wave mixing, Self phase modulation, Cross phase modulation, Stimulated Brillouin Scattering (SBS), Stimulated Raman Scattering (SRS). Mentioned undesirable effects are suppressed in different ways. This article is focused on comparison 10 Gbps DWDM transmission system which is using in commercially systems and 40 Gbps CWDM transmission systems. Those systems are affected by above mentioned phenomena.**

***Keywords*—CWDM, DWDM, Optical fiber, Transmission system.**

I. Introduction

At present, for the transmission is used a number of techniques. Recently they were used channels with time division but it was under pressure from increasing demands unsustainable. Current solutions are coarse wavelength division multiplexing (CWDM) and dense wavelength division multiplexing (DWDM). Depending on the requirements on the transmission system is selected either CWDM or DWDM. Each option contains advantages and disadvantages [1].

Combating of undesirable influence has a number of solutions. Among others is very important the proper selection of encryption of source data. The following studies will be given to experiments with combining different modulation and coding techniques.

II. Tasks were already solved

In the previous time, all efforts was focused to obtain a sufficient amount of study materials in contemporary issues and understanding the basic operation of the technology. Developments in optical networks is continuous and retain the current overview is therefore very important. The basic objectives were to study the theory of nonlinear phenomena incipient in optical fiber systems. The next item was understanding and studying of basic types of optical add/drop multiplexers (OADM). Last but not least, standards of Coarse WDM (CWDM) and Dense WDM (DWDM) systems were studied [2], [3], [4].

The sources for the study were not only books in the field, but also articles published in international conferences and proceedings. Unsubstitutable role played the documents of optical components' manufacturers and vendors.

Technology that brought a breakthrough in the transmission of more information is wavelength division multiplex (WDM) and its associated various modifications. Currently the focus is on DWDM. This standard ITU has wide application and it will be suffice for the long time because currently used optical lasers, modulators, demodulators and other parts of the transmission system do not reach their maximal capacity. DWDM systems offer in comparison to CWDM number of advantages that allow transfer more information with the same bandwidth.

III. Knowledge and Results Obtained During a Previous Year

Last year was devoted to obtain a sufficient amount of materials from commercially area and modeling our transmission system. Development in optical networks is continuous and retain the current overview is therefore very important. The basic objectives were to design own optical path and observe nonlinear phenomena in optical fiber systems. The next item was implementing of basic types of OADM, which are already an integral part of the optical WDM transmission systems. In dissertation thesis will be summarized results from experiments with different wavelengths, number of channels, modulation formats and coding input data.

IV. Experimental block scheme to verify properties of WDM system for 10 Gbps and 40 Gbps with different fiber length

The main goal of the optical communication system was to achieve multi-channel transmission of the size of the metropolitan network. Length of optical fiber is 150 km. As multiplexing technology has been selected WDM technology, with the possibility of using the ITU-T G.694.2 (CWDM) or ITU-T G.694.1 (DWDM).

Fig.1 shows the optical communication system. There is 16 channels system, it means 16 transmitters and 16 receivers. To verify the characteristics of the communication system were used transmission speed of 10 Gbps (100GHz channel spacing) and 40 Gbps (200GHz channel spacing), which meets the standard DWDM and CWDM. Transmission speed is overall range from 160 Gbps over 640 Gbps. Experiments were conducted for fiber lengths from 50 km to 150 km.

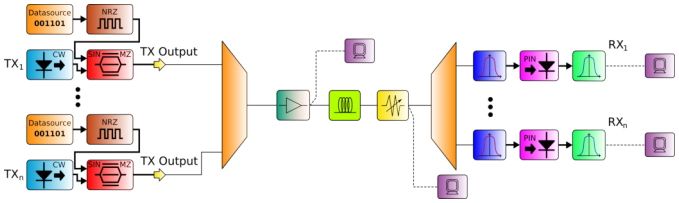

Fig. 1. Scheme of optical communication system.

A. Properties of 40 Gbps transmission system with 200 GHz channel spacing on different length optical fiber

The spacing between channels was set to 200 GHz because smaller spacing results in garbled signal. Channel spacing 100 GHz suffered FWM phenomena and many channels have not reached the threshold of 10^{-12} already at 75 km.

The transmission path starts at 192.4 THz and the last channel is 195.4 THz. The Fig. 2 shows the interdependence of BER and fiber length. On monitor length (150 km) have satisfactory results only channels 4 and 8. The threshold was set at the level of 10^{-12} because of the signals which are below this level are already very noisy and at the end of transmission path is very difficult to detect them. The measurement was taken at a distance of 200 km too but for us is relevant measurement within 150 km and the behavior of the signal in the observed area.

TABLE I
VALUES OF TRANSMISSION FREQUENCIES AND WAVELENGTHS FOR 40 GBPS

Channel	Frequency [THz]	Wavelength [nm]
1	192.4	1558.1729
4	193.0	1553.3288
8	193.8	1546.9167
12	194.6	1541.6238
16	195.4	1535.3122

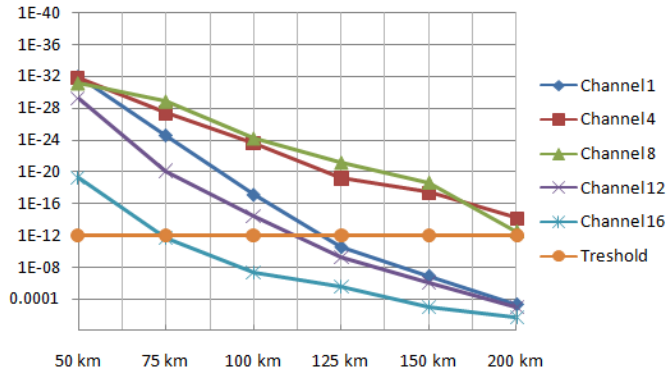

Fig. 2. The interdependence of BER and fiber length for 40 Gbps transmission.

B. Properties of 10 Gbps transmission system with 100 GHz channel spacing on different length optical fiber

The experimental scheme is the similar as in the case of 40 Gbps system (Fig.1). Channel spacing is set to 100 GHz. The first transmission frequency is 192.4 THz and the last 193.9 THz. Fig.3 shows the interdependence of BER and fiber length.

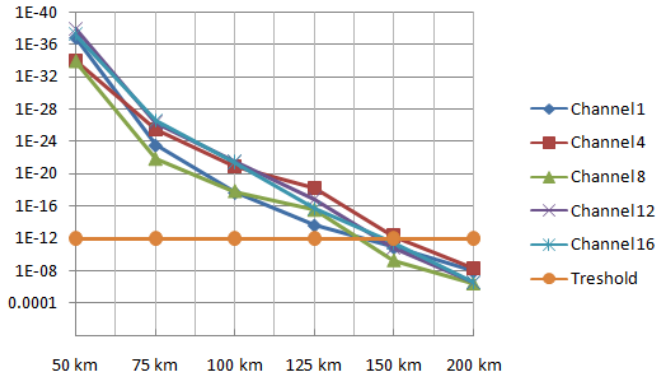

Fig. 3. The interdependence of BER and fiber length for 10 Gbps transmission.

System with 10 Gbps transmission speed and 100 GHz channel spacing offers slightly better value BER compared to 40 Gbps. Although, the current system is transmitted less data than 40 Gbps but there is still scope for using smaller channel spacing.

TABLE II
VALUES OF TRANSMISSION FREQUENCIES AND WAVELENGTHS FOR 10 GBPS

Channel	Frequency [THz]	Wavelength [nm]
1	192.4	1558.1729
4	192.7	1555.7471
8	193.1	1552.5244
12	193.5	1549.3150
16	193.9	1546.1189

V. CONCLUSION

Opportunities for the development of optical networks have not yet reached their maximum. A better transmission characteristics can be obtained using a suitable source of coding modulation signal as well. The proposed methods have been compared with those obtained from a commercial environment. All the results obtained from experimental measurements will be described in greater detail in the dissertation.

ACKNOWLEDGMENT

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Influence of nonlinear phenomena in CWDM system using EDFA

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***Abstract*—This article describes a standard of CWDM (Coarse Wavelength Division Multiplex) according to ITU-T G 694.2. The software from Rsoft company was used to create CWDM developed for simulation of fully optical communication systems. The essential element of CWDM to overcome long distances is an optical amplifier. EDFA (Erbium Doped Fiber Amplifier) is the most commonly used optical amplifier. The article points out the use of EDFA as an IN-LINE amplifier in the CWDM system. The four-channel CWDM was created using EDFA based on BER (Bit Error Rate) for a specific wavelength.**

***Keywords*—CWDM, EDFA, OptSim**

I. Introduction

A very important aspect of optical communication networks is that a single fiber can simultaneously transmit multiple signals of different wavelengths, which represent individual channels. In general, the most commonly used are wavelengths of 1300-1600 nm, which are the least loss. WDM (Wavelength Division Multiplex) has its own standards and these are CWDM and DWDM (Dense Wavelength Division Multiplex).

CWDM was created as a cheaper alternative to DWDM and uses fixed spacing between channels (20 nm). The spacing between channels is defined by ITU-T G.694.2 and it is 20 nm. The tolerance of each wavelength channel is 6-7 nm. This allows us to use cheap lasers in CWDM. Compared to DWDM, the tolerance of uncertainty of the wavelength is different [1], [2] and [3]. While in CWDM is the uncertainty 6 nm, in DWDM is much stronger. Due to this the cost and power consumption are less than in DWDM. If we use fiber type G.652.C/D, it allows us to use up to 18 channels in CWDM [5], [6]. When using a fiber type G.652.A/B, it allows us to use up to 12 channels. The technology is mainly used in metropolitan networks, which may be combined with the DWDM technology, thereby forming a topology with large bandwidth capabilities.

By using CWDM we can transmit in each channel Gbps Ethernet within 80 km. At a speed of 2.5 Gbps is the distance reduced to about 50 km. For creating CWDM for longer distances are used EDFA amplifiers. In practice, due to its characteristics it is most often used as an in-line amplifier.

II. Optical Amplifier the Type of EDFA

The history of EDFA dates back to the sixties of the 20th century. A real use in optical networks was however found in the nineties. The discovery of this technology is an important milestone in the development of optical communication systems. Since then EDFA is used in a wide range of applications - broadband optical amplifiers, optical sources or tunable lasers and can also occur in optical coherence tomography. EDFA is successfully used especially in WDM transmission systems.

EDFA allows a designer of optical communication systems to use it for a transmission of optical window around 1550 nm and contributes significantly to increase of transmission speed and transmission distance [4], [7]. Erbium-doped optical fiber is a type of silica optical fiber whose core is doped with erbium ions Er^{3+}. Electrons erbium-doped optical fiber can be excited to higher energy levels by energizing light with a shorter wavelength [8], [9]. EDFA is very effective in zones of C band (1530 nm - 1560 nm) and L band (1570 nm – 1610 nm) [10]. The ideal gain of EDFA is achievable in the 1530 nm - 1560 nm [11].

In Fig. 1 an increase in the input signal is shown and we can see that with increasing levels of the input power at the laser pump and constant wavelength, the overall erbium inversion is reducing.

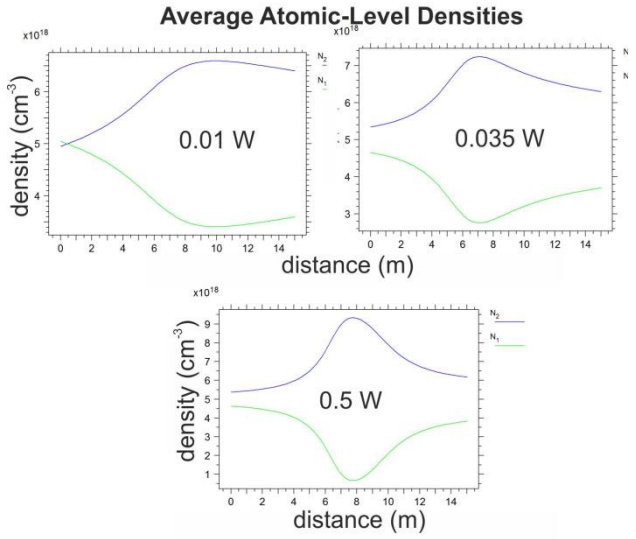

Fig. 1. Excited erbium state densities at different input signal levels: -40 dBm, -20 dBm, 0 dBm. N2 – Excited state, N1 – ground state.

The typical gain of erbium-doped optical fiber amplifier at a distance of about 10 meters is> 20 to 30 dB. Maximum achievable output power of the amplifier is limited by pumping capacity of the light source. The value of the power

may be in the range of 20 - 50 mW (13-17 dBm). In Fig. 2 is shown scheme of EDFA connection.

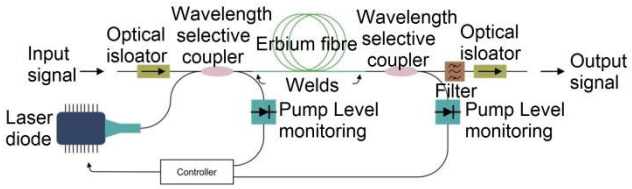

Fig. 2. Scheme of EDFA connection.

III. Creating CWDM using EDFA

For creating CWDM was used a software program *OptSim*. We have used 4 buildings representing the area at TUKE (Technical University of Košice). In the laboratory of optoelectronic systems we have a physical model representing the individual buildings at TUKE. These buildings are formed using a fiber-type G-652.B. The physical model serves as a basis for CWDM. The entire CWDM consists of four transmitters. Individual transmitters have a spacing of 20 nm. Each transmitter (TX) is set to a bit rate of 10 Gbps. Each TX contains of 4 blocks: data source, CW laser, modulation Mach-Zehnder and coding block NRZ (Non-Return to Zero). After transmitting part is place an optical loop. In the loop is 80 km of optical fiber and EDFA optical amplifier.

At the receiving end are the receiver and the multiplexer. Valuation of the optical line is based on BER at wavelengths 1530 and 1550 nm. In Fig. 3 are the eye diagrams at wavelengths 1550 and 1530 nm.

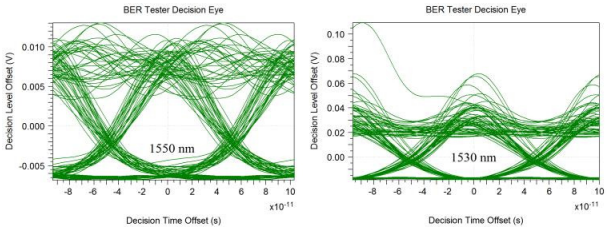

Fig. 3. BER for 1550 and 1530 nm.

IV. Achieved results and future work

In the first year of PhD studies, I was studying nonlinear phenomena CPM (Cross Phase Modulation), FWM (Four Wave Mixing) and SPM (Self Phase Modulation) that are in WDM systems. They were created and published 4,8,16 and 32-channel DWDM systems where there were observed nonlinear effects. In these systems were changed coding blocks (NRZ, Miller) developed in "*Matlab*" and compared various systems based on the BER.

In the second year of PhD, I started to create DWDM using EDFA for longer distances. I created DWDM with different spacings between the channels (12.5 GHz, 25 GHz and 50 GHz) in which I observed FWM phenomenon. Next, I changed bit rates in the adjacent channels to influence output phenomenon CPM. Also physical model has been expanded to all buildings based at TUKE.

At the beginning of the third year, I created DWDM where I changed optical amplifiers EDFA and SOA (Semiconductor Optical Amplifier). Furthermore, the optical line was created for the 3200 km distance to amend the bit rate from 20 Gbps to 10 Gbps and I pointed out to change of a BER. The output of my dissertation will be the system using optical amplifiers, which will lead to the elimination of non-linear phenomena at the output. This system will be designed to take into account CPM, SPM and FWM. Bit rate optical performance and spacing of individual channels will be created on the basis of published results. In Fig. 4 is shown the topology representing TUKE using EDFA.

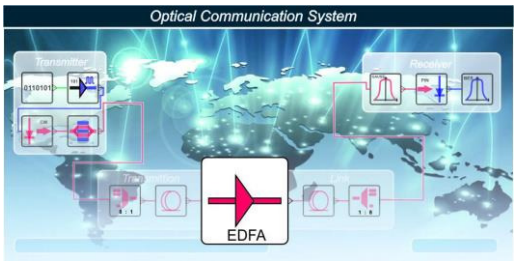

Fig. 4. Basic connection of EDFA for TUKE.

V. Conclusion

The aim of this article was a basic description of CWDM and EDFA. It was created a topology for showing changes BER for wavelengths at 1530 and 1550 nm. In Fig. 3 is shown that BER for 1550 nm has better value using EDFA as in-line amplifier. It is also an evaluation of what was carried out in the last three years for PhD and what will be the outcome of my dissertation.

Acknowledgment

This publication arose thanks to the support of the Operational Programme Research and development for the project "(Centre of Information and Communication Technologies for Knowledge Systems) (ITMS code 26220120020), co-financed by the European Regional Development Fund". This work was supported by research grant KEGA no. 023TUKE-4/2017.

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Influence of the Absorbers on the Measurement of Permittivity by the UWB radar system

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***Abstract*—This paper describes a simple method of measurement of the permittivity of the wall. It improves existing method by the application of the absorbers on the wall at particular places of reflection. It is possible to attenuate the reflections of the incident wave on places where a vector of electric field intensity is not parallel with the wall by this way.**

***Keywords*—Method, Permittivity, Radar, UWB**

I. Introduction

In recent years, the measurement of the permittivity have become increasingly interested in the research area of the object identification. The object identification has a big usage in many areas [1] [2]. The main focus of this paper is on the improving of the existing method of the wall permittivity measurement. This method, published in [3], can be used in the localization of objects behind the wall by the UWB radar system. Precise localization of objects behind the wall requires a good knowledge of wall parameters because every TEM wave which propagates through the wall is influenced by the wall parameters. There exist a lot of methods how to measure the wall parameters [4] [5]. For the localisation of objects behind the wall is used the UWB radar with antennas. This is one of the reasons why to use the free space method for measurement of the wall parameters. The main features of the free space methods are:

- Methods is simple for realisation
- They are non-destructive methods
- It is possible to use the same devices as for localization of objects

It is possible to measure the wall parameters by many ways in the free space [6]. It is needful to measure the wall parameters by the reflection (one side) method. The reflection free space method of measurement requires that the front of the incident wave has a vector of electric intensity parallel with the wall. The equations witch are used for measurement of permittivity of the wall supposed that the incident TEM wave is plane in every point of reflection. It is possible to accomplish that by the setting right distance between the wall and the antennas. It is needful to set the antennas and the wall to the distance ten times larger as wavelength of the incident wave. For the practise purpose, the distance is just several meters. The flatness of the front of wave is possible to fulfil by using the absorbers. Absorbers are situated on the wall in places where the curvature of the front of incident wave is considerable compared to the curvature of the plane of wall.

II. Dielectric theory

There are three main properties witch describe electric properties of materials which are not constants, but they are functions of the frequency. In this paper will be discussed just permittivity of materials.

Permittivity, also called dielectric constant, describes the interaction of materials with an electric field. A material is classified as dielectric if it has the ability to store an energy when an external electric field is applied [7].

From the point of view of electromagnetic theory, the definition of electric displacement (electric flux density) D is [7]:

$$D = \varepsilon E, \tag{1}$$

where ε is permittivity and E is intensity of the electric field. In practise, the permittivity of the material is written in relative form

$$\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}, \tag{2}$$

where ε_0 represents free space permittivity. Every dielectric has unbound carrier of electric charge. This results in the permittivity as a complex number.

$$\varepsilon = \varepsilon_0(\varepsilon'_r - j\varepsilon''_r). \tag{3}$$

The dielectric loss in the material can be represented as loss tangent which is defined as

$$\tan\delta_\varepsilon = \frac{\varepsilon''_r}{\varepsilon'_r}. \tag{4}$$

III. Free space method

I will introduce a technique of measurement permittivity of material which was published in [3] in this section of paper. This technique is improved by the suitable application of the absorbers. In this method we suppose that the measured material is a pure dielectric, so it means that the relative permeability of the material $\mu_r = 1$. Moreover this method requires that $\tan\delta_\varepsilon$ is very small compared to ε'_r. Then we can consider that $\tan\delta_\varepsilon = 0$.

In this method the scattering parameter S_{11}, corresponds to a reflection coefficient of a planar sample, is measured for normally incident wave. The relative permittivity ε'_r is calculated from measured S_{11} parameter after some mathematical expressions using the reflection coefficient from the border of the wall and from the space between interfaces wall/free space, but not from the reflection of the other side of the wall.

Then, the half-infinite model can be used. The permittivity can be calculated as

$$\varepsilon_r' = \left(\frac{1-|S_{11}|}{1+|S_{11}|}\right)^2. \quad (5)$$

IV. Measured system

The time domain measurement of impulse response was done by a pulse UWB radar GEOZONDAS, double ridged horn antenna, cooper slab as a reflector and absorbers ECCOSORB ANW-77. UWB radar transmits a narrow pulse with the peak amplitude of $U < 30\ V/50\ \Omega$ and with the width of pulse $t < 50\ ps$. The principle diagram of the measurement is shown in Fig. 1. We need to perform three measurements

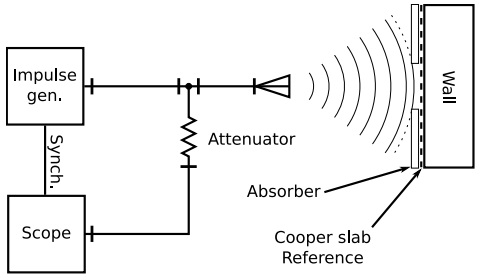

Fig. 1. Diagram of measurement

for the permittivity of the wall calculation:

- Impulse response of the wall $h_w(t)$
- Impulse response of the free space $h_f(t)$
- Impulse response of the cooper slap $h_s(t)$

Then, we can calculate relative permittivity of the wall by the next equation

$$\varepsilon_r' = \left(\frac{1+\left|\frac{\mathscr{F}(h_w(t)-h_f(t))}{\mathscr{F}(h_f(t)-h_s(t))}\right|}{1-\left|\frac{\mathscr{F}(h_w(t)-h_f(t))}{\mathscr{F}(h_f(t)-h_s(t))}\right|}\right)^2, \quad (6)$$

where $\mathscr{F}(.)$ is a operator of the Fourier transform. The accuracy of the measurement depends on the flatness of the front of incident wave. The flatness of the front of wave depends on the distance between antenna and the measured wall. Theoretically, we can create the plane front of the wave in the infinite distance. In practise, we can consider the front of wave as plane in a distance of ten times larger as wavelength of incident signal. Moreover, increasing of the distance results in decreasing of a signal performance. In practise, it is not possible to create plane front of the wave easily for wideband signal in free space. There is a possibility to create a dielectric lens, but this solution is narrowband. So, I decided to cover some places on the wall with the absorbers for this application. The places are selected very easily. It is needful to cover places on the wall, where the curvature of the wave is considerable compared to the curvature of the wall. It is possible to attenuate the reflection of the incident wave in places where the electric intensity vector of wave is not parallel with the wall by this way. With this knowledge it is simple to imagine the pattern, how to position the absorbers. The pattern is simple. It is a square with the hole in the middle. For the purpose of this paper I performed several measurements. At first, I performed confirmation measurement by the transmitting method. However, the result of the confirmation measurement is not frequency depended. Then I performed measurements by the reflection method with and without absorbers. Comparison of the measured results is shown in the Fig. 2.

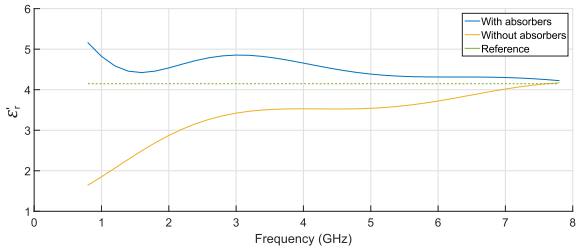

Fig. 2. The rusults of measurement of permittivity of the wall

V. Conclusion

This paper describes the improvement of the reflection free space measurement method of the wall permittivity published in [3], how it is proved by results in Fig. 2. As we can see in Fig. 2, the attenuation of the reflected incident wave in places where the wave intensity vector is not parallel with the wall has a positive impact on results of measurement. The curve of the measurement without the absorbers has upward trend. On the other side, the curve of measurement with the absorbers has more static trend. The green line represent the werification measurement performed by the simple transmission method. By this improved method, it is possible to attenuate the interference from the curvature of the TEM incident wave front.

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Interactions in Intelligent Rehabilitation Space

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***Abstract*— We summarize the state-of-the-art and our present research in the field of intelligent rehabilitation space. The process of rehabilitation tries to restore the tissues damaged by age, disease or injury to good health. Only in Slovakia the surgeons have treated 42,000 fractures in 2015. 65% of the fractures require rehabilitation of surrounding tissues after the bones have healed. 15% of the fractures are related to wrist. We focus our research on the intelligent rehabilitation and diagnostics of upper extremities. Our aim is to create an actuated rehabilitation platform supported by the methods of artificial intelligence and intelligent control.**

***Keywords*— wrist, rehabilitation, diagnostics, intelligent, robot**

I. Introduction

Physiotherapy and rehabilitation specialists often consider the wrist injury to be occurring very frequently and requiring the issue as most occurring and require long time to heal. Our motivation is making the rehabilitation process shorter and more effective. Wrist fractures are more frequent after the age of 60 years [1]. The trauma is associated with the inability to carry weight after the trauma has occurred, the injured wrist is supported by the contralateral hand for pain relief, swelling and/or hematoma develops together with a visible wrist deformity certainly reducing the range of motion [2]. The range of motion remains reduced also after the bones heal. The problem is the exact evaluation of the motorical impairment. We summarize the traditional measurement techniques used and state their advantages and disadvantages. We also summarize the state-of-the-art in the computer and robot assisted diagnostics and rehabilitation techniques.

II. Research topic

Our research activities focus on two main topics:

1. Diagnostics and measurement of the patient's wrist movements.
2. Robot assisted rehabilitation of wrist impairments

We have consulted the physiotherapy and rehabilitation specialists and researched the available scientific literature. The patient's profile contains the mechanism of injury, the method of treatment and the progress of treatment. The methods used different for every patient. Wrist diagnostics is used for example on stroke patients, on the patients that have suffered an injury of soft and/or hard tissues or on the patients with deteriorated by degenerative diseases or old age. There exist self-diagnosis and self-treatment procedures for all kinds of patients.

III. Wrist Movement Diagnostics

The wrist is a complex joint that bridges the hand to the forearm. It is a collection of multiple bones and joints. The bones comprising the wrist include the distal ends of the radius and ulna, 8 carpal bones, and the proximal portions of the 5 metacarpal bones [3]. These bones participate in complex articulations that allow variable mobility of the hand. Relative to the forearm, the hand is capable of 3 degrees of freedom (every abduction have normal degrees in bracket):

- Flexion and extension (Fig.2)
- Ulnar deviation and radial deviation (Fig.3)
- Supination and pronation (Fig.4)

The current methods used in the rehabilitations facilities in Slovakia are often outdated. The typical measurement of the range of wrist motion is conducted using a pen and a graph paper. Fig.1 shows the method for measuring the flexion.

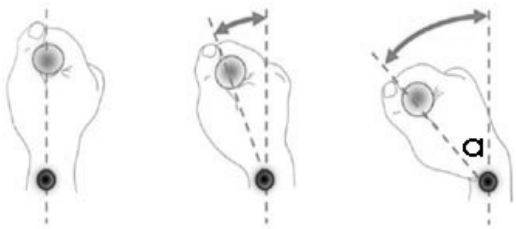

Figure 1: Classical diagnostics

The author of [4] measured the motion characteristics of the wrist joint. The largest wrist range of motion was a mean of 160° ± 10°, in the direction from maximal flexion to maximal extension. The largest stiffness (mean, 0.4 Nm/deg) was in the direction of flexion, while the smallest stiffness (mean, 0.15 Nm/deg) was in the direction of flexion [5].

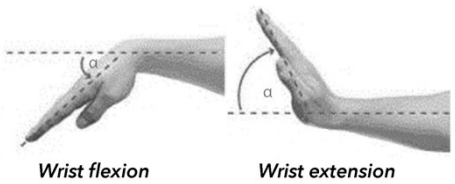

Figure 2: Wrist flexion and extension

The largest wrist range of motion in ulnar derivation and radial deviation was a mean of 75° ± 10°, in the direction from maximal ulnar deviation to maximal radial deviation [6].

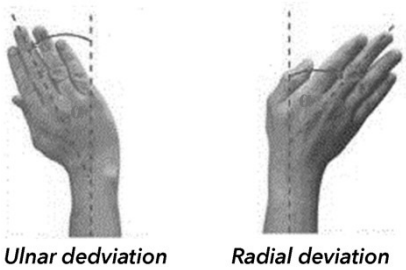

Figure 3: Wrist ulnar and radial deviation

Last degree of freedom is pronation and supination of wrist. The largest wrist range of motion was a mean of 180° ± 10°, in the direction from maximal supination to maximal pronation [5].

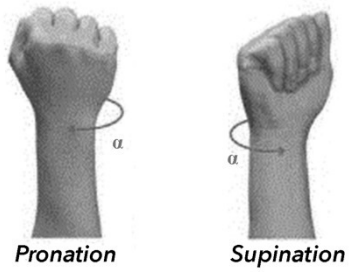

Figure 4: Wrist pronation and supination

Same as robotic arm are these movements of wrist combinable. Movement of the robot can be diagnosed with sensors or with encoders and same sensors can be used in the application of wrist movement diagnostics. Itself rehabilitation by doctor assist can replaced by the actuators and output level.

IV. Robotics and Rehabilitation

Currently, it is known many projects from healthcare, in which cooperate people with the robots, or where are used modern technologies. We will focus on the area of the wrist and mentions projects that already exist. In 1991, a novel robot, MIT-MANUS [7], was introduced to study the potential that robots might assist in and quantify the neuro-rehabilitation of motor function.

MIT-MANUS proved an excellent tool for shoulder and elbow rehabilitation in stroke patients, showing in clinical trials a reduction of impairment in movements confined to the exercised joints. The wrist robot has three active degrees-of-freedom: abduction–adduction or ulnar and radial deviation; flexion-extension and pronation–supination.

This unique 3- degrees-of-freedom robot can be operated standalone (see Fig. 5) or mounted at the tip of our companion planar robot, MIT-MANUS, allowing five active degrees-of-freedom at the shoulder, elbow, and wrist. Conventional therapy focuses on training of the proximal limb segments first, since the process of neuro-recovery typically progresses from proximal to distal limb segments. Owing to this sequence, however, a possible opportunity to harness synapses for distal limb segment control may be diminished or even lost. In these case is rehabilitation conducted by actuators. The pronation/supination (PS) motor is a MAXON motor, model #136201. Product specification sheets list the maximum continuous torque of this motor at 176 mNm and the motor constant at 78.5 mNm/A. The differential right and left motors (ADR and ADL, respectively) are each MAXON model #118899 motors with a published maximum continuous torque of 101.8 mNm and torque constant of 145 mNm/A.

Figure 5: Project MIT-MANUS

Not every project used a mechanical actuator. There are many clinical outcome measures in use pertaining to the upper extremity, such as: manual and quantitative muscle test, range of motion [8], standardized timed function tests (e.g. 9-hole peg test) [9], Jebsen-Taylor hand function test [10], Wolf Motor Function Test [11], Brooke test [12], Fugl-Meyer assessment, and many others that were developed to evaluate impairments in specific conditions. One of the most commonly used standard measures across multiple conditions is range of motion.

Traditional range of motion goniometry assessment consists of moving the joint through its angular range in different body planes and measuring the joint limits using a protractor goniometer. The range of motion measurement using this method can suffer from low accuracy and large inter- and intra-examiner variability as it depends considerably on the experience of the clinical evaluator [13]. For the evaluation of the reachable workspace, is used Kinect for Windows camera, which is capable of capturing color and depth images with 30 frames per second. The depth acquisition is based on active sensing of infrared pattern projected onto the scene, which provides a robust estimation of depth at each pixel with the resolution of 320 × 240 pixels and accuracy of 10– 40 mm in the range of 1–4 m [14].

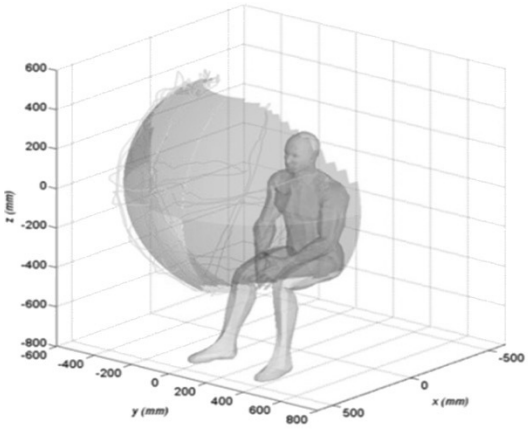

Figure 6: 3D view of healthy patient (total: 1,5 m^2)

To illustrate the application of this methodology as a potential outcome measure of upper limb function, there are shown the difference in the reachable workspace between a

healthy control (Fig. 6) and a subject with Facioscapulohumeral muscular dystrophy (Fig. 7). One of the typical symptoms of Facioscapulohumeral muscular dystrophy is shoulder girdle muscle weakness as exhibited in difficulty raising hand overhead.

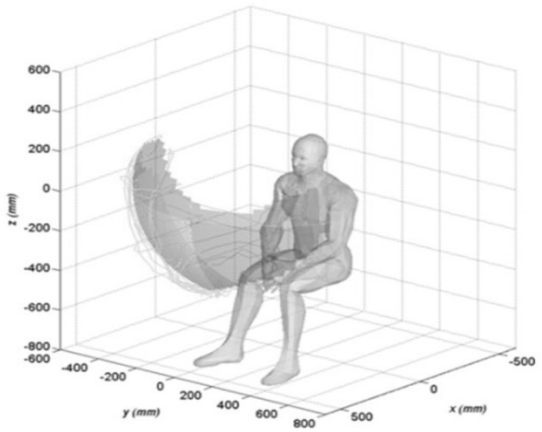

Figure 7: 3D view of healthy patient (total: 0,8 m^2)

In the last decades, robot-assisted rehabilitation has been used to promote motor ability in stroke patients. Although different studies show promising results in the treatment of both subacute [14, 15] as well as chronic [16, 17] stroke patients, the additive effects of robot-assisted rehabilitation with respect to traditional therapy still must be demonstrated. It is widely accepted that intensive repetitive task-oriented robotic rehabilitation is an effective intervention [18] but, at present, the mechanisms leading to impairment reduction following the robotic training are still unclear [16].

The basic idea behind study "Robot-Assisted Movement [19]" was that the considered robotic intervention provides strong afferent stimuli that are important for promoting neural plasticity. In the literature, this type of robotic intervention is not valued because it is considered to be passive since the robot follows a predefined motion law independently of the forces exerted by the subject; instead an assist as need approach is preferred [20].

An end-effector based industrial robot (Pa10-7, Mitsubishi, Japan) customized for rehabilitation purposes (see Fig. 8) allows for the execution of functional movements performed at physiological velocity [21].

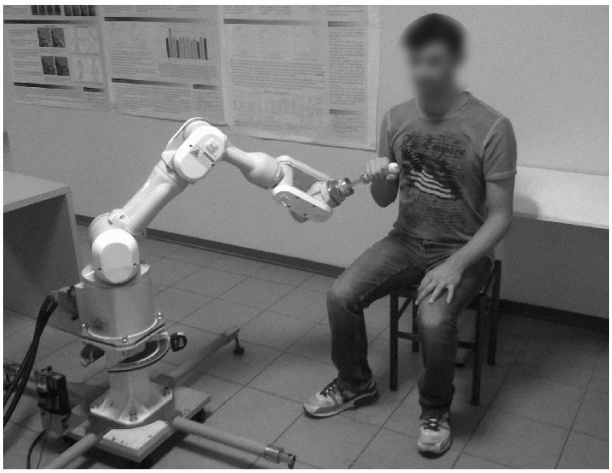

Figure 8: The Mitsubishi Pa10-7 robot platform

During the evaluation session, the following 3 trials were carried out:

- Right hand active no-assisted movement
- Left hand active no-assisted movement
- Robot-assisted movement (the right hand in the case of the healthy subjects and the left one in the case of the stroke patient)

At the beginning of the acquisition, 5 minutes of resting state condition was acquired for each subject. For each trial, at least 50 movements were acquired with a random pause between the end of a movement and the onset of the following one of 10 ± 2 s. The choice of using a random pause was taken to avoid premovement cortical activation phenomena.

In the robot-assisted movement, the trigger was a signal automatically sent by the robot controller to the EEG (See Fig. 9) acquisition system at beginning and end of movement. In the case of the free performed movements, an operator cued the subject to start moving and, simultaneously, sent the begin and end movement triggers using a computer keyboard.

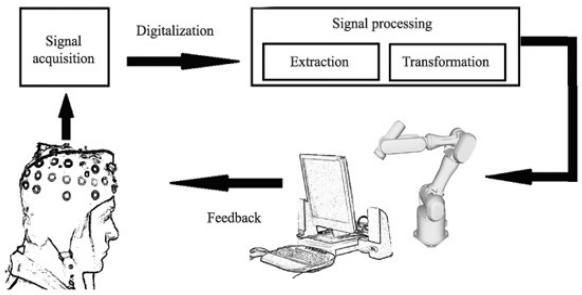

Figure 9: EEG scheme

It is widely accepted in neurorehabilitation robotics that to promote function in stroke patients active participation of the subject to movement is needed. In the common view, a robot should provide "as needed assistance" or "minimal assistance" [22] in order to permit the exploration of the effort-error relationship that stimulates motor relearning [20, 23, 24].

Concurrently, there is evidence in the literature that robotic interventions based on movements against gravity successfully reduce shoulder-elbow impairment in stroke [25]. Unfortunately, the assist-as-need principle is often of little applicability in training against gravity, especially in the case of low functioning patients with high strength and coordination impairments.

In these cases, when the patient is not able to control actively the robot, "passive mobilization," based on a rigidly imposed trajectory (path and motion law), is the only remaining option. In this framework, the authors wanted to verify the hypothesis they made according to which in healthy subjects a functional movement performed with total robot assistance (and classically considered to be passive) is actually accompanied by cortical activation like in the case of the actively (no-assisted) performed movement. Example of control movement are rehabilitations with exoskeletons.

Exoskeletons are particular rehabilitation robots that are worn like an outer shell of the body. In collaboration with the ARTS lab at Scuola Superiore Sant'Anna (Pisa, Italy), was

developed an innovative control method for an elbow exoskeleton (the NEUROExos see Fig. 10) based on adaptive Central Pattern Generators. Conceptually, the elbow moving back and forth (continuous flexion/extension) can be viewed as an oscillator. The adaptive CPG comes to synchronize with this oscillator, and is able to learn its amplitude and frequency. In turn, the adaptive CPG feeds back some torque to the user through the joint actuator, therefore providing movement assistance [26].

Figure 10: Human subject wearing the NEUROExos

Developing wearable exoskeletons poses many challenges in term of energy efficiency, robustness, control, etc... For that reason, also investigate advanced methods to optimize both the morphology (position of the links, number of actuators, ...) and the control of a lower-limb exoskeleton. Ideally, both should be co-optimized, such that the device would embed a sort of "structural intelligence" resulting in efficient dynamical interactions between the user, the mechanics, and the controller.

V. Conclusion

The work presented studies that was performed to verify that fully robot assistance with rehabilitation is really effective and helpful. We are focused on every aspect of the rehabilitation process and we want to create a robotic mechanism, which can patients help every day during treatment. Next goal is helping doctors with the quality of solutions and with revealing improvement or deterioration of rehabilitations. In conclusion, it was demonstrated that robotic full assistance does not inhibit brain activity but, conversely, it seems to promote the cortical organization and that assistance is helpful.

Consistently with the literature and papers from the whole world, the presented data suggest that a procedure based on the use of new technologies and robot-assistance might be promising for assessing patients' potentialities for recovering and for rehabilitation. Further studies will be done to verify whether the approach may be used to set robot-assisted movements and assistive parameters or rather to customize the robotic treatment on the patients' picture. We want create rehabilitation platform with gratitude to Tatra banka foundation as Tatra banka E-Talent.

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Layers Based on Silver Nanoparticles Realized by Inkjet Printing Technology

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***Abstract*—This paper is a summarization of the last year of post gradual study. Solved research tasks and published articles are presented here. This work involves the dependence of the silver layers' electrical resistance on sintering conditions as well as the impact of surface properties of polymeric substrates on the nano-ink behavior. The paper also describes the drops' deposition process optimization by managing of the controlling signal in the print head.**

***Keywords*—Inkjet printing, nano-ink, sheet resistance.**

I. Introduction

The unstoppable development of nanotechnology brings new possibilities in the area of electronics technology. One of these technologies is inkjet printing technology that offers a lot of advantages, such as creation conductive, semi conductive, isolation or other function layers onto various flexible polymeric substrates. Described non-contact printing method presents the digital printing that works with small ink quantities with very low viscosity based on nanoparticles of special materials. This printing technology is suitable especially for applications, where the precise printing with high accuracy is desirable [1].

Inks, used for inkjet printing technology may be divided into 3 groups. The first, most used inks are based on nanoparticles of conductive organic poly(3,4-ethylenedioxythiophene) polystyrene sulfonate (PEDOT:PSS) or inorganic (Ag, Au, Cu) materials. The second group consists of semi conductive inks, which are based on carbon nanotubes, as well as on organic materials, such as poly(3,3'''-didodecyl quarterthiophene) (PQT-12) or poly(3-hexylthiophene-2,5-diyl) (P3HT). The last group of inks serves to creating of isolation layers. For this purpose, organic polyvinylpyrrolidone (PVP), poly(methyl methacrylate) (PMMA) and inorganic (Zr, TiO_2, SiO_2) materials are used [2], [3].

II. Initial Status

Nowadays, deposition of special nano-inks onto the flexible polymeric substrates with high accuracy and precision is required in the lot of field of electronics. The line edge, relief of the printed structure and the structure of necks play a key role for final quality. On the other hand, printing of the viscous liquid drops contain nano-particles of noble metals requires the controlled surface's properties of polymeric substrates. The substrates' temperature, surface tension and the wettability of substrates have a significant impact on the deposited structure [1], [5].

Printing the structures and lines with width less than 50 μm is extremely difficult. There are many technological factors that affect the quality of printed structures. For this purpose, the quality of surfaces is needed to analyze. The roughness, wettability and surface tension of substrates play a significant role to drop spreading. Surface treatment represents an important step to optimize the technological process of printing [3], [4], [5].

After studying theoretical background about inkjet printing technology, substrates' surfaces and their modifications as well as drop spreading we want to solve these PhD theses:

1. Optimization of technological factors affecting the structure of silver layers realized by inkjet printing.
2. Analysis of adhesion mechanism between layers based on silver nanoparticles and substrates and proposal for methodology of their measurement.
3. Analysis of properties of silver layers realized by inkjet printing technology and analysis the impact of various parameters to the quality.
4. Application of analysis' results for the design of 2 selected electronic components on a flexible substrate by inkjet printing technology.

III. Solved Tasks in The Previous Year

Tasks which are summarized in the following section were solved in the last year of postgraduate study based on dissertation thesis.

A. Dependence of electrical resistivity on sintering conditions of silver layers printed by InkJet printing technology

The paper aims to find an optimal sintering conditions of silver based nano-inks for achieving the high electrical conductivity of the deposited layers applied on polyimide foils as well as the influence of ageing on the electrical conductivity. For this reason, the investigation in the field of silver layers deposited by inkjet printing technology is presented in this paper. The four-point resistance measurements were realized for the detailed and precise analysis of the two different silver based layers resistance after different sintering conditions depending on the type of nano-

ink varied about the recommended values. HAST (Highly Accelerated Stress Test) tests were also applied as an ageing method for confirmation the high electrical stability of the silver layers. The results prove the strong influence of the temperature and time of the sintering process on the sheet resistance of investigated silver based layers deposited by inkjet printing technology on polyimide foils. The HAST tests caused the significant changes in the electrical conductivity for both nano-inks presented in this paper. The existence of noticeable dependence among the resistivity, thermal treatment and ageing was proved.

It can be generally declared that the silver based nano-inks which were sintered at sufficiently high temperature for strictly defined time has a high long-term stability. It is necessary to consider the suitable sintering conditions for all of nano-inks regarded to the concrete application and the temperature resistance of the selected polymeric substrate. For achieving the lowest sheet resistance of the silver layers the high sintering temperature or short sintering time must be maintained.

B. Investigation of nano-inks' behavior on flexible and rigid substrates under various conditions

This paper aims to find the optimal deposition conditions for achieving the homogenous structure of the silver layers onto three types of polymeric substrates as well as on the rigid substrates. For this reason, the detailed investigation of the silver-based layers deposited at different technological conditions by microscopic methods is presented in this paper. The special test pattern has been designed and deposited at different substrate temperatures by using two types of generally available silver-based nano-inks. Cross-sections and 3D profiles of the deposited silver layers have been profoundly analyzed by using the optical profiler Sensofar S Neox on the generally used polymeric (PI, PET and PEN) and rigid substrates (951 and 9K7 LTCC, glass and alumina). The results prove the strong correlation between the substrate temperature during the deposition process and the final shape of the created structure which has the direct impact on the layers' homogeneity. The results also prove the theory of the coffee ring effect creation in the inkjet printing technology [7].

For the illustration of the impact of substrate temperature on the final shape, the Fig. 1 shows the 3D profile of the optimized line deposited on the PEN substrate Teonex® Q51. The line consists of silver-based nano-ink dots adjusted to achieving of the smooth edges [7].

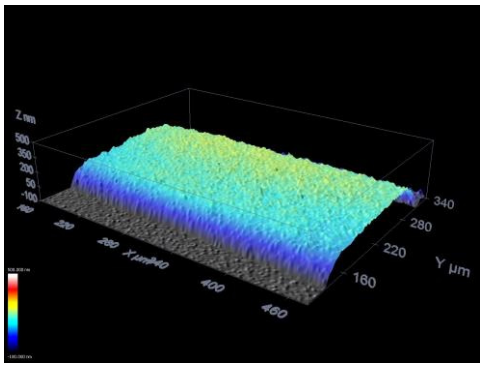

Fig. 1. 3D surface profile of channel in the silver-based line UTDAgIJ on the PEN Teonex® Q51 substrate deposited at 90°C.

The achieved results prove the theory of the coffee ring effect creation caused by the high temperature of the substrate in the inkjet printing technology which adversely affects the homogeneity of the deposited structures. With regard to the achieved results, it can be concluded that the coffee rings are created at 70°C for the nano-ink Amepox JP-6n on all the investigated substrates. In the case of the nano-ink UTDAgIJ, the coffee rings are created at a lower temperature on the PI, PEN and glass substrates [6], [9].

C. The deposition process optimization by controlling of the piezo elements in the print head

The aim of this paper is optimization of the deposition process in jetlab® 4xl-A inkjet printer by controlling of the actuating signal drives the piezo element in print head used in the Department of Technologies in Electronics at Technical University of Kosice. The implemented optimization process significantly contributes to the precision printing of the silver based nano-inks onto the polymeric flexible and rigid substrates. By changing the shape of the actuating signal the small volumes of drops are achieved which allows to create the structures with smaller width and higher precision. The careful adjustment of the inkjet printer before the printing is a time consuming process which had to be done for every kind of nano-inks as well as for substrates. This paper offers the optimized actuating signal for silver based nano-ink UTDAgIJ manufactured by UT Dots, Inc., using the nozzle with diameter 70 µm [8].

ACKNOWLEDGMENT

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Logical Model Design of Program Systems' Security

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***Abstract*—Today's information society requires development of complex, reliable, and secure program systems. One of the possibilities to do so, is developing them using component-based systems and secure them by the Intrusion Detection Systems. In this paper, we show our initial proposition for exact verifiable logical model of program systems' security.**

***Keywords*—Category theory, Coalgebra, IDS, Linear logic**

I. Introduction

A development of verifiable logical model of the program systems' security can be based on observable behavior of component based systems with the Intrusion Detection System (IDS). That can increase reliability and security of program system while designing program systems. To develop such a model, it is necessary to choose appropriate language (formalism). By using this formalism, it will be possible to exactly formulate behavior of program systems. In our approach, we use category theory and logical systems.

II. Category theory

Category theory is a mathematical study of universal properties of structures for exact formulation and observation of quite different mathematical fields [1]. It allows to abstract and explicitly define their properties. In our approach [2], [3], we use it to observe and model behavior of state-based program systems.

Barr and Wells in their publication [4] describe a category as a mathematical structure consisting of

- a class of objects,
- a class of morphisms.

Objects can represent for example mathematical or data structures. Morphisms model relationships between them. In computer science categories can model for example processes, construction, or behavior of program systems [5]. We use categorical structures called coalgebras. For that, it is necessary to introduce the following categorical notions.

- A functor, which is a morphism between categories.
- An endofunctor, which is a functor on one category.
- A polynomial endofunctor, which is an endofunctor constructed by the operations of product, coproduct, or exponential.

Coalgebras are constructed on signatures [6]. A signature is a mathematical structure consisting of:

- a class of type names, and
- a class of operations over type names divided to *constructors* and *deconstructors*.

Deconstructors determinate a polynomial endofunctor over base category.

Based on the introduced notions above [7], the coalgebra of polynomial endofunctor P over category $\mathbf{C}$ (or P-coalgebra) can be formally defined as an ordered pair (X, ω), where

- X is a state space and it is a class of objects of category $\mathbf{C}$,
- $\omega : X \to P(X)$ is transition operation of coalgebra and it is a tuple of deconstructors.

III. Linear logic

Traditional logical systems such as propositional or predicate logic are not sufficient for formulation of exact behavior of complex program systems. Therefore, we have chosen a linear logic formulated in [8] as main logical system. The linear logic has many advantages compared to other logics, such us: stronger expressing power achieved by introducing new logical connectives, resource-based treating of formulæ , or a time-spatial theory called Ludics [9]. Every formula represents action/reaction or available/consumed resource.

Syntax of linear logic can be expressed by following production rule in Backus-Naur form:

$$A ::= a \mid \mathbf{1} \mid \ \bot \ \mid \mathbf{0} \mid \top \mid A \otimes A \mid A \,\&\, A \mid A \oplus A \mid A \parr A \mid A \multimap A \mid A^{\bot} \mid !A \mid ?A. \tag{1}$$

The items in (1) express following: the a is a set of atomic formulæ, the $\otimes$ expresses parallelism, the $\&/\oplus$ express outer/inner non determinism, the $\parr$ expresses exclusive disjunction, the $\multimap$ expresses dynamics, the $()^{\bot}$ expresses consumed resource or reaction, the $!/?$ express unlimited or potentially unlimited resource respectively. The $\mathbf{1}, \bot, \mathbf{0}, \top$ are constants of the logic.

IV. Coalgebraic model for description of IDS's behavior

The first part of our long-term goal is a design of a formal *coalgebraic model for description of IDS's behavior* [10]. For that, we have done following steps.

- In [11], we have converted network signatures of real network attacks used by IDSs to detect network intrusions [12], to coalgebraic signatures.
- In [3], we have used coalgebraic signatures to model IDS as a coalgebra of polynomial endofunctor over

category of infinite stream of packets. Therefore, we have firstly constructed mentioned category, and then we have specified a polynomial endofunctor on such a category.
- In [13], we have specified behavior of IDS during attacks as a formula of our modal linear logic, which we have proved in Gentzen sequent calculus.
- In [14], we have constructed a time-spatial structure of the formula from [13] using Girard's time-spatial theory called Ludics.

A. Modal linear logic

We had to define our own logical system in order to implement steps mentioned above. To comply with the coalgebras, we had to extent linear logic to *modal linear logic*. We have chosen appropriate fragment of linear logic, and extended it about modal connectives as follows

$$\varphi ::= a \mid \mathbf{1} \mid \bot \mid \varphi \otimes \psi \mid \varphi \parr \psi \mid \varphi \multimap \psi \mid \varphi^{\bot} \mid \Box\varphi \mid \Diamond\varphi. \quad (2)$$

Where $\Box\varphi, \Diamond\varphi$ express necessity or possibility of formula φ respectively. In [14], we have introduced its language, semantics using Kripke's sematical method of possible worlds, and its prove system by Gentzen sequent calculus.

B. Coalgebraic modal linear logic

Because the coalgebras can model infinite streams, we have extended our approach with adding coalgebraic modal operator $\nabla\Phi$ [13]. The $\nabla\Phi$ will from all possibly valid formulæ $\{\varphi_i \mid i = 1, 2, \ldots, n\}$ choose one, which is necessary valid. It is defined as follows.

$$\nabla\Phi \equiv \Box(\parr\Phi) \otimes (\bigotimes(\Diamond\Phi)) \quad (3)$$

- $\Phi = \{\varphi_i \mid i = 1, 2, \ldots, n\}$,
- $\Diamond\Phi = \{\Diamond\varphi \mid \varphi \in \Phi\}$,
- $\parr\Phi = \varphi_1 \parr \varphi_2 \parr \ldots$,
- $\bigotimes\Diamond\Phi = \Diamond\varphi_1 \otimes \Diamond\varphi_2 \otimes \ldots$.

V. Conclusion and Future Work

In the future, we would like to apply results of our work in extending passive approach of IDS (which needs admin's intervention) to active one.

We plan to use BDI (Believe-Desire-Intention) architectures and its logic. Therefore, we are working on an extension of our logic with a modal connectives of the BDI logic. Our initial proposal of logical model for active program systems' security is depicted in the figure 1.

The component **IDS** consists from our coalgebraic model for description of IDS's behavior, by which we can detect possible intrusions. Based on that, the component **Bel** concludes that intrusion necessary occurred. The component **Bel** interacts with security policy of organization represented by the component **Des**. Based on that a plan will be chosen to deal with the captured intrusion by the component **Inten**, which represents a database of the plans (reactions) on intrusions. Besides the component **IDS**, all other components will consist from database of proven formulæ.

The mention methods and the achieved results are all foundational starting points for the following future plans.

- Usage of a coalgebra of polynomial endofunctor for modeling of a program systems' complex security in the component based programming paradigm.

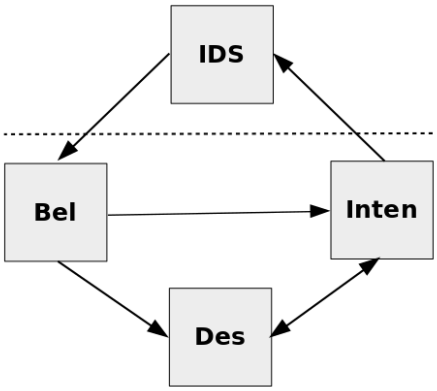

Fig. 1. Proposed logical model

- Formulation of non classical resource oriented logical system for description
  - of component based systems' state oriented dynamics, and
  - expression of intelligent agent's mental situation, regarding to realization of organization's security policy.
- Investigation of a possible connection between the resource-oriented logical formalism with an intelligent architecture and its time-space extension from the theory of Ludics.

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Look up table controller based on fuzzy logic controller

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***Abstract*— The paper deals with possibility of implementing fuzzy logic (FL) controller for control of the output voltage of a phase-shifted PWM (PS-PWM) soft-switching dc-dc converter as look-up table (LUP) controller. The converter is a full bridge dc-dc converter with controlled output rectifier and an active snubber on the secondary side. Despite proven advantages of use a fuzzy logic control for DC-DC converters, one of the main drawback can be considered computational demand, which could negatively affects the response of converter on sudden changes of load and raise up the price of the converter, due that there is needed a microcontroller with higher computational capacity. In the paper is consideration of use a look-up table controller, which is derived from original fuzzy logic controller, which significantly raise up the computation speed, but requires more memory and is less accurate.**

***Keywords*— Fuzzy Logic Control, Look-up Table, MATLAB**

I. INTRODUCTION

Fuzzy systems have demonstrated their enhanced performance in many different areas including electrical drives and power converters, robotics, etc. Although initially fuzzy systems were associated only to the artificial intelligence (AI) that has refrained to the development of theoretical fuzzy systems, in 1985 Japanese researchers Seiji Yasunobu and Soji Miyamoto demonstrated the superiority of fuzzy control systems for the Sendai railway. From that moment on, the importance of fuzzy logic controllers in industry have grown significantly with estimated $10 billion dollar-per-year industry worldwide [1, 2]. The using of FL have several advantages as that there is not required precise mathematical model, there are very robust and has excellent immunity to external disturbances. However, FLC requires substantial computational power due to complex and heuristic decision making processes, namely fuzzification, rule base storage, inference mechanism and defuzzification operations [4]. The importance the fuzzy logic in industry lead's to intensive research to effective application of fuzzy logic to embedded systems, and there are introduced many different hardware and software implementations of fuzzy logic [2, 3].

In application with FL, where is required low computational demand is often considered use of look-up table controllers, which data are computed offline and written to the table. Look-up table controller can be understood as array of data that describes relationship between variables. In a broad sense they represent "pseudo-equations to make up for a lack of 'real' equations or perhaps to replace complicated equations with simpler ones" [5]. A LUT controller is one of the most common types of controllers, which are commonly used in industry. The reason for its popularity are the strong nonlinearity and multimodal behaviors that can be, in many cases, formalized only on experimental data [3].

In application of control of DC-DC converter with soft switching is a demand to evaluate a control loop as fast as possible within a few microseconds and in [6] is proven the improvement of stability of converter during load changes. As computational speed of Mandami FLC isn't fast enough, there is consideration of replacing FLC controller by LUT controller, which data are computed offline based on original FLC controller, in order to approximate FLC controller, and combine the advantage of quality of regulation of FLC and computational speed of LUT controller. For this purpose, there was created a program in MATLAB, which can generate LUT controller in language C, which can be easy implemented to microcontrollers.

II. LOOK-UP-TABLE CONTROLLERS BASED ON FUZZY LOGIC CONTROLLER

In this chapter we assume, that there is FLC controller, which use 2 inputs, and has a one output value. The process of creating LUT controller based on FLC can be divided to the two parts. First part is to create a "bunch of data", which represent the output values of FL for different combinations of the inputs, which are linearly arranged in chronological order. The computational of these data is usually made offline. The second part in design of the controller is to specify algorithm for assignment the output of controller based on the inputs, which determines the "position" of the output value inside table. The output of controller is computed by interpolation based on neighbor points. In most application, for 2 dimensional look up tables are used three different interpolation algorithms, which differs in accuracy and computational demand:

- 2D nearest-neighbor
- Bilinear
- Bicubic

The simplest algorithm is 2D nearest-neighbor algorithm, which takes the nearest specified point in LUT, and the output of the controller is equal to that point value. The main drawback of this method is less accurate interpolation against other methods, but the main advantage of this method is very small computational demand. The bilinear algorithm obtains final value by taking a weighted sum of the four nearest neighbors surrounding the calculated location as shown below in fig. 1.

This algorithm is characterized by fast computation and accurate results. The bicubic interpolation can be accomplished using either lagrange polynomials, cubic splines, or cubic convolution algorithm. The algorithm takes into account 16 neighbors values, so can achieve very accurate results, but the drawback of algorithm is slower computational speed.

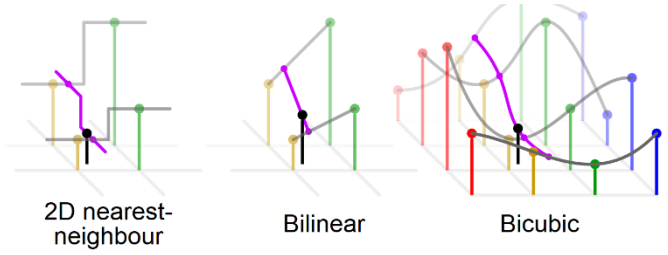

Fig. 1. Comparison of some 2-dimensional interpolations [7]

III. Testing Accuracy of Designed LUT Controllers

In order to verify designed LUT controllers accuracy against FL controller there were create a series of tests. Firstly there was computed High density data table containing 250 000 outputs of FL controller with different combination of input values. Then there were computed smaller LUT controllers, which differs in sizes of LUT, and these controllers evaluate every single pair of input value, so they created its own data table similar as FLC. By the comparison of individual values of these tables there is determined full scale error.

There were tested LUT controllers with different sizes of LUT for both 2D nearest-neighbor and bilinear types of interpolations. In fig. 2 and 3 is shown the maximal full scale error and mean absolute full scale error of created LUT controllers. As been expected, the LUT controllers with bilinear interpolation was more accurate.

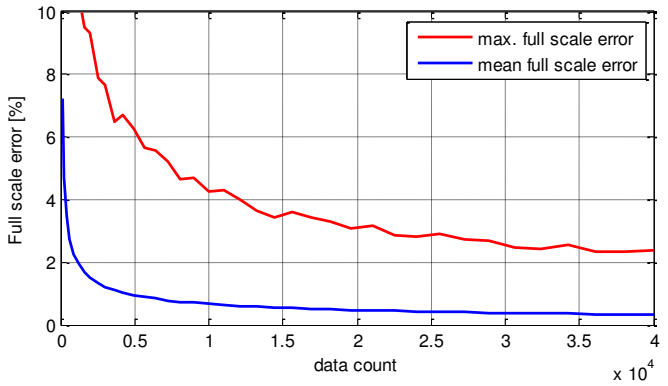

Fig. 2. Full scale errors for LUT controllers with different sizes with nearest neighbor interpolation algorithm

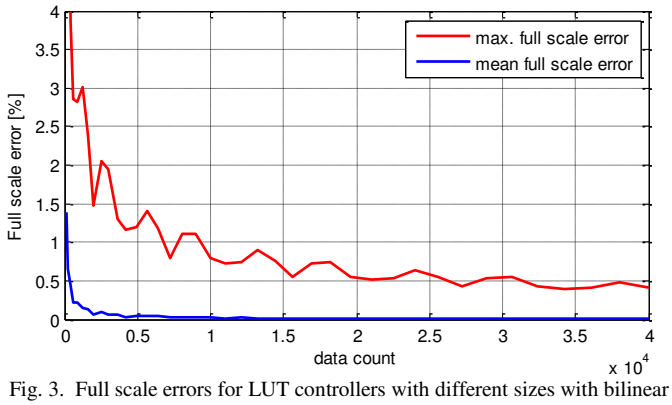

Fig. 3. Full scale errors for LUT controllers with different sizes with bilinear interpolation algorithm

In fig. 4 is shown the full scale errors surface of designed controller with bilinear interpolation. The full scale errors of the LUT controller was drawn based on 360 000 computed samples of FLC and the LUT controller is size of 50x50, which represent 2500 different values written into LUT.

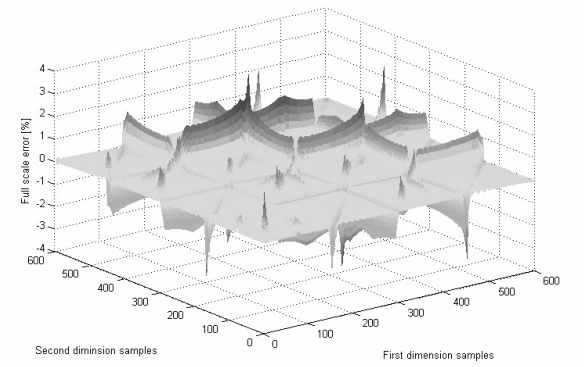

Fig. 3. Full scale errors surface of LUT controller

IV. Conclusion

The paper is aimed to possibility of implementing a fuzzy logic controller as look-up table controllers. By created test, there is prove that designed LUT controllers can accurate replace FLC controllers with two inputs in order to simplify controllers code and improve execution speed. There were tested LOT controllers with two different interpolation algorithms, and it's seems that the 2D neighbor algorithm is a way faster against bilinear interpolation algorithm, but needs a more storage capacity to reach the accuracy of the bilinear interpolation algorithm. As the drawback of these types controllers can be considered increased memory requirements for the microcontroller and the lost linguistic information provided by fuzzy controllers, which could leads to troubles with adaptive fuzzy controllers and its optimization.

Acknowledgment

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Magnetic Nanofluids as New Cooling and Insulating Liquids in Power Transformers

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***Abstract*—This paper deals with my knowledge, experience and results, which I collected during last year of PhD. study. This paper deals with nanofluids, especially magnetic nanofluids which could be replacement for conventional insulating/cooling liquids as mineral oils.**

***Keywords*—magnetic nanofluid, insulating liquids, cellulose, degradation**

I. INTRODUCTION

Developing of insulation liquid systems is accelerated from year to year. Mineral oil is mainly used in power transformers. The using mineral oil is limited by petroleum reserves and it has non-environmentally effects at leakage. In the world the number of transformer insulation systems that are filled with an alternative liquids, not based on petroleum, have increasing trend. Silicone and natural oils or liquefied gases are located in this "alternative" area. However, the requirements for higher quality and quantity of electric power bring (yet) only one solution for developing the transformers, namely: the increase of tank and cooling surface.[1] - [3]

Second important part of transformer insulation system is Kraft paper and pressboard, products from cellulose. These two parts of insulation system are dependent each other and it has influence on lifetime of device. The degradation of cellulose products has different rate for each fluid. Therefore, monitoring and knowing of specific phenomena are required.[4]

Since 1990's, researchers and engineers developed possible substitution for conventional thermal/insulation liquids composed of nanoparticles dispersed in these conventional liquids - nanofluids. Motivation for works of many researchers is in development of stable suspension without settle and with excellent thermal and the insulation properties. One of solution for improvement cooling/insulating properties in transformer is substitution of the used mineral oil by nanofluid based on previous oil, or using new liquids which are environmentally friendly and have electrical, chemical properties similar as mineral oil. [5]

II. COMPOSITION OF NANOFLUIDS

Nanofluids, containing low volume of nanoparticles, can be one solution of problem of big sized power transformers. Nanoparticles used in nanofluids have been made of various materials, such as oxide ceramics (Al_2O_3, CuO), nitride ceramics (AlN, SiN), carbide ceramics (SiC, TiC), metals (Cu, Ag, Au), semiconductors (TiO_2, SiC), carbon nanotubes, and composite materials such as alloyed nanoparticles $Al_{70}Cu_{30}$ or nanoparticle core–polymer shell composites. Liquids used in transformers have a role in case of nanofluid as a carrier liquid. An important part of these liquids is surfactant - the surface active compound, which has been added in order to disperse nanoparticles. Surfactant consists of long chain molecules with polar and non-polar part. Polar part is attracted by nanoparticle and non-polar by fluid.[5]

Nanofluid consisting of magnetite particles Fe_3O_4 is called the magnetic nanofluid (MNF) with its specific properties described in [6] and [7]. Oleic acid is mainly used surfactant in this case of MNF.

One of important tasks in area of liquid dielectrics is monitoring of electrical, chemical, mechanical properties and their changes with degradation degree. Spectroscopy of conventional liquids is today on considerably high level, but important questions in case MNF are: Is it necessary development of new spectroscopy method for MNF? How can the fluid affect cellulose products under mechanical, chemical, electrical and thermal stress?

III. SOLVED/UNSOLVED TASKS OF LAST YEAR

During the last decade some of my colleagues from department started several works, which were based on monitoring dielectric properties and their changes with increasing thermal degradation for mineral oils, synthetic and natural esters and in MNF [7].

Understanding of polarization processes in dielectrics, measurement methods and knowledge from area of well-known dielectric spectroscopy in insulating liquids were a good stepping stone for identification changes in MNF. [6]

Important aspect for spectroscopy of the MNF is measuring of parameter, which could be good reflection for changes inflicted thermal, chemical, electrical ageing. In my case it has been observed by frequency domain relaxation spectroscopy: before and after thermal degradation the parts of complex permittivity were measured and calculated.

We performed the experiment with negative influence of the magnetic nanofluid on the structure of cellulose paper. The paper samples were immersed into magnetic nanofluid in glass

vessel. The two NdFeB magnets with magnetic induction 40mT were placed on ends of propeller under the glass vessel. The propeller was powered by DC motor set on 2 rad/s. In Fig. 1 can be seen structure of cellulose 1 hour after impregnation, cleaned up with mineral oil (carrier liquid of MNF) and dried.

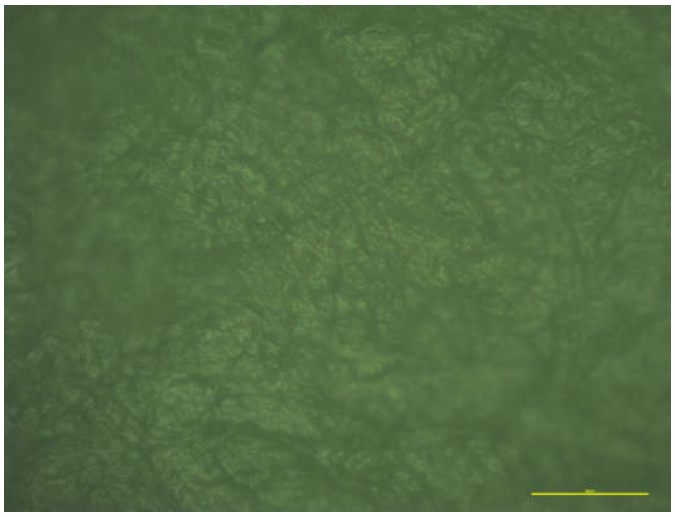

Fig. 1 Microscopic view on magnetic nanofluid impregnated cellulose paper in 100μm scale, after impregnation

Other samples of paper were selected from vessel after mechanical stress in 100h intervals. Every sample was subjected to cleaning and drying process. On Fig. 2 can be seen the last sample after 1197h. The damage of cellulose fibers and chains can be observed, based on much more brighter areas in figure.

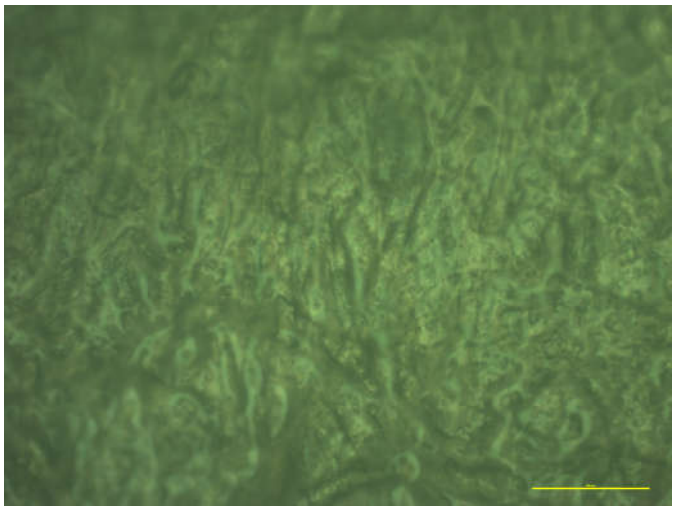

Fig. 2 Microscopic view of magnetic nanofluid impregnated cellulose paper in 100μm scale, after 1197 hours of mechanical degradation

In the other experiment we observed polarizations in pressboard immersed in MNF and mineral oil with/without presence of cooper wire, which simulated part of winding and it had function of catalyst for aging. The aging was executed at temperature 353,17K, measuring every 150 hours reaching up to 500 hours. Subsequently changing measurement every 200 hours to 1000 hours, when stability of colloidal suspension was broken.

Another part of my work is coordinate diploma students with my supervisor on their works. We work on experiments about polarization in solid XLPE materials used in HV cables and thermal stress of new insulation liquids based on liquid gas and nanofluids.

IV. Proposals for next works

In future work can be suggested the miniature of the transformer winding, which can be immersed in MNF and thermal stressed. Likewise, there can be created model of 1 phase transformer filled with MNF with thermal sensors and regularly monitored of dielectric properties of MNF. Insulating liquids like natural or synthetic esters can be used as carrier liquids for MNF in view of theirs biodegradable properties and higher flash point.

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Magnetic properties of rapidly quenched composite materials with amorphous and nanocrystalline structure

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***Abstract*—In this paper, composite ferromagnetic materials with exceptional magnetic properties are introduced. Special interest is dedicated to the characteristics of nanocrystalline and multilayered ferromagnetic materials and possibilities to improve their soft or hard magnetic properties for desired applications. First Order Reversal Curves (FORC) method is proposed as a measurement technique, enabling characterization of the composite ferromagnetic systems and interactions between individual phases.**

***Keywords*—Ferromagnetic materials, Composite materials, Nanomaterials, First Order Reversal Curves**

I. Introduction

Current demand for new materials with excellent physical properties is growing at a rapid pace. Development of alloys with exceptional properties is a necessary consequence of the technology advancements and the endeavor to decrease energy consumption. High efficiency and energy performance, in conjunction with mechanical and temperature stability are desired features expected from developed alloys and compounds.

Number of ferromagnetic materials fulfill such requirements and thus play an important role in several fields of applications, such as electronics, sensor applications or electrical engineering. Various compositions, geometries or designs allow acquirement of unique characteristics without need to compromise on the price or quality.

This review is dedicated to an introduction of the nanocrystalline and multilayer ferromagnetic materials, and methods of their characterization. Special interest is devoted to a First Order Reversal Curves method, a multifunctional measurement technique that allows acquiring more complex view on ferromagnetic properties of the composite samples.

II. Aims of PhD thesis

A PhD study is dedicated to the research of the fundamental magnetic properties of the composite ferromagnetic alloys. Sample series will be produced in form of the single or multilayer ribbons. These specimens will be examined in the amorphous (as-quenched) or nanocrystalline state, which will be achieved by thermal treatment in the external magnetic field. Magnetic properties and structure characteristics will be studied using variety of measurement techniques in standard and extreme conditions, such as elevated temperatures and high magnetic fields.

Amongst the measurement techniques, special attention will be given to the First Order Reversal Curves method. This method allows the study of single, as well as multiphase ferromagnetic structures, and provides important information about individual magnetic phases and effective interactions.

III. Composite Ferromagnetic Materials

A. Nanocrystalline ferromagnetic materials

Composite ferromagnetic materials offer potential of improved ferromagnetic properties, unachievable in sole amorphous alloys. Special attention is given to nanostructured compositions. Components of these samples are designed with at least one nanoscale dimension. Geometrical classification distinguishes various nanostructure elements, including 3-dimensional nanoparticles embedded in surrounding carrier, 2-dimensional nanowires or columnar structures, or 1-dimensional layers and thin films [1].

Nanometer-sized clusters of ferromagnetic atoms have shown outstanding magnetic properties, compared to individual atoms or bulk crystalline solid samples. These characteristics greatly depend on size distribution, morphology and chemical composition [2]. Production of nanoparticles can be achieved using various industrial synthesis techniques, including mechanical milling, C-arc and plasma technology, powder synthesis or nanocrystallization of amorphous precursors.

The latter method is used for processing of the alloys with general formula $FM_{1-x}(TM,M,NM)_x$ [2]. Magnetic properties originate from presence of the ferromagnetic metals FM (Fe, Co or Ni), which form majority of the compound. Their nanocrystallization is supported by addition of a noble metal NM, which serves as a nucleating agent for the ferromagnetic phase. Early transition metal TM enables controllable growth of the nanocrystals and, along with metalloid M, promotes glass formation in the precursor. Resulting specimen is consists of ferromagnetic crystals with size of few or tens of nanometers, embedded in the amorphous matrix. Such alloys are known for excellent soft magnetic properties [3], [4]. Nanocrystallization can be attained after annealing under high

vacuum or in protective gas atmosphere above primary crystallization temperature of the sample. It is where formation of the ferromagnetic elements occurs and the residual metallic matrix remains unaffected (Fig. 1).

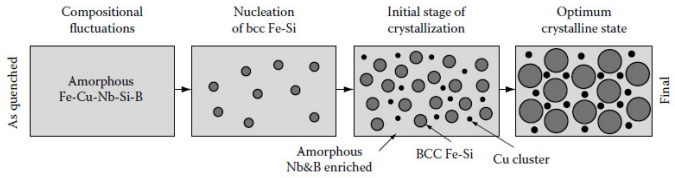

Fig. 1: Nanocrystallization of the FINEMET alloy [5].

Modification of the ferromagnetic properties was explained by Random Anisotropy Model [6]. Given the cluster of the crystal grains, magnetic anisotropy K is driven by mutual exchange interaction rather than randomly varying anisotropies on the scale of the particles. This happens, if the mean grain size D is smaller than ferromagnetic exchange length L, given by value of exchange stiffness between individual grains A. This length falls into nanoscale interval for most Co and Fe-based alloys (5-10nm and 20-40nm respectively [7]). Consequently, local anisotropies are suppressed and average anisotropy constant K is proportional to D^6. This behavior will reflect on the values of coercivity ($H_C \propto K$) and initial permeability ($\mu_i \propto 1/K$). This is why formation of the nanocrystalline structure positively modifies soft magnetic properties in studied group of alloys.

Application of magnetic field during heat treatment can in some alloys result in further enhancement of soft magnetic characteristics. Easy direction of magnetization (i.e. orientation of the easiest approach to magnetic saturation) in material is driven by magnetic anisotropy, which can vary with shape, fabrication or crystal structure. Magnetic field annealing markedly suppresses these factors. It enables creation of preferred direction of magnetization by atoms rearrangement on the local scale. Mobility of ferromagnetic atomic pairs at annealing temperature is sufficient to align them into direction of the applied field, in order to reduce magnetic anisotropy energy [8]. After the cooling process, this directional order is stabilized and such induced anisotropy is usually sufficiently high to prevail [1]. This results in further improvement of soft magnetic properties. Hysteresis curve of the sample, annealed in longitudinal magnetic field (Fig. 2), has rectangular shape, and is characterized by low coercivity and high magnetic permeability values. On the other hand, sheared hysteresis loop with well-defined linearity can be achieved after annealing in transverse magnetic field (Fig. 2). On contrary, heat treatment without applied magnetic field can lead to deterioration of the soft magnetic properties. As the local magnetization supersedes influence of the external magnetic field, acting self-magnetic annealing process [3] preserves magnetic domain structure of the amorphous state (Fig. 2).

Improvement of soft magnetic properties of the nanocrystalline samples, using the thermal treatment method, can be achieved only if several processing conditions are satisfied. Annealing temperature must not exceed secondary crystallization temperatures, i.e. crystallization of the residual matrix has to be restrained. Moreover, in order to create directional order of the atomic pairs, temperature should also not exceed a Curie temperature of the alloy, as the process of pair ordering is not active in the paramagnetic state [9]. Induced anisotropy reaches highest values when applied magnetic field is sufficiently high to fully saturate the sample.

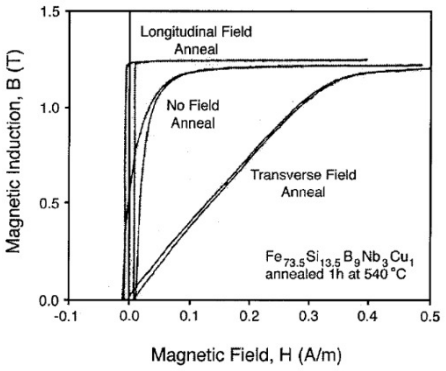

Fig. 2. Hysteresis loops of the FINEMET alloy, annealed in zero, longitudinal and transverse magnetic field with respect to the ribbon axis [5].

B. Multilayered ferromagnetic materials

Multilayered ferromagnetic structures, consisting of bounded layers of the soft and hard magnetic alloys, can achieve exceptional hard magnetic properties. Hence nanocomposite materials are also suitable for hard magnetic applications. Particular interest is dedicated to increase of the energy product $(BH)_{max}$. This parameter is an expression of maximum amount of magnetic energy stored in a material, and is represented by largest rectangle inscribed under demagnetization curve.

Beneficial improvement comes from combined characteristics of both components: soft magnetic phase contributes with large saturation magnetization, while hard magnetic phase is responsible for high magnetic anisotropy and coercivity [10].

Such magnetic compositions are referred to as exchange spring magnets [11]. Nucleation of reversed domains and domain walls formation in the soft magnetic phase is impeded by the exchange coupled hard layer (Fig. 3). This results in the high value of coercivity, as the demagnetization of the soft layer in the low-field region is avoided. On the other hand, major demagnetization curve is a characteristic of a single, soft magnetic component, despite the presence of the hard phase.

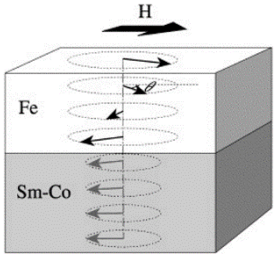

Fig. 3. Representation of the exchange spring state in hard (Sm-Co)/soft (Fe) magnetic bilayer [12].

Several theoretical [13], [14] and experimental [12],[15] papers have shown, that effectiveness of the coupling depends on the thickness of the soft layer. Controlled magnetization processes in the entire volume of the soft layer are possible only if its spatial dimensions lie within the range of exchange interaction, determined by the value of the domain wall width in the hard phase δ_H.

Soft magnetic layer with thickness lower than critical value is fully coupled to the hard magnetic layer. Magnetic properties of the composite system are averaged, depending on the volume fraction of the individual layers (Fig. 4a). This also applies for the energy product $(BH)_{max}$, as elaborated and derived in [14]. Therefore it is possible to design composition

and structure of multilayer specimen with desired hard magnetic properties.

Increase of the soft magnetic layer thickness above the critical point results in deterioration of hard magnetic performance. Magnetic moments in the soft layer stay parallel to ones in hard layer, if the applied magnetic field is lower than nucleation field. Its value scales as $t_s^{-1.75}$ [13], where t_s is the volume fraction of the soft layer. Further increase above the critical field value causes continuous reorientation of magnetic moments in the soft phase, with angle of rotation rising with distance from the interface. Individual magnetic phases are hence distinguishable due to altered shape of hysteresis loop (Fig 4.b), compared to one of the fully exchange-hardened multilayer.

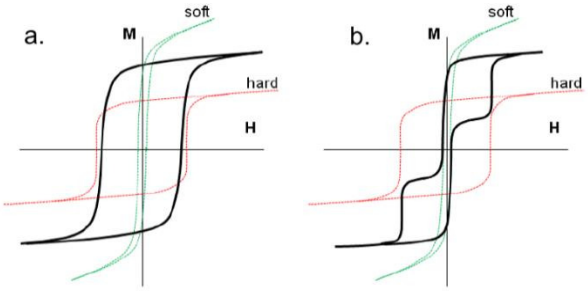

Fig. 4. Hysteresis loop of hard/soft exchange-spring multilayer with soft layer thickness a. below critical value; b. above critical value [10].

IV. First Order Reversal Curves

A. Model

Experimental research of composite materials can focus on either improvement of soft or hard magnetic properties, or study of exchange coupling interactions between individual magnetic phases. Exploration of the latter can be carried out using the First Order Reversal Curves (FORC) method.

Experiment is based on the work of Mayergoyz [16], in which magnetization output signal was characterized as a function of magnetic field input. It was formulated as an identification technique of the Preisach model of hysteresis. This model assumes assembling of the elementary magnetic particles, each represented by rectangular hysteresis loop, so-called hysteron (Fig. 5). Sole magnetic particle is positively saturated (M=1), if the applied magnetic field is higher than characteristic field h_a (up-switching field). Decreasing the field under the h_b (down-switching field) value, a negative saturation is achieved (M=-1), as magnetic moment of the particle changes its orientation. Final shape of the hysteron defines coercivity h_c of the elementary particle, and bias (interaction) field h_m from the surrounding neighborhood.

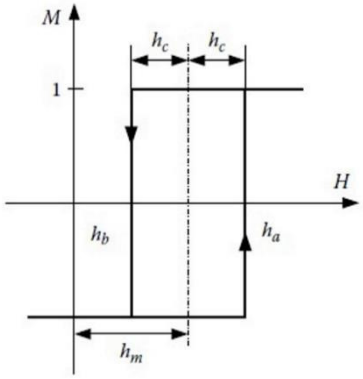

Fig.5. Hysteron of the elementary ferromagnetic particle [5].

Suppose array of non-interacting elementary magnetic particles $P_i(H_{sw})$, described by symmetric non-biased hysterons (h_m=0) oriented in the same (positive) direction. Each particle can be described by one value of switching field $H_{sw}=h_a=-h_b$. Starting a measurement of magnetization at a reversal magnetic field $H_r>-H_{sw}$, orientation of the particle $P_i(H_{sw})$ is not altered, and the total magnetization does not change. If $H_r\leq-H_{sw}$, magnetic moment of the particle $P_i(H_{sw})$ is first to switch to negative orientation. If the magnetization signal is measured during the increase of the magnetic field back to the positive saturation, altered particle switches back at $H=H_{sw}$, thus contributes to the change of the magnetization at point ($H_r=-H_{sw}$, $H=H_{sw}$). Repeating this process with further decrease of the reversal field value H_r will cause more magnetic moments of the particles with $H_r\leq-H_{sw}$ to switch to negative orientation. Magnitude of the contribution to the change of magnetization (i.e. FORC distribution) will be function of the reversal field H_r and value of the measurement magnetic field H.

Assuming presence of the intrinsic magnetic field, generated by magnetic moments of the system of particles, switching fields of individual particles H_{sw} experience shift, caused by change of coercivity and/or bias values. Effective magnetic field sensed by the system is composed of the external magnetic field H and interaction field H_{int}. In general, interaction field, defined as $H_{int}=\alpha M(H)$ [17], offers satisfactory interpretation. Various models, e.g. Moving Preisach Model [18], were also proposed, giving closer insight on the micromagnetic switching events. Value and orientation of the interaction field depend on the character of the magnetic system (magnetizing: $\alpha>0$, demagnetizing: $\alpha<0$) and its magnetic state at magnetic field H.

B. Measurement and calculation of the FORC distribution

Measurement of FORCs starts with the saturation of the sample in sufficiently high magnetic field H_{Sat}. Thereafter is its value decreased to a desired reversal field value H_r. Magnetization is subsequently measured at the increasing magnetic field values H until saturation field H_{Sat}. This process is repeated for several values of H_r, with decreasing trend until $H_r=-H_{Sat}$. In the end, a set of successive FORCs (ideally more than 100) is obtained (Fig. 6). FORC distribution is then calculated as a mixed second derivative with respect to H_r and H [19]:

$$\rho(H,H_r)=-\frac{1}{2}\frac{\partial^2 M_{FORC}(H,H_r)}{\partial H\partial H_r} \quad (1)$$

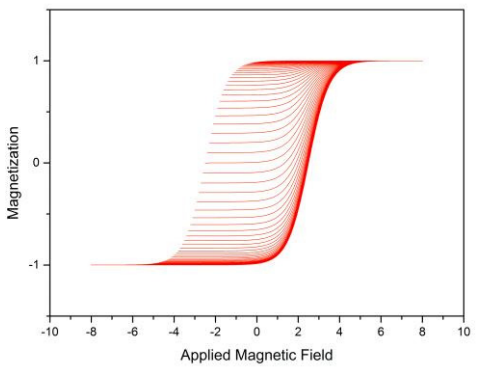

Fig. 6. Set of simulated FORCs.

The FORC diagram is a contour plot of the FORC distribution $\rho=M(H, H_r)$ with H and H_r values on the horizontal and vertical axes, respectively (Fig. 7). Rotating the plot counterclockwise, a new set of coordinates are defined, and the FORC distribution becomes coercivity $H_C= (H_r-H)/2$ and bias field $H_U= (H_r+H)/2$ distribution.

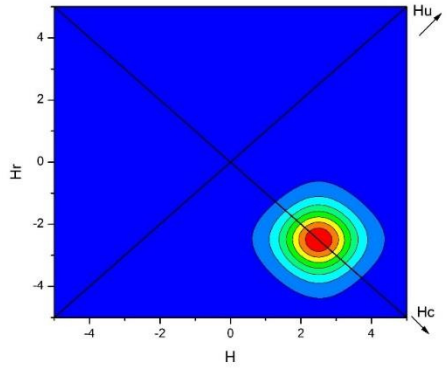

Fig.7. FORC distribution of the simulated set of FORCs from the Fig.6.

From the experimental point of view, FORC method examines susceptibility variation in different intervals of measurement field H. The non-zero value of FORC distribution is obtained only for non-parallel subsets of neighboring FORCs (Fig. 8, one starting at $H_{r,i}$, and another at $H_{r,i-1}$ or $H_{r,i+1}$).

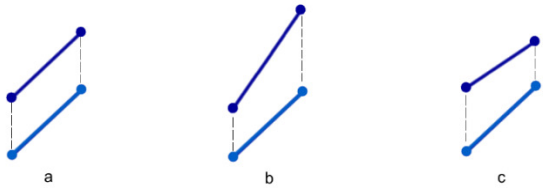

Fig. 8. Curve variation of neighboring FORCs between two measurement field points. Distribution (a) $\rho=0$; (b) $\rho < 0$; (c) $\rho > 0$.

Calculation of the FORC distribution at any point requires a regular grid of points from neighboring FORCs (Fig. 9). Magnetization is afterwards fitted using the second-order polynomial surface function [19], given by formula:

$$M = a_1 + a_2H + a_3H^2 + a_4H_r + a_5H_r^2 + a_6HH_r \quad (2)$$

FORC distribution at the particular point is equal to $-a_6$. Size of the point grid is given by relation $(2SF+1)^2$, where SF represents smoothing factor. Optimum value can be calculated from the standard deviation of residuals σ_r. Ideal degree of smoothing corresponds to the SF value, where $\partial\sigma_r/\partial SF$ has its minimum. Lower SF values may not be sufficient to remove measurement noise. Smoothing at high SF values causes enlargement of the signal contour, masking real magnetization signal.

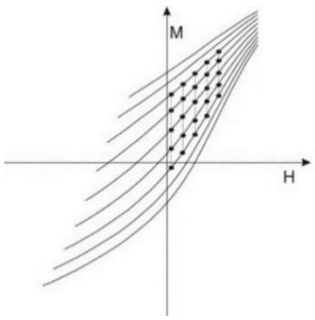

Fig. 9. A subset of nine consecutive FORCs with grid of points given by SF=2 [20].

C. Exploitation of the FORC distribution

FORC method is widely used for phase identification and micromagnetic modeling in fields of physics, as well as geology. Currently, it is commonly used for the exploration of exchange coupling in hard magnetic multilayers with orthogonal anisotropies [15]. Optimization of the interactions within and across individual magnetic phases, with precise design of physical dimensions helps to obtain systems with high magnetic sensitivity and thermal stability. This increases their potential for spintronic and magnetic recording media applications.

Furthermore, FORC measurements are also used, i.a. for research on microstructure development in ferromagnetic materials [21], exchange couplings in soft/hard magnetic multilayers [22] or detailed characteristics of magnetic hysteresis processes [18]. This versatility will be utilized for phase identification and characterization of interactions in the composite ferromagnetic materials, studied within the frame of PhD thesis.

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Making Development Environments Aware of Code Concerns

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***Abstract*—Despite advances in the abilities of integrated development environments, the means of transferring the knowledge gained from code exploration to higher abstraction levels are still lacking. This paper outlines an approach that could elevate the role of code concerns in development environments to facilitate program comprehension. Also the work being done to build a concern model and challenges of visualizing it through concern-oriented code projections are described.**

***Keywords*—code projections, development environments, program comprehension, software concerns**

I. Introduction

Each evolutionary or maintenance activity on a software system requires that the performing programmer understands the problem at hand. However, the process of understanding a program—also called *program comprehension*—is being hindered by the existence of a *semantic gap* between a problem and its solution. Much information regarding the problem is lost or scattered in the implementation and there is no direct mapping from one to the other. Thus, looking at a system implementation, it is hard to answer questions about the original intent behind a particular piece of code [1].

Many tools were created to support program comprehension. As reported by Maalej et al. [2], particularly Integrated Development Environments (IDEs) are used for code reading. Mostly because IDEs integrate many tools that a programmer can use to navigate among related elements within a codebase to more quickly and accurately create a mental model of the solution. But tool support for transferring the gained knowledge to a higher level, i.e. to understand the *problem* being solved by that solution (whether a concern realized by the code, or even the original programmer's intent), is still lacking in contemporary IDEs. This state can be attributed primarily to the endeavor of IDE makers to render their tools usable "out-of-the-box", i.e. just with the information available from a particular source code. Another issues is a dominant system decomposition created by an author of the code that may not fit naturally with a workflow preferred by other programmers. Combined with a lack of contextuality of the IDE tools [3], programmers need to navigate through a much larger amount of code than is necessary for their current task.

In our previous work we have explored possibilities of bringing code concerns into focus within development environments [4]. Our proposed approach, also described in [5], tries to leverage the idea of *code projections* in a sense of providing dynamic views of a system implementation.

II. Approach Outline

The ability of contemporary IDEs to work with a parsed code representation was pivotal for transition from treating code in an editor just as a string in a buffer to a projectional editing [6], where knowledge of a code structure can enable multiple code representations. A kind of a middle ground between these two approaches is currently occupied by parser-based IDE editors [7]. A parser-based editor has access to an IDE-specific form of an abstract syntax tree of the code being edited and uses it as a model for code structure-aware features, like semantic code highlighting, contextual code completion, or refactoring.

The core idea of our approach is to use this just described IDE property to achieve integration of concerns and their subsequent visualization providing a higher-level context to the code. The approach is described in the following three steps: (1) integration of concerns, (2) projection building, and (3) projection visualization.

A. Integration of Concerns

Metadata describing concerns can be found in different forms. For example, in code-level decorative markings (e.g., Java annotations) [8], in structured comments, or even other—external to the code—software system artifacts (e.g., history of a version control system [9]). Feature location techniques and tools often produce lists of relevant program elements [10].

All these data can be used, after transformation to a unified format, to augment the code model built by an IDE. This model can then be utilized in various IDE views to make them aware of the identified concerns.

B. Projection Building

A code projection built according concern-related metadata, further referred to as a *concern-oriented projection*, can be described as a view of (a subset of) program elements pertaining to chosen concerns, and possibly through relations of code elements. Thus there need to be a way for a programmer to specify properties of program elements that should be included in a projection.

Projection building can be realized with a special query language that would operate on the concern-augmented code model. Such query language can be based on existing program query languages, but it has to support querying custom metadata.

C. Projection Visualization

The goal of concern-oriented projections is to provide alternative perspectives on a source code to facilitate program comprehension. Thus, the resulting visualization needs to be understandable and unambiguous with regard to the original source code.

The requirement of understandable projection should be achievable by preserving a sufficient context from the scope of the original code fragment in a projected view. The means to achieve this may be similar to existing user interface features that extend the displayed context in editor windows, like minimap highlighting and gutter icons.

III. Capturing the Concern Model

To integrate concern metadata into a code model (thus creating a *concern model*), it is important to determine the types of program elements that can be associated with a concern; a too coarse granularity level can lead to loss of details, while a too fine one increases the effort needed to capture the concerns. As we show in a previous review [11], tools managing code concerns usually use a granularity level of classes, class methods and fields. In the same paper we described a case study conducted to learn which concern granularity levels would be used by programmers in a manual code tagging in their own code. The result was that apart from the mentioned granularity levels, the statements level (usually sub-method code fragments) seemed to be also useful.

For the aforementioned study, we created a custom code tagging tool as an Atom[1] code editor plug-in. This editor does not feature a parser-based infrastructure, but it was not relevant for the created tool and the editor provided a simple to use API. Later we added a proof-of-concept code projection combining all fragments tagged with the same tag into a single virtual editable "file" (see Fig. 1). It works by creating a new text buffer from all the relevant code fragments and proxying all edits to the original location. Unsurprisingly, the limitation of not knowing the code structure quickly showed up. Primarily because there was no direct way (other than using external, language-specific tools) to process context of fragments tagged at the sub-method level.

As a follow-up to this work, we are working on a plugin for *IntelliJ IDEA*[2] IDE, that will provide means for assigning concerns to specific types of code elements, going down to the statement granularity level. The types of concern-assignable code elements will be configurable to allow a comparison of different concern model granularities with regard to a balance between provided details and a cost of creating such model.

IV. Future Work

The tool for capturing a concern model, built within an IDE with a parser-based infrastructure, will serve as a basis for experiments focused on visualizations of these concerns in the editor and other IDE views. *IntelliJ IDEA* IDE supports custom data providers that can be used to achieve filtering or augmentation of views showing code structure. The main focus and challenge, however, will be on an in-editor projection of concerns. Even though the IDE provides an interface for working with the parsed code representation, the underlying editing is still being done on a text buffer representing content of a file. And from the evaluation point of view, two main research questions should be answered. First on effectiveness of the additional *statement* concern granularity level and second on the usefulness of in-editor concern-oriented projections for program comprehension.

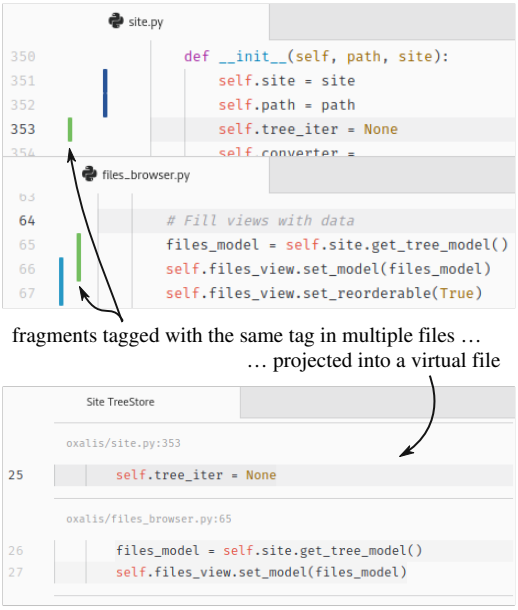

Fig. 1. Projection with the Code Tagger tool in the Atom code editor

Acknowledgment

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Modeling Fun Factor in Electronic Entertainment and Video-Games

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***Abstract*—With hundreds of millions worldwide market revenues, it is surprising that mostly self-report methods are still the only metric used for assessing user experience in electronic entertainment (EE). The fun factor of EE consumers is difficult to measure using only such methods, which is why we propose a model based upon correlations of psychophysiological measurements and self-report methods. Focusing on autonomic nervous system which control involuntary physiological responses, we will eliminate subjects' bias and interpretation difficulties. We will use multiple psychophysiological measurements - heart rate, electrodermal activity, respiratory activity and electroencephalogram in combination with self-report methods to create dataset for our research. Using several methods for processing and analyzing time-series data we will be able to determine which of selected measurements affect the fun factor of EE consumers during their experience. In initial set of experiments, we successfully collected heart rate data of the subjects and found several observable patterns in its experience.**

***Keywords*—Fun factor, Psychophysiological measurements, Electronic entertainment, Correlations, Time-series data**

I. Introduction

Electronic entertainment (EE), especially video-games has undergone an extensive growth over the past decade. In USA alone (country with biggest video-game market) the sales went from $7.3 billion in 2006 to $23.5 billion spend on game industry in 2015 - see Fig. 1. Global value of video-game industry is in the neighborhood of $99.6 billion, with estimated $120 billion until 2019 [1].

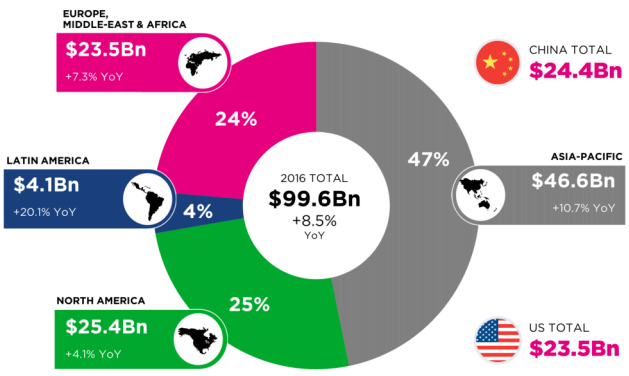

Fig. 1. Year-over-Year (YoY) analysis of video-game industry in 2015 done by Global Games Market.

Companies creating electronic entertainment content are gathering as much data about their customers as possible. Considering that most of the EE content is consumed online, the data are fairly easy to collect. According to Zook [2], leading development companies even collect data that are seemingly not directly connected to gameplay or other content to be used in the future.

Yet, the assessment of user experience in video-games is still done using old-fashioned self-report techniques, such as questionnaires and interviews. We propose an approach for assessing players' experience more effectively while eliminating some disadvantages of self-report techniques such as untruthfulness or emotional bias. Using different psychophysiological measurements, we plan to create a model of fun factor of players. We will investigate correlations between these measurements in combination with players' self-report. After creating the model, we will attempt to find patterns which should help developers predict how players will react to particular events in the future. Also, one of the goals of the work will be to compare several selected methods based on their performance in modeling the fun factor of players.

II. Problem Domain

In this paper we will be focusing primarily on video-games as an EE domain. Even though movies are also an interesting field for future research, significant amount of past research about video-games in combination with our interest and experience made video-games the main goal of our research. Also, unlike video-games, the movie industry has significantly smaller European market in comparison to USA, which in combination with our plan to address results of our research to business sphere has made video-games our priority. Nevertheless this research still briefly pursue movies as a domain for psychophysiological measures research.

A. Autonomic Nervous System

Based on previous research, where different psychophysiological measures were proven as good indicators of stress and arousal [3], we have chosen several of them for our work. All the measurements used in our research are parts of a human nervous system, more specifically the autonomic nervous system (ANS), which controls involuntary physiological responses. One of the most important features of measurements controlled by ANS is that they function automatically - therefore can not be affected or controlled willingly, reducing the risks of unsuccessful experiments. Initial experiments have

already proven that using absolute values of psychophysiological measures is not practical due to major variability in readings connected to subjects' states prior to the experiment. Instead, the deviation from average values of subject in each experiment session will be used. In Fig. 2, we show three sessions of experiments performed by same subject where average HR of subject is varying significantly even though the experiment setup and time of day remained the same.

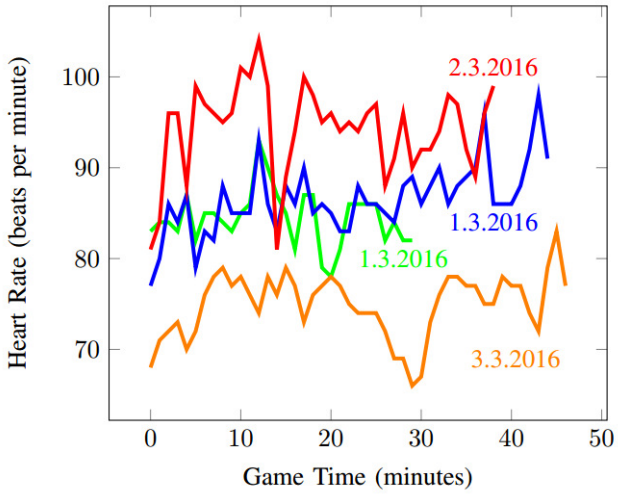

Fig. 2. 4 games of Dota 2 played by tested subject in 3 sessions.

B. Psychophysiological Measurements

Implementing psychophysiological measurements (PPM) has to be done very carefully and with great care due to the many variables that can alter the result. Temperature, humidity, attachment of electrodes, individual differences, differences concerning gender (womens' readings even differ depending on the menstrual cycle), age, time of the day, consumed stimulants such as coffee or energy drinks, medicaments, drugs, etc. can cause different reactions in sensors and in people [4]. Following is the list of psychophysiological measurements we plan to use in our research:

1) **Heart Rate + Heart Rate Variability (HR)** is a measure of cardiovascular activity which reflects emotional state [5].
2) **Respiratory Activity (RA)** is measured as the rate of volume at which an individual exchanges air in their lungs [6].
3) **Electrodermal Activity (EDA)** measures the activity of the eccrine sweat glands and is said to correlate linearly to arousal [7].
4) **Electroencephalography (ECG)** provides data about the brain's electrical activity with millisecond accuracy, for example it's processing of visual emotional stimuli [8].

III. Methods

In order to measure fun factor in video-games we should be able to model relations between changes in psychophysiological measures and subjects' emotional states. Our experiments will produce simple time-series data (see Fig. 3) which should prove straight-forward in order to model such relations. Furthermore, possibility of previous states affecting subjects'

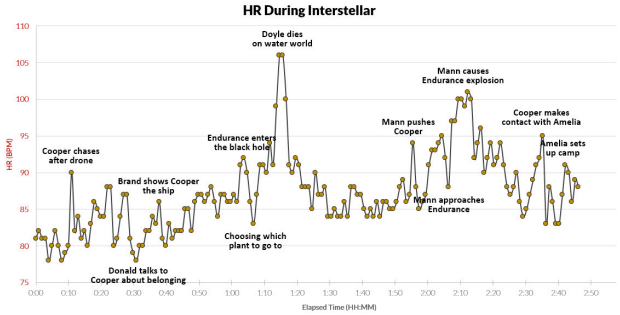

Fig. 3. HR of a subject watching the Interstellar movie.

present emotional state procure the need to take these into account. This means using methods that are able to consider such specifics, such as:

1) **LSTM Neural Network** should be able to exploit possible dependencies of consecutive psychophysiological values in our data.
2) **Hidden Markov Model** may provide some hidden (unobservable) patterns in time-series data which we will gather during the experiments.
3) **Random Forest** should allow us to extract rule-represented knowledge from successfully trained model.

IV. Previous Results & Future Work

We have already published results of some initial experiments that have been done in our research [9]. During these experiments, one subject participated in 18 games of Dota 2 [10], consisting of approx. 20 hours of gameplay. These experiments exposed several interesting patterns, concerning both game-specific events as well as overall useful facts about the measurements. We repeatedly detected increased HR in specific game situations (deciding fights, first contact with opponent) or decreased HR in times subject waited for his character to respawn after death.

However, as stated in Sec. I, for successful training of fun factor model, simply measuring psychophysiological states of subject is not sufficient for prediction purposes. We plan to combine these measurements with specifically designed interviews as well as video recording of subjects' gameplay in order to determine fun factor of the subject. With this information, experiments should pose as a training set for our model, with goal to predict fun factor of players in the future.

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Modular multiport power converter

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***Abstract*—The paper is dedicated to design of multiport power converter. In the paper, short introduction into the topic and comparison of conventional converter and multiport converter topology is described. Next, design challenges of proposed converter are presented. At the end, future steps of research are proposed.**

***Keywords*—multiport, power converter, microgrids**

I. INTRODUCTION

With growing usage of renewable energy sources, such as fuel cells, photovoltaics, battery systems, etc., in different applications, the need for reliable power conversion systems that interconnects these sources is in great demand. The main disadvantages of different sources and loads connection in single system are their different supply voltage levels. Interconnection of these sources and loads may be realized differently.

Most common method is to use several DC/DC or DC/AC converters using one or more DC or AC bus (see Fig.1). This topology requires multiple energy conversions. The main disadvantage of these traditional solutions is the low efficiency due to the utilization of the additional converter for the energy storage system. Also, the multi-stage architecture may result in increased size, lower power density, and relatively high cost [1][2].

Other method to interconnect different electrical sources and loads is to use multiport converter (see Fig. 2). Multiport converters are able to transform energy from one port to any other in one conversion step. In applications with very different voltage levels of connected sources and loads multiwinding transformers are used.

TABLE I
CONVENTIONAL AND MULTI-PORT TOPOLOGY COMPARISON

	Conventional topology	Multi-port topology
Common bus	yes	No
Conversion steps	More than one	Minimized
Control	Separated control	Centralized control
Power flow management	complicated	Simple, fast
Transformer usage	multiple	Single multiwinding / multiple parallel connected
Implementation effort	high	Low
Semiconductor switches	multiplied	reduced

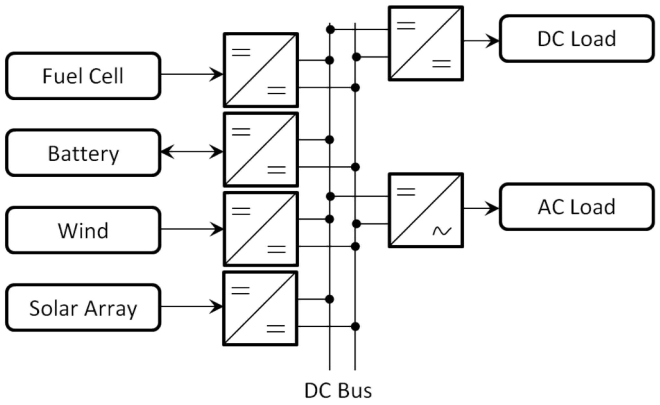

Fig.1Conventional topology

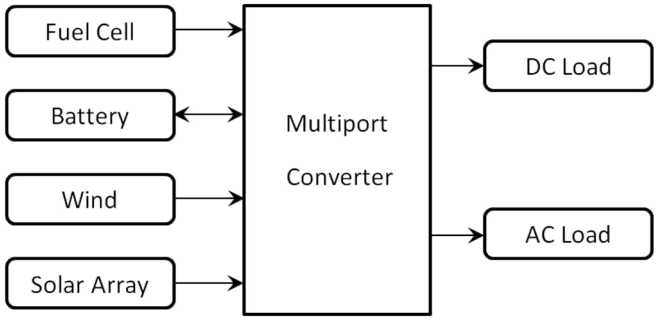

Fig. 2Multiport converter

II. MULTIPORT AGAINST CONVENTIONAL STRUCTURE

In applications where an energy storage element is indispensable, at least one port connecting the storages should be bidirectional. In general, all ports are considered as bidirectional. It means that there is no need to explicitly distinguish input sources or output loads. Therefore that type of converters are called multi-ports instead of multi-input or multi-output converters. [2] [4]

Multiport topology disposes with an advantage against conventional structure in terms of the number of power devices and conversion steps. Number of power devices is reduced because there are shared. Less power switches results in higher system efficiency caused by reduced switching loss. Multiport structure is very promising from the viewpoints of low cost, centralized control and compact packaging. Closer comparison is listed in Table I. On the other hand, converter is more complex, so its design and control is more challenging.

III. Proposed Multiport Converter

Our work is focused on multiport converter for electric vehicles and house microgrids with strong emphasis on modularity. In this case, modularity means, that some converter parameters, such as number of ports, power and type of sources and loads connected to the converter, may be modified as simple as possible. Therefore, using multiwinding transformer in power converter is not suitable. Multiwinding transformer should be designed for certain application. Removing windings from multiwinding transformer is not so complicated. Arose air gap causes increasing of the leakage inductance and that results in worse transformer efficiency. Adding windings may run into core geometry limits. Moreover, transformer core had to be designed to maximum power of all sources. If one source would be added, whole transformer core should be replaced. These limitations are abhorrent with our application.

Proposed converter should use several two winding transformers connected in parallel (see Fig. 3). Thank to this number of energy conversions compared to conventional topology should be reduced. Besides, contrary of the classic multiport topology high modularity will be preserved.

Except modularity, low weight and size of the converter is also very important. Therefore, high frequency planar transformers will be used. Planar transformers dispose low loss and great heat dissipation [5] [6]. Also volume will be low with use of planar EI core.

Proposed converter should be able to maintain several different sources which are listed in Table II.

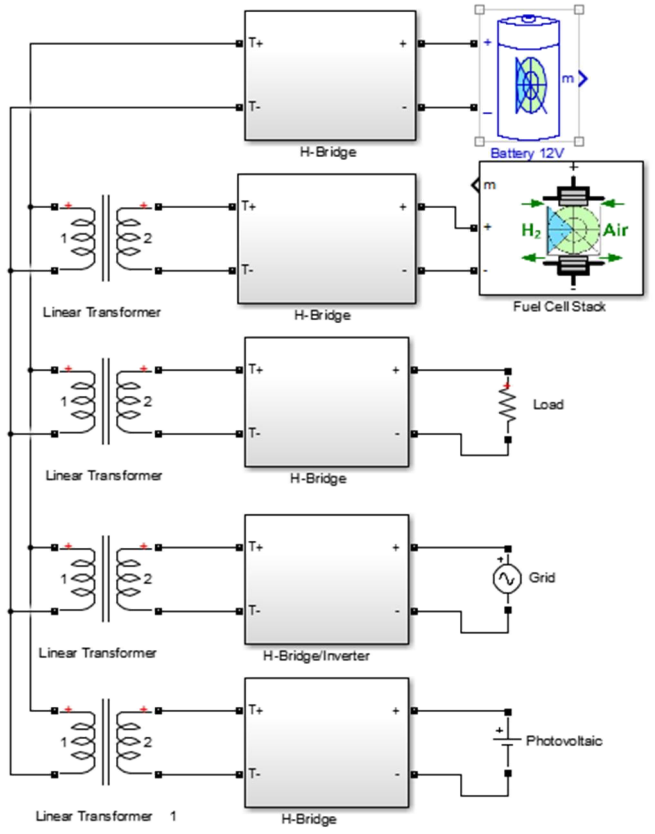

Fig. 3Proposed multiport power converter

TABLE II
SYSTEM RATINGS

	Max. Power [W]	Operating voltage [V]
Battery	300	10-14
Fuel cell	720	20-45
Solar panel	240	29-36
Grid	-	220~
Load (synchronous motor)	3000	3x83~

IV. Future Research

Based on the analysis of the multi sources converters the future research activities will be aimed on the specification of design for our converter. Design has to be simulated, optimized and evaluated. Control strategy for each converter cell has to be designed and implemented. After that, we will develop higher-level control system. That system should be able to control certain cells. In addition, it should manage all sources by different modes (high power consumption, high power production) and predict them by certain criteria.

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Monitoring Infrastructure for Better Healthcare

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***Abstract*—Because of the increasing number of elderly and disabled people, there is an urgent need for a real-time health monitoring infrastructure for analyzing patients' healthcare data. Healthcare Industrial IoT is a combination of communication technologies, Things (devices and sensors), interconnected apps, and people that would function together as one smart system to monitor, track, and store patients' healthcare information for ongoing care. This paper deals about concept definition of a platform that connects advantages of the IoT technologies with the emerging cognitive computing and will be applicable in the areas such as Smart Home, Industry 4.0 or HealthIIoT.**

***Keywords*—IoT-driven healthcare, Cognitive computing**

I. INTRODUCTION

Nowadays, there is a big drive for implementation of cognitive computing solutions that are patterned after several key aspects of human thought. Cognitive Expert Advisors are in the top of the Gartner Hype Cycle for 2016. It is expected that the Healthcare Industrial IoT (HealthIIoT) will be one of the main players in the Industrial Internet of Things (IIoT). HealthIIoT is a combination of communication technologies, things, apps, and people that would function together as one smart system to monitor, track, and store patients' healthcare information for ongoing care. [1] Currently, HealthIIoT is still in its preliminary stages with regards to design, development, and deployment. IoT has the potential to rise many medical applications such as remote health monitoring, chronic diseases, and elderly care patients. Therefore, various medical devices, sensors, and diagnostic and imaging devices can be viewed as smart devices constituting a core part of the IoT. [2]

II. INITIAL STATUS

IoT platforms currently focus on connecting a set of sensors and devices to collect, record, transmit and share data for possible analysis. We want to focus on algorithms for smart data acquisition and low battery consumption and broaden possibilities with advanced machine learning (ML) algorithms such as cognitive computing. We have specified following technical and research tasks:

1. Survey of cloud providers, IoT services and ML frameworks.
2. Smarter data acquisition with use of ML models, which encrypt and filter data, and therefore they save costs for connection and cloud services.
3. Create methodology for better application of ML algorithms, such as Deep learning, as cloud services for data analytics from ubiquitous IoT devices.

III. TASKS SOLVED IN THE PREVIOUS YEAR

In previous research, we focused on problems from data acquisition up to data mining and visualization. We can divide them into these problems:

A. Survey of cloud providers and machine learning methods

We did a survey of cloud providers, ML methods, and we used them for control of systems with slow dynamics. We published some results at the conference K&I 2016. [3] Furthermore, based on our experience and surveys such as [4], we applied for grants. Now we have granted access to the two of the most promising IoT platforms - IBM Bluemix and Microsoft Azure.

B. Case studies of data analytic tools

We have analyzed user requirements and their work with the data analytics solutions in the industrial and IT companies. We noticed that no matter how high their expectations are, they use only basic functionality of these solutions. We published our findings and principles for better choose of data tools and the way of better data presentation for industrial employees at the conferences SAMI 2015, 2016, and 2017.

C. IoT Gateway for better data acquisition

We described smart IoT gateway that focuses on data acquisition, integration at conferences APMS 2015, 2016 and broaden it for ML services and predictive control. [5] Thanks to advanced data acquisition, we save network traffic and costs for cloud services. Nowadays, we are implementing these ideas in the startup named Enterprise IoTNet.

D. Startup competitions

Nonetheless, we were successful at several startup competitions with the idea of smart devices connected to the cloud platform that helps with health care and decision-making process. Last year we obtained grant FEI-2015-34 with a proposal of CHECkuP - Cognitive HealthCare Platform. This platform should be core of my dissertation.

E. Training for the patients with spinal cord injuries

I completed training in the United Kingdom and had a chance to work with patients with Spinal Cord Injuries (SCI) in the summer and winter of 2016. Patients with ICS usually require 24/7 care; therefore there is an urgent need to have someone trained nearby patient at any time to prevent serious situations as an autonomic dysreflexia or a death. On the following picture, there is fully ventilated patient with C1 SCI.

Fig. 1. Picture that shows patient with spinal cord injury that is fully ventilated, machines for cough assist and ventilator with humidifier

IV. Concept of Cognitive HealthCare Platform

This concept of platform is suitable for Smart Home, Industry 4.0 or HealthIIoT. In this case, our platform constantly monitors activity and life conditions nearby patients and it tries to avoid critical situations. It consists of independent blocks as you can see on the following picture.

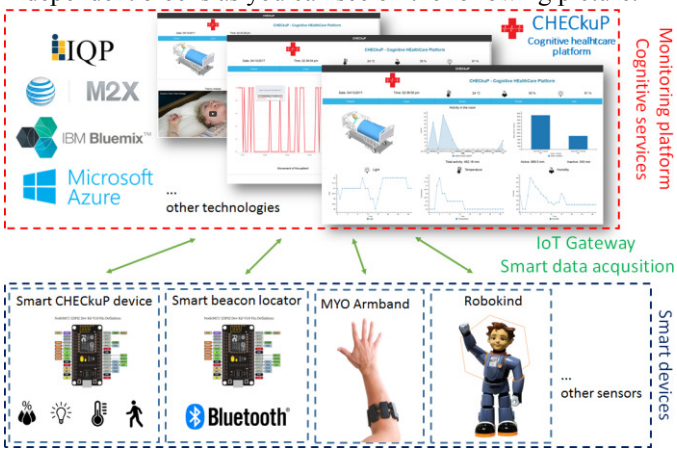

Fig. 2. Platform consists of independent blocks that are interconnected [6]

A. Smart embedded devices

We have developed and used set of devices based on the cheap Node MCU WiFi modules with several sensors that are connected via IoT Gateway to the cloud. We use IBM Bluemix IoT services. We see research possibilities in algorithms for secure data flow and low energy consumption.

B. IoT Gateway

The proposed platform collects data from sensors and sends only important data to the cloud. In the gateway, there are methods that filter data based on the rate of change and information entropy. It sends only important data to the cloud that are encrypted by a deep auto encoder. We also considering the use of other networks such as LoRaWAN.

C. Monitoring platform

Hence, we detect unusual situations; we are able to send notifications to selected people and use, for example, robot Hanson for feedback from the patient. Data are stored only for few days and then deleted. Thanks to this features platform can use only lite versions of cloud services and runs for free.

V. Future Work

In future work, we want to focus on the development of other sensors, implementation of cognitive services and we want to create metrics to measure numbers critical events for evaluation. We are also planning to test proposed platform and measure quality of care for SCI patients. We can divide and summarize our plans in the next paragraphs.

A. Additional sensors that broaden research possibilities

We want to add more sensors and buy development platform for eHealth applications called MySignals from Libelium [7]. Therefore, we will have physiological data of the patient and it will allow us building models that are more precise. Interconnected wearable patient devices and healthcare data are subject to security breaches where we see another good research topic. There are already described techniques like watermarking to minimalize those threads [1].

B. Implementation of cognitive services

Cognitive services together with deep learning should help with decision-making. We have already done a survey and we are planning to use Watson from IBM. One of the versions of Watson includes medical literature, patents, genomics, and chemical and pharmacological data that researchers would typically use in their work.

VI. Conclusion

In this paper, we presented actual status and plan for cognitive healthcare platform. We have been quite successful with these ideas at several StartUp competitions last year. We have already done monitoring part with the set of devices that connect via IoT gateway to the cloud where we are detecting unusual situations. In the future, we are planning to broaden our platform for a new set of sensors and implement cognitive services together with deep learning that should help with decision-making. After that, we want to implement and hence improve care of patients with spinal cord injuries.

Acknowledgment

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Multi- objective Optimization and Decision Making Problems of Assembly Lines

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***Abstract*—This paper summarizes my recent work in the field of multi- objective optimization of assembly lines. Introduction to the topic is followed by tasks and results from previous years. Up-to- date research tasks are closely described in the main part, followed by the description of the future steps leading to finalization of my thesis, with focus on the engineering and scientific contribution of my dissertation.**

***Keywords*—assembly lines, modeling, criterion, multi- objective decision making, multi- objective optimization.**

I. Introduction

Both decision making and optimization are the subject of many research teams throughout the world, mainly because of the wide usage possibilities and wide range of decision making and optimization methods. Computational processing of these methods enables people to leave the decision making on the algorithms built on mathematical basis. This fact ensures the objectiveness of the decisions and strategies chosen by these methods.[1]

Main goal of my research is the definition of complex methodology for assembly line optimization with focus on finding the optimal assembly line configuration and optimal production process definition.

Means of multi- objective decision making (MODM) and multi- objective optimization (MOO) were chosen, because in most cases, more than one criterion has to be taken into account while solving decision making problem. Also, more than one main objective can be defined in optimization problems dealing with assembly lines (profit, time, efficiency, environmental effects, reliability, safety etc.).

Due to lack of the experimental data, my research also deals with the modeling of assembly line processes in order to realize experiments and raise the data for further processing and usage in MODM and MOO processes.

II. Previous Tasks and Results Achieved in the Research Field

In order to define the complex methodology of assembly line optimization, tasks within my research can be split into 3 main categories:

- modelling of the assembly lines,
- multi- objective decision making,
- multi- objective optimization.

In modelling, models of assembly lines are developed using Stateflow diagrams within the Simulink library of the MATLAB environment. During previous years, model of the Flexible Manufacturing Company (assembly line in DCAI) was created. Its detailed description was published in [2].

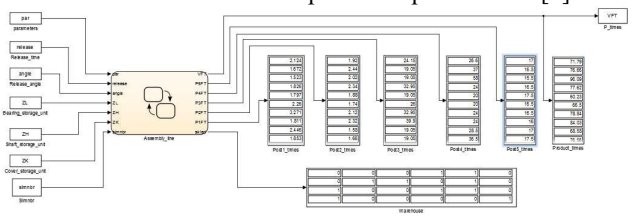

Fig. 1. Stateflow model of Flexible assembly line

During previous years of my postgraduate studies, I was working on many tasks dealing with MODM. Computational processing of many different MODM methods was realized (ELECTRE I – IV, AGREPREF, TOPSIS, AHP). Application use of these methods in solving optimal assembly line configuration task can be read in [3] and in my AEI article: *Solving optimal assembly line configuration task by multi-objective decision making methods,* which is now under review process. Theoretical background of these methods can be found in [4]. Another potential of use of the MODM methods can be found in [5].

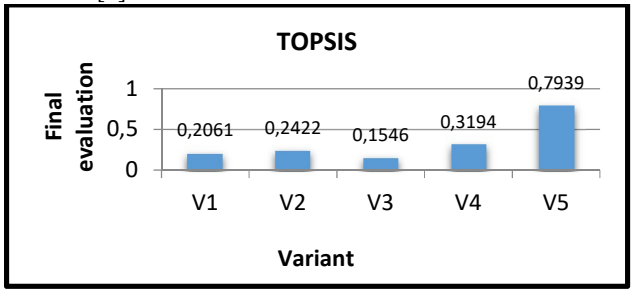

Fig. 2. Results of TOPSIS methods used for solving optimal assembly configuration problem

Dealing with the problem of optimal production plan of mixed – model assembly line, methods defining of the set of non- improving elements and compromising methods were implemented into the MATLAB environment in order to solve tasks of MOO of assembly lines. Closer description of the application solving these tasks can be found in [6].

III. Tasks and Results Solved in Last Year

Tasks described in this chapter are realized within our group

in DCAI. Its other activities are the main topic of [7].

A. Stateflow models of assembly line and queueing system

Designing the model of assembly line is the necessary step in further MODM or MOO process, because outputs of the model are used for proper evaluation of the criteria. Furthermore, with the model it is easier to find the weak spots in production process and adopt the solutions before building an actual assembly line.

Parameters from both simulation models of assembly lines are transferred into another Stateflow model: model of queueing systems.

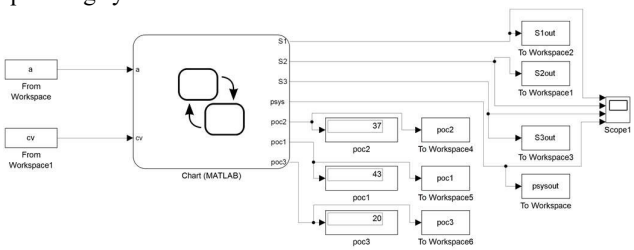

Fig. 3. Stateflow model of M/M/c queueing system

This model can simulate the situation, when there is more than one identical workplace in particular weak spot (place, where overlays take place and production process is not fluent) of the assembly line. Model can cope with various inputs both for the queue and for the service (exponential distribution, Gaussian distribution, continuous uniform distribution etc.).

Outputs of this model (number of products constructed on particular workplace, percentage of using of every workplace, number of used workplaces in particular time) will be used in evaluating possible alternatives in finding optimal configuration of assembly lines. Outputs of both model are exported into MS Excel, what makes the data available for further processing and analysis.

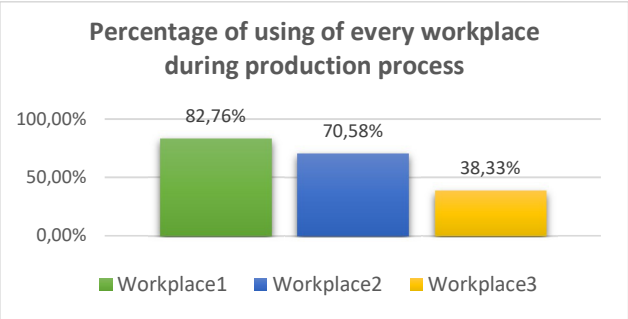

Fig. 4. Further analysis of simulation data

The other of part my recent research was focused on finding key parameters (likelihood of waiting in queue, inputs and service intensity, average waiting time, average service time, average time in queueing system etc.) of two types of queueing system (M/M/1, M/M/c), so queueing systems with 1 queue and 1 or c service places. Theoretical background of these methods can be found in [8] and [9]. Scripts with counting these parameters of the simulations were implemented in MATLAB environment and their outputs are used in MODM and MOO processes.

B. Information system AMANDA

Our research group is also working on Experiment ALICE on LHC in CERN: Study of strongly interacting matter at extreme energy densities. Within this project, I am the part of research team working on the upgrade of information system for off- line data access called AMANDA. This system provides users with the information about values of various elements, which can be downloaded from CERN server and subsequently used for further data analysis.

IV. Future Research Steps

In my future research, emphasis will be given to synthesis of various MODM methods in order to bring more objectivity into the decision making process.

Part of my future activities will be also dealing with finalization of complex methodology for decision making process, from choosing the objectives and criteria, through proper evaluation of their weights and relevance for particular criterion in order to find best solution for MODM problems.

In MOO, my research will be focused on combination of mathematical methods and methods of artificial intelligence, where goal is to find the best solution for various MOO tasks dealing with assembly lines. All these steps and goals should lead to finalization of my dissertation.

Acknowledgement

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Multiple Static Person Detection, Localization and Estimation of Their Respiratory Rate Using Single Multistatic UWB Radar System

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***Abstract*—In the past period, great efforts have been made to develop methods for the people detection based on monitoring their respiratory motion using ultrawideband (UWB) radar. The basic principle of the respiratory motion detection consists in the identification of signal components obtained from a sensor possessing a significant power in the frequency band 0.1 -- 0.7 Hz (frequency band of human respiratory rate) corresponding to a constant range between the target and radar antennas. An approach for a joint localization and breathing rate estimation of persons will be introduced in the paper. The performance of the procedure to be proposed here will be evaluated for the experimental scenario intent on through-the-wall localization and respiratory rate estimation of two static persons using single UWB radar employing one transmitting and two receiving antennas.**

***Keywords*—UWB radar system, target detection, target localization, Welch periodogram.**

I. Introduction

In the recent years a society is facing the various unwanted trends. Increasing number of the terroris attacks in the recent years and higher security risks are one of the main reasons for a demand of the constant monitoring of the public areas. Also, objects like power plants, water reservoirs or other critical points of the infrastructure has to be protected even better. Therefore, an acknowledgement about the possible intrusion into such critical objects is very needful. Especially, there is need to detect the presence of the unknown people. For this purpose, an UWB radar can be used with advantage.

For its operation, an UWB radar emits a high-resolution signal spread over a frequency band of width $B \geq 0.5$ GHz. The signal has the ability to penetrate through various solid non-metallic obstacles e.g. walls, furniture etc. Emitted signal partially reflects from all objects and persons that are present in a monitored area and travels back towards the radar antennas.

A standard antenna configuration used within our measurement consists of one transmitting antenna (marked as Tx) and two receiving antennas placed from both sides of the Tx antenna (marked as Rx). By this way it is possible to detect and even localize a living person within the monitored area.

UWB radars are already able to detect and localize a moving person e.g. [1]. Our previous research [2] shows up a detection and localization of a static person, even with an estimation of his respiratory rate. Static person can be defined as a person which co-ordinates are not changing. The only observable movement of a static person is the movement caused by a respiration i.e. breathing.

In this paper, this method is evaluated on a scenario where two sitting human targets are situated in a room without doing any movement except of a respiratory motion. These targets are illuminated by a signal from an UWB radar. The targets are situated in such a way that a shadowing effect appears between them [3]. Moreover, an estimation of their respiratory rate will be performed.

The performance of the introduced procedure will be illustrated for through-the-wall scenario with the presence of two static persons. The achieved results will show that the proposed procedure can provide the robust detection, the good accuracy of localization, and the respiratory motion frequency estimation as well.

II. Detection of Static People Through Their Respiratory Motion

UWB radar used in our experiments transmits a signal spread by a binary sequence (specifically M-sequence) that is reflected back to the Tx antennas by all illuminated objects. Current state of the monitored area is stored in so-called impulse responses that are grouped into a so-called radargram. Radargram is represented by signal propagation time (so-called fast time), observation time (so-called slow time) and by a signal amplitude. The example of a radargram for the presented scenario is depicted in Fig.1 and Fig.2. Static person can be found within a radargram at a constatnt value at fast time axis, with the changing amplitude value along the slow time axis. Spectral analysis of such signal can show up the frequency components of this signal within the frequency range 0.2 Hz – 0.7 Hz.

The static persons can be localized using the procedure of UWB sensor signal processing that is presented in [4]. This procedure consists of a set of phases of signal processing such as background subtraction (implemented by the exponential averaging method), target echo enhancement (implemented by a low-pass filter applied along the observation time axis), target detection (implemented by the combination of Welch periodogram [4] and OS-CFAR detector with guarding interval), TOA estimation and TOA association (implemented by the trace connection method), and target localization (implemented by a simple multilateration-based method). The

detailed description of these methods is beyond this paper. The one and only reader can find more information in [5].

III. Experimental results

UWB radar used in the experiment operates with following parameters: radar type M-sequence; binary sequence length 12 bit (4095 samples per impulse response); master clock 13.82 GHz; impulse response duration 296.3 ns; max. range 44.5 m; range resolution 0.0185 m; measurement speed 20.6 IR/s. The beginning of the coordination system [0;0] is represented by the Tx antenna. Position of the target P1 was set to [-0.44 m;4.74 m] and position of the target P2 to [-0.44 m;1.7 m]. Radar was equipped with three double-ridged horn antennas DRH10. Important results from the signal processing procedure are shown below.

After successful target localization, a breathing rate estimation is computed from the lines of the fast time (and their vicinity). Power spectrum of each selected line is computed and then all the power spectrum estimates that belong to one target are averaged into one periodogram. The peak with the highest value corresponds to the respiratory rate of the particular target.

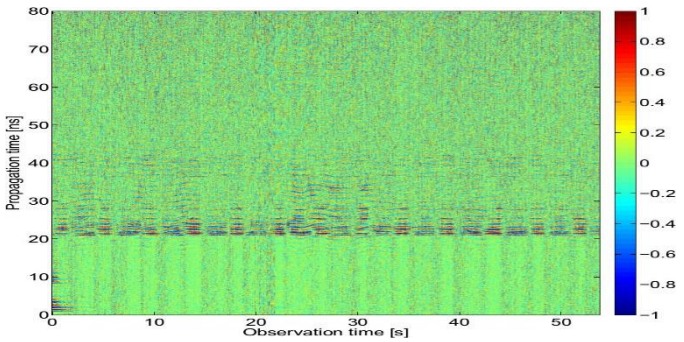

Fig. 1: Radargram after background subtraction

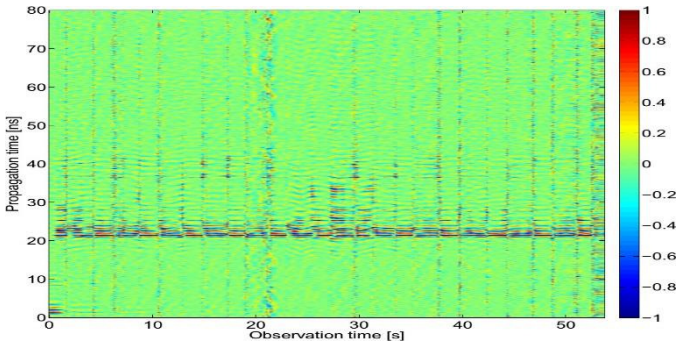

Fig. 2: Radargram after target echo enhancement

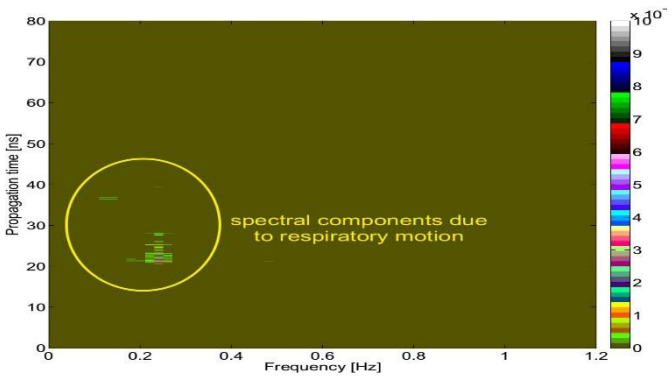

Fig. 3: Radargram after power spectrum estimation

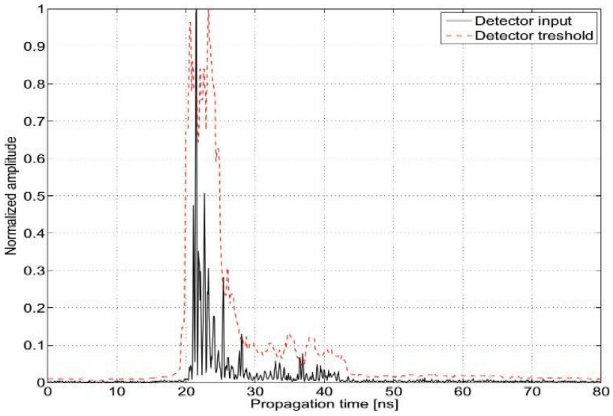

Fig. 4: Integrated target power and detector threshold

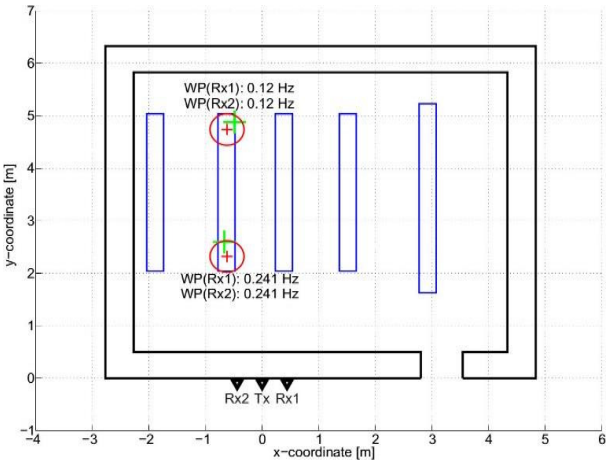

Fig. 5: Target localization and breathing rate estimation using Welch periodogram method

IV. Conclusion

A novel method for multiple detection and localization of static targets by means of UWB radar is presented here. Moreover, respiratory rate for all targets is estimated.

Acknowledgment

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Navigation and Infrastructure in Intelligent Space

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***Abstract*—This paper provides a description of a proposed fuzzy cognitive map based controller and an overview of our proposed Internet of Things infrastructure. A description of these technologies is also provided and it also summarizes the work done in the last year.**

***Keywords*—Internet of Things, Intelligent space, Fuzzy Cognitive Map.**

I. Introduction

The term Internet of Things (IoT) has become rather popular in these past few years, which has led to various new research topics related to it. The term "Internet of Things" was coined Peter T. Lewis in September 1985 [1]. From the perspective of technical standardization, IoT can be seen as a global infrastructure connecting physical and virtual things and enabling advanced services based on information and communication technologies (ICT) [2]. By "things" we understand virtual or physical world objects, which are capable of being identified and incorporated into a communication network. Another way to look at IoT is as an environment in which objects, animals or people are provided with unique identifiers and the ability to transfer data over a network [3]. These definitions greatly overlap with the term Intelligent space (ISpace), which can be defined as a room, or an area equipped with an array of various sensors, embedded systems, information and communication technologies and other devices that allow it to perceive and recognize events happening inside of it. In our field we look into the possibility of combining the advantages and technologies of IoT with those of robotics. In the previous paper we have focused on the definitions of IoT, ISpace and proposed an applicable scenario [4]. In this paper we provide a continuation in the form of a fuzzy cognitive map (FCM) based controller and an IoT infrastructure proposal overview.

II. FCM for Localisation and Path Planning Tasks

As described in [5] FCMs are a suitable candidate for the needs of navigation. In general, a FCM is an oriented graph with nodes representing notions and its edges representing relations (Fig. 1). Notions are generally states or conditions and edges are actions or transfer functions that transform a state in a node to another one in another node. FCMs were originally used for education, but later their modelling and simulation abilities have found their use in technical applications as well [6].

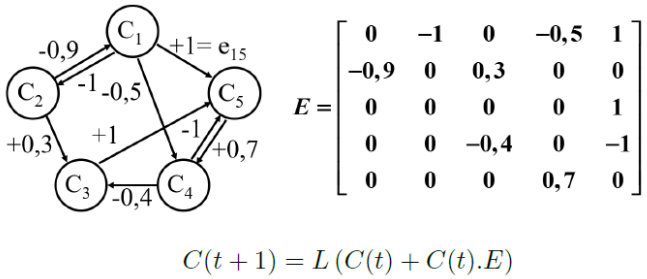

Fig. 1. FCM example with its connection matrix E. [5]

For our purposes, we created an enhanced version of the FCM based navigation system first presented in [7]. Although FCMs are in general closed systems without exclusive input or output nodes, our system implements them for an intuitive interface (Fig. 2).

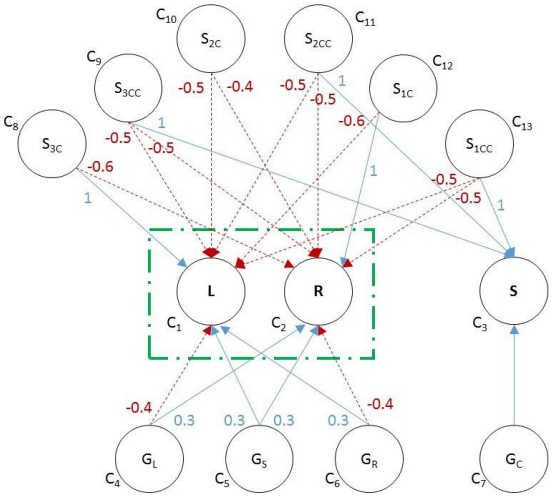

Fig. 2. Design of our controller FCM [5]

The input nodes of our system receive environmental sensor data (from ISpace and robots) and then process them using the appropriate membership functions. This brings the input values into the desired [-1; 1] range, which is necessary for transfer functions to work. The output nodes then represent the decisions the system makes.

To evaluate our system we conducted a number of experiments. As our mobile robots a pair of Lego vehicles was used, one based on NXT and the other on EV3 central brick. For our environmental ISpace data we used a RFID grid similar to one in [8] (Fig. 3). To help us evaluate the experiments an overhead camera was used to monitor the vehicles movements.

Fig. 3. Testing area with robots and RFID tag grid [5]

The experiments were evaluated according to the following criteria were chosen:

1. Percentage difference of the real trajectory compared to the optimal one.
2. The average deviation of the real trajectory compared to the optimal one.
3. Deviation of the real trajectory endpoint from the goal position.

Experiments themselves showed that the implemented system is able to guide the agents to their goals, while also avoiding obstacles and each other. Since our two robots were constructed differently the experiments showed that the system is even able to guide them when their physical parameters are different.

III. IoT Infrastructure proposal

In our previous experiments we relied on rather simple IoT/ISpace setups [5][7][8]. To be able to conduct more advanced experiments and explore further applications we proposed the following IoT infrastructure based on the resources available to us [9].

The network infrastructure of our local area network consists of sensors, clients and a server for Fog computing. Since it is a subset of the Technical University of Kosice network it has access to services provided by the university. Outside of that other external services may be used such as cloud by Microsoft, IBM and Amazon.

Hardware in our center includes various sensors, specifically Kinects and IP cameras with microphones (Fig. *4*). Every Kinect used in our ISpace setup is connected to a Mini-PC, which allows us to use the Kinect as something like an "IP camera" that can stream depth image or color image on predefined ports. Alternatively the Mini-PCs can preprocess the Kinect data themselves and/or send data to a server on the local network or to the Internet cloud. The IP cameras are equipped with a 1-megapixel CMOS sensor and can stream image enabling viewing resolution of 1280x800 at 30 fps [10]. They are used for image processing projects on our local server. Our center also has a number of mobile robots at its disposal. These include Nao, Lego Mindstorms, Turtlebot 2 and Qbo robot. For improved localization accuracy we may use our RFID tag grid.

On the software side the mini-PCs have Microsoft Windows as their operating system and utilize Kinect for Windows SDK and Codding4Fun Kinect Service libraries. The local server is running Windows server 2008 and using the virtualization program Hyper-V it is also possible to run other operating systems like Ubuntu, Cent OS, etc.

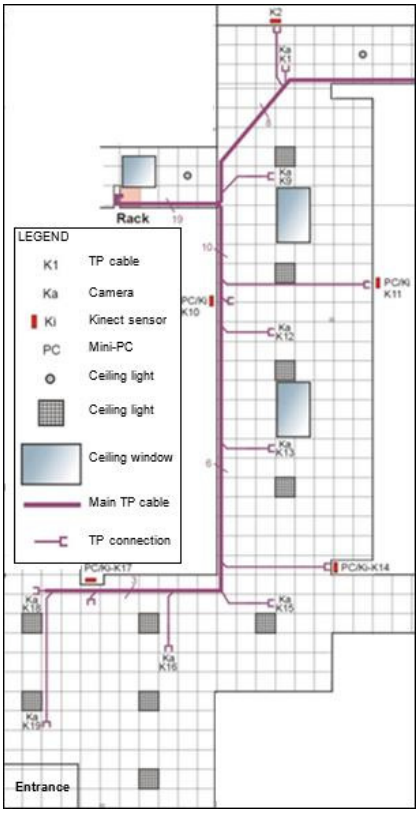

Fig. 4. Deployment of cameras, mini-PCs and Kinects [11]

Acknowledgment

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Neural network error classification in dual ASR unsupervised acoustic corpora building

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***Abstract*—To achieve better speech recognition results are more robust acoustic models necessary. Generally, more acoustic data in corpus result in better acoustic models. Loads of transcribed acoustic data give options in acoustic model training or adaptation process. Demand for perfect quality transcribed acoustic data in the field of speech recognition is very high. Obtaining manually transcribed acoustic data is very time and highly cost-consuming process. In last decade were many methods for unsupervised or lightly-supervised acoustic model training proposed. The another method for obtaining automatically transcribed data with neural network classification in the system core. A dual unsupervised system for automatic acoustic corpora building with 3 different confidence measure feature vectors in filtration step is proposed in this paper.**

***Keywords*—Automatic speech recognition, Neural network, Speech corpora, Unsupervised acoustic model training.**

I. Introduction

Transcribed speech data plays important role in the automatic speech recognition (ASR) research and its improvements. The key point is that large speech corpus containing lots of speakers, different speaking styles. Transcribed speech in different acoustic conditions may be also helpful in some applications.

If trained annotator wants to manually transcribe 1-minute long speech recording, then it may take from 5-20 minutes of highly focused work. To improve transcription quality is a further review of another annotation is required. Large corpus usually consists of several hundred or thousands hours of transcribed speech.

It is not very reasonable to create large speech corpus manually. These days is very common to mix manually transcribed and automatically obtained transcriptions to a single corpus. Highly accurate manual transcriptions are essential for building the ASR, while a huge amount of automatically obtained data in a little lower quality may add robustness to the system.

II. Automatic acoustic model training

Recently, multiple methods for semi or automatic acoustic corpora building in order to automatically train acoustic model were proposed. One semi-automatic (lightly supervised) system uses audio data with non-aligned text transcriptions such as audio-books or closed captions. Speech recognition system trained with a small amount of manually transcribed data is used to time align text with audio. Texts may contain errors, may be shortened or edited for some reasons. On top of the text to audio time alignment, a lightly-supervised system should correct errors or omit unaligned texts to increase automatic transcriptions quality. [1], [2].

Another way around is to use speech data without any kind of transcriptions. Speech recognizer trained with a few manually transcribed speech data is used to iteratively recognize untranscribed data and retrain or adapt acoustic model with new automatically transcribed data. Unsupervised methods converge to a certain level of accuracy, but it cannot be used for high-end ASR systems. Nowadays, good quality speech recognizers are used for recognition of untranscribed speech to enhance corpus with new data. Mixed corpus may improve robustness of a system, or may increase accuracy in specified task [3], [4], [5].

The key problematic in this field is to detect errors in speech recognition hypotheses. Errors in speech corpus may pollute parameter estimation in training process data and consequently reduce the resulting accuracy of ASR. Two main attitudes to error detection are used. One uses confidence measure in a decoding process of untranscribed speech data. The manually set threshold for confidence measure is used to filter words from hypotheses which are likely incorrect. This process highly reduces amount of obtained data, but in other hand reducing word-error-rate in resulting corpus (WER) [6]. The second way is to use statistical methods such as word co-occurrences, because speech recognizer errors may be found in regular patterns rather than in random distribution. This method may be used only when recognizer accuracy is very high as 99%. [7].

III. Dual unsupervised acoustic corpora building system

For experiments, dual unsupervised ASR system was built. The system is based on two ASR systems each with an independent acoustic model, which are trained with different manually transcribed speech data. This split training set assuring complementarity of these systems where is the assumption that those systems should not make correlated errors. Intersections in output hypotheses may be used for corpus creation, while rest of data is likely incorrect and is omitted. On top of this intersections is good to use confidence measure (CMS) thresholding to get even more accurate data. On the other hand CMS thresholding reducing the volume of obtained data. The unsupervised system and speech recognizer was described in more detail in [8], [9], [10].

IV. Experimental results

To generate hypotheses from test dataset, dual ASR unsupervised system was build and used. Dataset consists of 272 hours of speech recorded from commercial TV station. Details about this data set may be found in [11].

Confidence measure threshold of this system was set to 0 which skips CMS thresholding. The idea was to substitute basic CMS thresholding with neural network pattern recognition. Each word utterance in output hypotheses has 3 or more words. This makes problem with basic CMS classification because feature vectors have different lengths. From test data was found that largest utterance has 69 words. In the first experiment, the length of CMS vectors was adjusted by extending short vectors to the size of 25 with interpolation and longer vectors were shortened with decimation. For classification of vectors, Matlab's Patternnet trained with Scaled Conjugate Gradient was used. A number of hidden neurons in hidden layer and number of layers was changed from 10 - 500 and hidden layers from 1 to 4. Changing of this parameter didn't make much difference. For all experiments was set a number of hidden layers to 4 and 100 hidden neurons in each layer. Classification of fixed length vectors contained CMS values of words achieved 5,09% WER and obtained 46,47% of input data. This method compared to baseline (classification of input zero vectors) gains absolute improvement only 0,36% in WER and reduction of obtained data by 11,38%. This method has similar results to Fixed thresholding method with 0,2 CMS threshold as examined in [8].

In the second experiment, calculated feature vectors were used. Parameters in feature vector were: size of utterance, mean CMS, minimum CMS, maximum CMS, percentage words with lower CMS than mean CMS, 0,5 CMS cross-rate (how many times CMS crossed 0,5 value upwards or downwards). This vector representation was classified with neural network same as in the first experiment. Results of this experiment achieved almost the same WER, but with much less obtained data ratio, only 38,17%. This method is then less effective than the first experiment.

The third experiment used interpolated or decimated CMS vectors same as in the first experiment. Shortened or extended vectors was fit to the 9th-degree polynomial function which coefficients were used as parameters in feature vectors. This method achieved the highest obtained data ratio of all three experiments, but on the other hand, WER is highest.

TABLE I
Experimental results compared with baseline classification and fixed CMS thresholding method

	Classification accuracy	**WER**	**Obtained data**
Experiment 1	68,80%	5,09%	46,47%
Experiment 2	70,30%	5,07%	38,17%
Experiment 3	67,20%	5,27%	51,33%
Baseline	66,80%	5,45%	57,85%
Fixed CMS 0	-	6,19%	59,34%
Fixed CMS 0,2	-	5,01%	46,45%
Fixed CMS 0,4	-	3,50%	29,63%
Fixed CMS 0,5	-	2,76%	20,85%
Fixed CMS 0,6	-	2,19%	12,98%
Fixed CMS 0,65	-	1,93%	9,62%
Fixed CMS 0,7	-	1,61%	6,61%
Fixed CMS 0,75	-	1,50%	4,25%

V. Conclusion

In experiments, the novel method for automatic corpora building was examined. The results of the experiments were compared to previous research of fixed CMS thresholding. From the results in table I it may be seen that WER values are high as 5% and obtained ratio in range 38-51%. Proposed neural network classification of un-thresholded hypotheses obtained from dual unsupervised ASR system didn't bring satisfying results and it is considered as a not effective method for automatic acoustic corpora building.

VI. Future work

Proposed methods didn't bring satisfying results. In the future research, different methods for vector parametrisations will be examined. The core of the system has to be modified to allow different filtration methods and practices. Feature vectors will be supplemented with n-gram probability calculated from language model in order to get better results in neural network classification.

Acknowledgment

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Non-Standard Situations in Multi-Camera Environment

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***Abstract*—Presented research is focused on the analysis and design of tracking and detection technologies and their interconnection in the multi-camera environment. Main interest is the design of a tracking system with capability of detecting non-standard situations across multiple cameras. Another feature to be introduced is the ability to monitor vital signs from the video and face detection based on the image from multiple cameras.**

***Keywords*—abnormal behavior, face detection, monitoring of vital signs, multi-camera systems.**

I. INTRODUCTION

There are many different approaches for detection and tracking of object using a single camera. However, providing only one camera monitors the environment it might be very difficult to avoid overlapping objects. This issue can be partially solved by implementing prediction models based on object movement with obstruction on this subject. This approach fails when the object is unseen for longer time or it moves unpredictably. When utilizing multiple cameras detection and tracking of objects that overlap with other objects can be more exact and their localization in complex scenes can be simplified [1].

The number of applications dealing with the detection continues to grow. This paper is aimed on specific problems that can be solved using video detection, e.g. face detection, detection of abnormal behavior from camera system and monitoring of vital signs.

Detection of abnormal behavior becomes one of the most important parts of video content analysis. Detecting of behavior can be divided into two basic parts – observation of visual signs or analysis of object trajectories. This article is aimed at both those aspects

II. PARTIAL RESULTS

The main scope of this research is the analysis of technologies which are useful in process of object tracking and analysis of images in multi-camera systems.

A. Multi-camera system in Computer Networks Laboratory

Multi-camera environment was designed and then also deployed in the premises of Computer Networks Laboratory at Faculty of Electrical Engineering and Informatics. Model of camera locations is shown in Fig. 1. This system was created for research and CCTV purposes. Cameras are placed in various laboratories having different angles and creating environment with and without overlapping views.

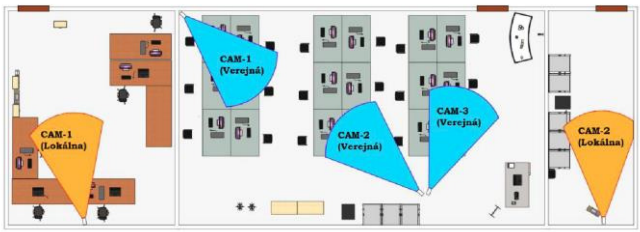

Fig. 1 Model of camera locations and their views, [2]

B. Object tracking in multi-camera system

System for detection and tracking of objects in multi-camera systems can be divided to several parts as shown in Fig. 2. These parts cooperate on evaluation of the scene caught by cameras. System consists of the following parts:

- *preprocessing of images* (low-rate operations for transformation images to useful form),
- *object detection*, detection of objects of interest in separate cameras,
- *object classification*, objects are compared and assigned to identical counterparts detected by other cameras,
- *object tracking*, tracking moving objects through scenes,
- *parameters extraction for evaluation*, these include position, dimension, completeness, speed and visibility of key parts of objects,
- *evaluation of parameters*, information which camera has the best view on object of interest.

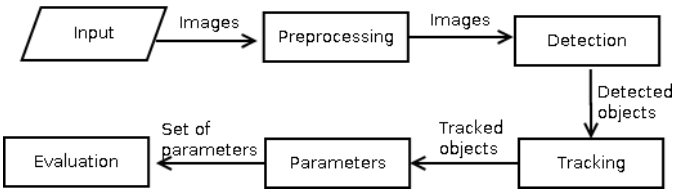

Fig. 2 Parts of multi-camera object tracking system

C. Video-based monitoring of vital signs

The basic human vital functions include respiration activity, consciousness and heart activity. Each of these functions has its own properties and possibilities of measurement on which it is possible to evaluate the health status of a particular person. The most often, the method for measurement of vital

signs are mentioned in the medical environment. In this case, based on specific examinations one has the opportunity to learn information about own health and prevent the occurrence of various civilization diseases.

Monitoring of vital signs can be carried using conventional medical equipment e.g. electrocardiogram or encephalograph. However, there are also many possibilities to monitor sings through modern devices e.g. smartphones which have sensor for measuring heart rate.

This research is also focused on the way of monitoring the vital signs utilizing video. Principal interest are signs visible to the camera system, such as breathing (chest lifting, extension nostrils), heart rate (on the carotid artery, on the wrist), changes in pupil size or change in skin color. One of the existing similar device is vital signs camera [3]. Its algorithm is following the color of skin. Every time the heart beats, the color changes due to extra blood in the coil. These small skin color changes are not detectable by the human eye but using the algorithm which boosts the color changes in image it is possible to calculate the exact heart rate signal by analyzing the frequency of color changes.

D. Face detection from multi-camera systems

Face detection in biometric systems is an important part of security, authentication and authorization. Biometric face recognition technology received significant attention in recent years due to its potential for a wide range of applications. Face detection can be found as an authentication tool for unlocking mobile devices as well as applications for recognition of people in photographs. The most commonly used methods for face detection are Eigenface algorithm [4], FisherFaces algorithm and OpenFace from Google [5] shown in Fig. 3.

Another goal of this research is to propose algorithm for face detection in environment of multi-camera system in Computer Networks Laboratory. The detection is to be performed once the person enters the room. The image is stored in a database and compared to previous the detected faces. The system learns over specific time and should acquire the ability to distinguish specific individuals.

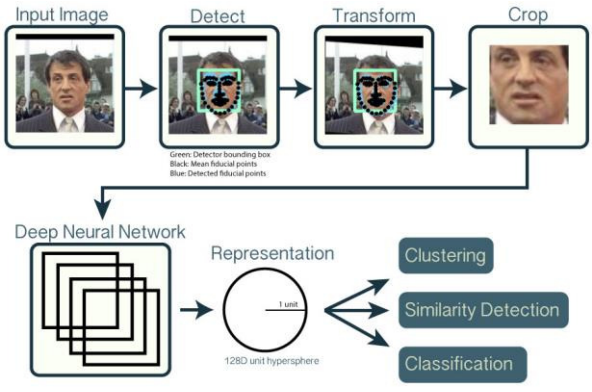

Fig. 3 OpenFace from Google, [5]

E. Abnormal behavior detection in video

Non-standard behavior is described as anomalies that do not match with pre-defined behavior. In order to determine the non-standard behavior, it is necessary to pre-establish a set of standard behavior. Creation of the individual sets is carried out through the exact definitions or through creation of certain requirements that must comply with the behavior. This assumption is to be achieved statically or dynamically. Static set represents exactly predetermined behaviors that are considered as standard. On the other hand, dynamic way is based on sequential learning and creating model of standard behavior.

Several libraries were developed to enable more effective identification of this type behavior. These include predefined patterns of motions. Movement can be easily classified through the comparison of collected date with these patterns. The most relevant known libraries are:

- *KTH,* includes activities such as boxing, walking, running, waving or clapping and all these activities are located in different environment [6],
- *Hollywood,* this library covers activities such as sitting down and standing up or handshaking [7],
- *LIRIS,* it includes opening and closing door, going in and out the door or typing on a computer [8],
- *HMDB,* extensive library containing 51 different activities [9].

III. CONCLUSION

Following the presented research, the remote control of camera system is possible and research in this area should be expanded. System would be able to control the movement of cameras as well as its basic features such as zoom in/out, focus and start recording. This control should be based on the detection of non-standard behavior like motion in prohibited places, recognition of unknown face or abnormal breathing or heartbeat. The future research is to be focused on the proposal of descriptor that is to enable extraction of information of moving object in the input from the camera or multiple cameras.

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Object Location and Identification in Context of the Industry 4.0

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***Abstract*—This article deals with different approaches to location and identification of the humans and objects in certain areas in the context of the Industry 4.0 and respectively the Operator 4.0. Industry 4.0 enables new types of interactions between operators and machines. With the growing number of the human-automation symbiosis systems there is also growing number of applications that use position determination, object identification and collision prevention depend on accurate scene analysis. In this paper, I will describe how the cameras are used to locate and identify objects and then how the measurement of the WiFi and Bluetooth is used for the similar applications. My objective is to make a fusion between camera technique and iBeacon technology. This solution will ensure safety and wider possible of use because of the two-factor location and identification.**

***Keywords*—depth map, iBeacon, identification, Industry 4.0, localization, Operator 4.0**

I. Introduction

Industry 4.0 enables new types of interactions between operators and machines, interactions that will transform the industrial workforce and will have significant implications for the nature of work, in order to accommodate the ever-increasing variability of production. An important part of this transformation is the emphasis on human-centricity of the Factories of the Future [1], allowing for a paradigm shift from independent automated and human activities towards a human-automation symbiosis (or 'human cyber-physical systems') characterized by the cooperation of machines with humans in work systems and designed not to replace the skills and abilities of humans, but rather to co-exist with and assist humans in being more efficient and effective [2] [3] [4].

With the growing number of the human-automation symbiosis systems there is also growing number of applications that use position determination, object identification and collision prevention depend on accurate scene analysis. It is needed to accurately locate and identify object and humans to ensure safety. This can be done with the use of cameras, for example by using the depth cameras or stereo vision. Another principle to ensure position determination and object identification is to use location techniques like Global Positioning System (GPS) or measurement of signal strength (RSSI) of the WiFi or Bluetooth signal. In my research I want to combine two different techniques, to ensure proper identification and location.

II. Locating and identifying using the cameras

Laser scanning techniques, which sample a scene point by point and row by row with a single laser device are rather time-consuming and not that good for dynamic scenes. On the other hand, stereo vision camera systems suffer from inaccuracy caused by same looking areas with homogeneous patterns. Another principle is based on the estimation of the distance by time-of-flight measurements for modulated, incoherent light based on the photo mixing detector technology (PMD) [5]. Laser scanning is based on the time of flight principle. The process of acquiring 3D spatial data is fast and accurate but the cost of the devices involved is very high [6]. Many applications for identification of the objects are also based on single camera, like [7].

A. Stereo vision

Vision-based techniques entail the acquisition of depth information from a set of 2D images or video frames. These techniques can be applied using ordinary cameras and a computer; thus, they are economically feasible. In addition, modern vision-based algorithms offer the same precision as laser-based 3D spatial data acquisition methods. Over the past few years, a number of commercial vison-based devices and software have been developed for acquiring 3D spatial data to be used in different domains. These techniques can be divided into two major categories, as follows [8]:

- Long-range photogrammetry techniques such as aerial photogrammetry. These techniques are mainly used to generate topographical or thematical maps and digital terrain models. High costs and specific requirements to train personals using those devices usually make it infeasible to apply these techniques to construction site activities and the acquisition of 3D data of infrastructure.
- Close-range photogrammetry techniques. As compared to the first category, the devices used in these techniques cost less. They are appropriate for use in close-range applications such as archaeological investigations and spatial data acquisition for infrastructure.

Recovering 3D information from 2D images is the fundamental goal of vision-based techniques. The problem of obtaining the missing dimension, i.e., depth, from a pair of stereo images is essentially the correspondence problem: given a point in one image, find the corresponding point in the other image. Finding potential correspondences usually involves matching some image property between two or more images. If the images are from neighboring positions, they will vary only slightly, thereby simplifying the matching process. Once the correspondence is determined, obtaining the depth is a purely

geometric problem. Figure (Fig. 1) illustrates the calculation of the depth of point P using two images captured by known cameras $C1$ and $C2$, given the corresponding points $p1$ and $p2$ within those images. The points $p1$ and $p2$ are projections of P [8].

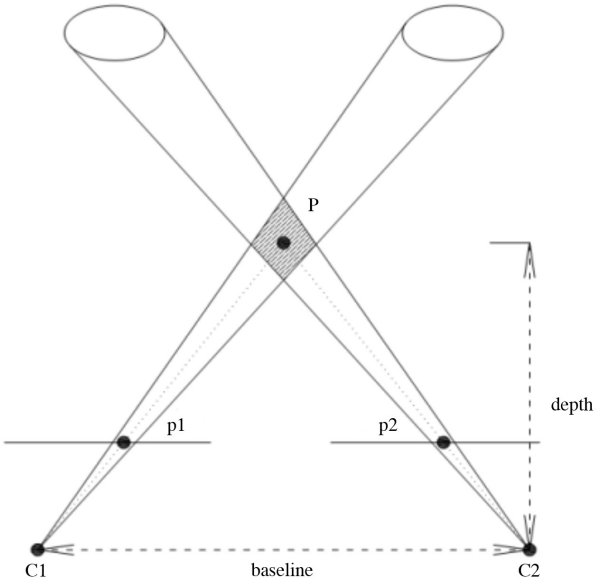

Fig. 1. Geometric Representation for Depth Calculation in a Stereo Setup of Cameras [9].

Sometimes it is necessary to obtain panoramic range information of 360 degrees because obstacles may approach from various directions. There are two methods to obtain panoramic images. One is to capture a sequence of images with rotating a camera and then to integrate the images into one panoramic image (e.g., [10], [11]). Although this method could obtain a high-resolution image, it takes a long time to get an image and is not suitable for the robot in dynamic environments. The other method is to use a special lens or mirror to obtain an omnidirectional image at once. Although the image resolution is low, its real-time nature is more suitable for some applications [12].

B. Time-of-flight measurement

Photonic Mixer Devices, the so-called PMD sensors, base on time-of-flight principle. This camera technology realizes three-dimensional imaging without complex electronics and without scanning with a solid state imager similar to a CMOS device. This imager detects both the intensity and the distance in each PMD pixel or voxel respectively [13]. Time of Flight systems consist of an optical transmitter and an optical receiver and they have already been described in detail in many technical publications [14] [15] [16].

A PMD camera consists of the PMD chip and its peripheral electronics, an illumination source, the receiver optics, a system for controlling the camera including digital interfaces and software. Each component of this camera system more or less affects the key parameters as measurement range, the field of view, frame rate and accuracy. Each application or market has different requirements concerning these parameters and additional conditions like sunlight stability, rejection of other IR-emitter systems, size, and weight [13].

III. Location and identification by use of the signal strength metering

Nowadays, when satellite navigation systems such as GPS, GLONASS, or Galileo are available for everyone, it is usually not a problem to locate a person or a mobile device outside. A situation can get more complicated in high-density urban areas with rare line-of-sight to the satellites of the corresponding system. The situation is most complicated inside buildings with no line-of-sight.We can outcome this by the measurement of the signal strength of the WiFi signal, or by other words triangulation, the position can be determined without direct visibility to the receiver and can also be done through the walls. There is also an option to measure RSSI of the bluetooth devices, also called beacons. With enough bluetooth devices that is in range, the position determination can be quite accurate. This beacons can run on the battery for months or few years. beacons can also be used to identify machines and this beacons can replace RFID and NFC tags. Moreover, the range of the beacons is longer than the range of the RFID or NFC tags.

According to [17], indoor positioning based on WiFi infrastructure delivers interesting results with a low density of access points in the environments. Regarding the performances that are awaited from the technology, different techniques can be applied. For the most complex one, fusing information from the WiFi network, with information coming from inertial navigation sensors, it is possible to get performances close to the meter accuracy. Figure (Fig. 2) shows use case scenario where the user has to be positioned along the corridor as he walks from one office room (e.g. room A or B) to another room (e.g. room I or J). The top figure (a) shows the position fixes obtained from the proposed software. The track of the user can be clearly seen. The maximum deviations from the true path are less than 4 m in most cases. The bottom figure (b) shows the position fixes which have been smoothed using a sliding window average postprocessing filter. In this case, the maximum deviations from the true path are less than 2 m and 90% of all observations are within 1 m from the true path.

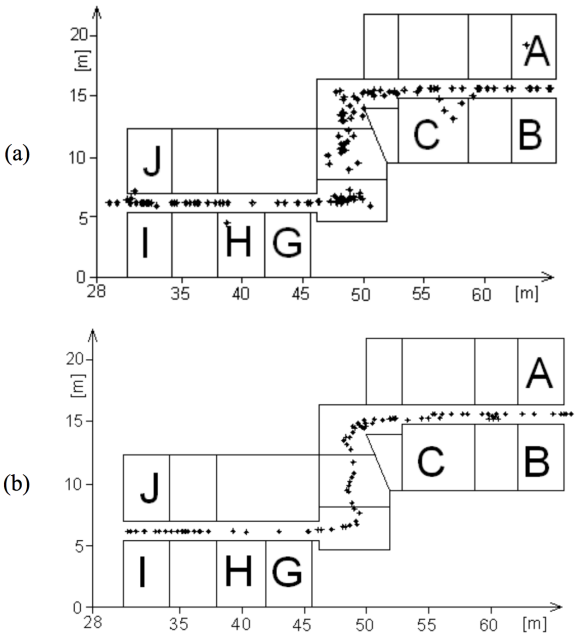

Fig. 2. Position fixes in a navigation scenario along the corridor for unfiltered observations (a) and using a sliding window average filter (b) [17].

Another approach is to use Bluetooth Low Energy (BLE) which can be a very good alternative supplementing WiFi access points. the key advantage of BLE comprises low energy consumption. This also makes it possible to place the beacons in the spots where WiFi access points would be difficult to power.

A main advantage of the using beacons as described in [18] is that the proposed solution is the client-side power efficient since the iBeacon protocol is built upon BLE, a highly power efficient version of the Bluetooth standard protocol.

In another paper [19], authors propose a system for indoor route guidance using iBeacon. Their image of indoor route guidance is like the route guidance by car navigation system. Before coming to the next intersection, the system announces the next direction to go to the destination at the right place and timing (see Fig. 3). They think that this type of route guidance can be realized when the beacon module plays two types of role: quiet and notified beacon modules. They introduce an indoor route guidance system by placing these modules along passage ways in a building appropriately to change the contents of advertised information displayed on the smartphone depending on the history of automatic triggering of the modules.

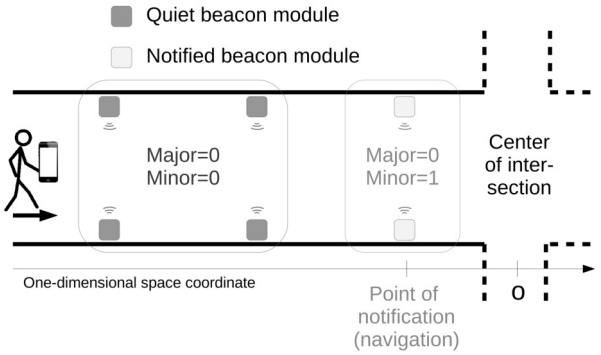

Fig. 3. An idea of the layout method for indoor route guidance using multiple beacon modules [19].

There are also many works about improving indoor WiFi navigation with added sensing of beacons like [20] [21].

In paper [22] authors perform direct comparisons between WiFi and BLE in order to provide an objective overview as to which technology is best suited for indoor localization, through an extensive measurement campaign. They derive channel models in both indoor and outdoor settings, which they expect to be useful to other researchers. Given that both modalities operate in the 2.4 GHz ISM band one would expect similar performance. However, they demonstrate, somewhat surprisingly, that BLE can outperform WiFi in a like-to-like trial, with an RMS error of 3.8 m compared to 5.2 m, a 27% improvement. Experimental results are shown on figure (Fig. 4). As can be seen from figure there is only a little differentiation between BLE and fusion of WiFi and BLE, so indoor localization can be done without using WiFi.

By use of the beacons that will be placed in factories and on the machines, this solution will also match The Operator 4.0 concept. The Operator 4.0 represents the 'operator of the future', a smart and skilled operator who performs 'work aided' by machines if and as needed. It represents a new design and engineering philosophy for adaptive production systems where the focus is on treating automation as a further enhancement

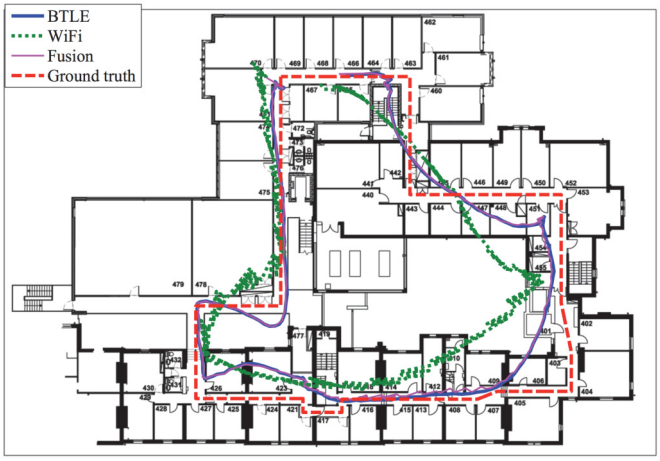

Fig. 4. Ground truth and estimated trajectories [22].

of the human's physical, sensorial and cognitive capabilities by means of human cyber-physical system integration [23].

IV. iBeacons

iBeacon is a protocol developed by Apple in 2013. Various vendors have since made iBeacon-compatible hardware transmitters - typically called beacons - a class of Bluetooth low energy (BLE) devices that broadcast their identifier to nearby portable electronic devices.There are two interrelated reasons for the excitement around iBeacons. Most importantly, the technology enables a device to make extremely precise determinations of what is nearby. Even under ideal conditions, GPS technologies struggle to do better than a few meters, and GPS is often limited indoors. iBeacons can enable a determination within centimeters. Any device with Bluetooth 4.0 (or later) hardware is capable of acting as a beacon, the investment required for hardware is only a few dollars.

Devices with iBeacon technology can be powered using coin cell batteries for a month or longer. Mobile devices can also be configured to generate iBeacon advertisements [24].

An iBeacon advertisement provides the following information via Bluetooth Low Energy [24]:

- **UUID** (16 bytes) - application developers should define a The Universal Unique Identier specific to their app and deployment use case.
- **Major** (2 bytes) - further specifies a specific iBeacon and use case. For example, this could define a sub-region within a larger region defined by the UUID.
- **Minor** (2 bytes) - allows further subdivision of region or use case, specified by the application developer.

The UUID, major and minor values provide the identifying information for the iBeacon. Generally speaking, this information is hierarchical in nature with the major and minor fields allowing for subdivision of the identity established by the UUID [25].

A. Dedicated Beacon Hardware

- Estimote is one of the earliest developers of beacon technology, Estimote sells a developer kit that includes three beacons for almost one hundred Euros.
- RadBeacon is a USB dongle that performs the transmission functions of an iBeacon. All you have to supply is USB power.

B. General-Purpose Hardware

- Newer mobile phones - can act as beacons by using one of the many free programs that use the BLE hardware through the appropriate development frameworks. This includes mobile phones running Android, Windows Phone or iOS operating system with at least Bluetooth 4.0 connectivity.
- The Raspberry Pi Zero W - is a tiny cheap computer with included Bluetooth 4.0 and 802.11n wireless LAN connectivity. It also includes 40 GPIO pins to connect peripherals.
- Any Arduino (or another micro-controller like ESP8266) can also act as beacon when HM-10 (or newer) Bluetooth module is connected.

By late 2016, Bluetooth Special Interest Group released the fifth version of its wireless standard. Bluetooth 5 reflects a hunger for the IoT market, especially the growing segment of "beacon" devices. It promises major upgrades in range (4x) and speed (2x), without sacrificing the low-energy features that define the current generation of Bluetooth products.

V. Conclusion

With my proposed solution, I want to generate depth map with use of the stereo-vision and the time-of-flight technique and combine this with iBeacon technology. This will allow to locate and identify the objects and humans on the scene. This solution will ensure safety because of the two-factor location and identification. Sometimes it is quite hard to identify object just from the depth map, we only know that "something is there". Because of this, I want to combine it with iBeacon to ensure proper identification. As beacon technology can also be used to locating, this solution will ensure that object will be located even if it is hidden from line of sight of the cameras.

By use of the beacons that will be placed in factories and on the machines, this solution will also match The Operator 4.0 concept. The operators can use mobile phones to display actual informations of the machine that is nearby. Moreover, only the relevant information will be displayed automatically on the mobile phone display. There will be not needed to push any buttons when the operator wants to check machine status, he only needs to be near the machine. This beacons can also transmit some useful informations like temperature, humidity, CO level, illumination. Any device with Bluetooth 4.0 (or later) hardware is capable of acting as a beacon, the investment required for hardware is only a few dollars per piece.

Acknowledgment

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On-line Redundant Diagnostic and Backup System for a Small Aircraft Turbojet Engine

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***Abstract*—The paper describes the work and results obtained in the previous year of my PhD study. The research focuses on increasing safety, reliability and efficiency of an aircraft turbojet engine by immediate detection of failures and their isolation. This paper describes a design of an on-line diagnostics and backup system, together with the test results of this system on a small turbojet engine iSTC-21v.**

***Keywords*—Backup, diagnostics, small turbojet engine, voting method**

I. Introduction

Currently, due to the increasing complexity of systems, it is important to ensure and maintain their high performance and reliability [1]. The problem of reaching a certain level of stability and performance in the case when unexpected scenarios occur, particularly in expensive autonomous systems and safety critical systems requires to use a different method than just having an adaptive or robust controller [2]. An example of such system is the issue of increasing the survivability of an aircraft when errors or failures of the sensor or aircraft component occur during a flight. It entails the need for ensuring accurate fault detection and isolation [3]. So the primary goal of our work, and also our motivation, is to create a diagnostic and backup system for a small turbojet engine which will be able to ensure that the engine will perform a required function under stated conditions and not to cause danger to persons, environment or equipment.

II. On-line Diagnostic and Backup System

We have proposed a real-time diagnostic and backup system [4] and implemented it on the small turbojet engine iSTC-21v. Its main advantage is to provide reliable engine operation, reduction of operating and maintenance costs, diagnostics of the engine condition, increase efficiency and safety. Essential elements of the system are nine diagnostic modules for each of the measured parameters of the iSTC-21v engine. These parameters are temperatures T_{2C}, T_{3C}, T_{4C} pressures P_{2C}, P_{3C}, P_{pal}, fuel flow supply Q_{Pal}, thrust F_t and speed of engine's compressor n. Inputs to the diagnostic modules represent signal from sensors. Those either directly enter the selected diagnostic method or they are used to acquire modeled values of the parameter through models calculated by experimental identification methods [1]. As an example, the designed structure of a diagnostic module for parameter Q_{Pal} is shown in Fig. 1, where estimated values are modeled through Time Delay Neural Network and Output – Error model.

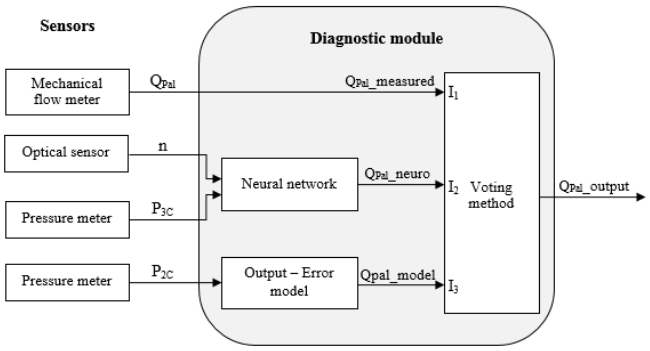

Fig. 1. The scheme of the diagnostic module for parameter Q_{Pal} [4]

In the previous SCYR article [5], we have mentioned nine methods of experimental identification that we have used to create experimental models of the engine parameters. The following section describes the usage of these experimental models for the purpose of fault detection and isolation, so they do not have an influence on the smooth operation of the engine.

III. Diagnostic Method

As a diagnostic method is used the modified voting method. Inputs to this method are either the measured data from the sensor (I_1) or modeled values of parameter computed by a polynomial model (I_2) and neural network (I_3). These inputs are then transferred into the block of pair comparison, where each pair is compared and evaluated on the basis of the permissible deviation value. The size of this maximum allowed deviation for each couple is calculated as the sum of the allowed deviation values for signals that make up the pair. For the sensors, it is represented with accuracy by which they work and for models that value is set as the maximum absolute error (MAAE). The permissible deviation for parameter Q_{pal} is shown in Table I.

TABLE I
Table of Maximum Allowed Deviation for Individual Inputs

Parameters	Inputs (I_i)	Allowed deviation value	Pair comparison	Sum of allowed deviation
Q_{Pal} [l/min]	I_1	0,05	I_1 and I_2	0,16
	I_2	0,11	I_1 and I_3	0,24
	I_3	0,19	I_2 and I_3	0,3

Based on the results of pair comparison, if the two pairs of input variables exceed the sum of the maximum allowed deviation, the input that was in both pairs is considered as faulty. In case that all three pairs overrun the permissible deviation value, it checks the inputs to the models (measured data from sensors). If the system evaluates this data as accurate, then also the output of the model is set as correct.

The output of the voting method is the most accurate signal (based on the allowed deviation value – Table I) of the parameter which was diagnosed by the system as correct.

IV. Testing of the Diagnostic and Backup System

A. Errorless engine operation

The functionality of the implemented system for on-line diagnostics and backup has been tested in the Laboratory of intelligent control systems of jet engines (LIRS LM) during the operation of the small turbojet engine iSTC-21v. First tests were run during the faultless engine operation and the results for parameter Q_{pal} are shown in Fig. 2.

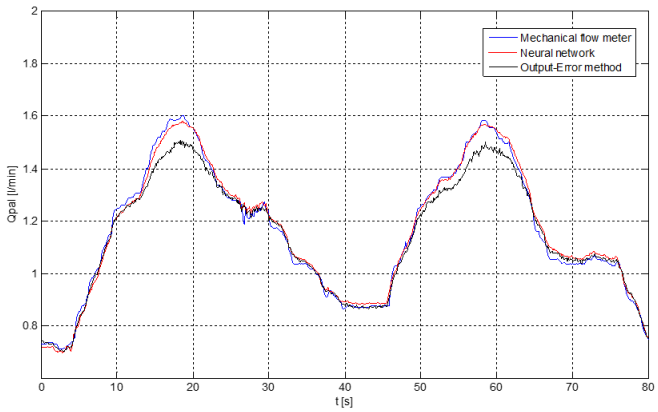

Fig. 2. System test for parameter Q_{Pal} during errorless engine operation

B. Failure of individual inputs

Failure of inputs is represented by a decrease of the measured data to zero. As the sensors cannot be physically damaged, it was simulated during standard engine run in such way that at specific intervals, the actual value of the selected input was set to zero. In the 20th second was measured data from sensor Q_{pal} set to zero and in the 40th second was simulated outage of the sensor n (input to neural model). In 60th second were set back the correct data of the sensors. As can be seen in Fig. 3, the implemented system was able to react to these outages using a backup (data acquired by experimental models).

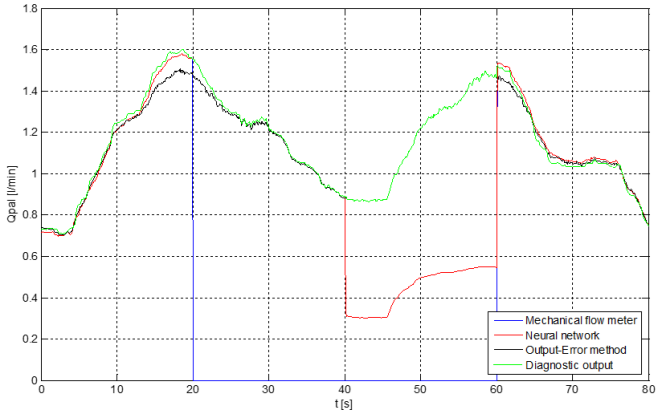

Fig. 3. Response of the system to individual inputs failure (parameter Q_{pal})

C. Presence of random input values

The random value appears as a rapid increase in the size of inputs of the voting method over their true value. This fault was simulated in such way that a certain value was added to the real values of individual inputs at a chosen time. The test was similar to the previous, with the difference that inputs was not set to zero, but they were increased by a certain amount. It represents in a fuel flow supply Q_{Pal} the value of 0,5 l/m and in a speed of engine's compressor n the value of 5000 ot./min. The test results are shown in Fig. 4.

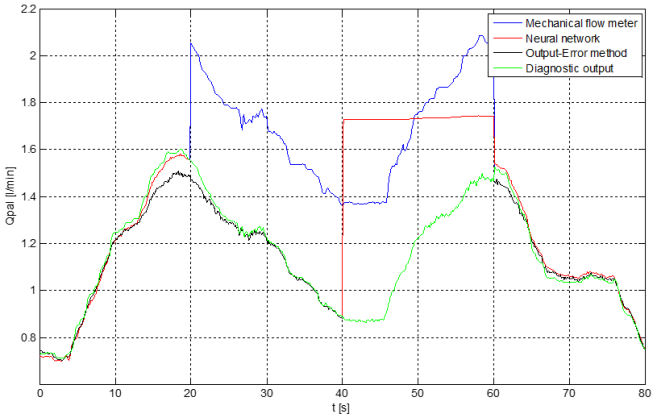

Fig. 4. Response of the system to random values of inputs (parameter Q_{pal})

V. Conclusion

This paper reviews our work during the last year. We concentrated on improving original voting method [4] and testing new, more accurate models. Based on the results (see Fig. 3, Fig. 4), it can be concluded that the implemented on-line redundant diagnostic and backup system is working properly.

Our current research focuses on the classification of the detected faults to distinguish between sensor error and engine component failure.

Acknowledgment

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Optical Correlator in Microchips Pattern Recognition System

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***Abstract*—This paper is focused on design of the microchip pattern recognition system that is able to recognize microchip pattern based on given criteria from input scenes. The user-friendly software is used for preprocessed input scenes. Cambridge optical correlator is used to compare input scene with reference pattern stored in database. The use of optical processing technology will increase the speed of processing amounts of data.**

***Keywords*—Cambridge optical correlator, edge detection, Fourier optics, microchip pattern recognition.**

I. Introduction

Systems that offer fast and highly accurate processing results are an essential part of today. These systems include technologies based on optical data processing, which are preferred over electrical systems. Optical systems use light for processing and transmitting large amounts of data in real-time. The Cambridge optical correlator is primarily designed to compare and identify the images using optical correlation for the image comparison [1][2]. The Cambridge optical correlator uses software "Fourier Optics Experimenter" (FOE), which allows users to investigate the possibilities of Fourier optics in different research areas. The disadvantage of this emerging system is its size [3]. Many companies dealing with issues of Fourier optics are trying to miniaturize this system. Nowadays, its size shrunk by about half and it opened new possibilities for its use [4][5].

Goal of this paper is to present the microchip pattern recognition system (MPRS) based on optical correlator. This system is capable of recognize microchip pattern that are used in ID cards, credit cards and SIM cards. Cambridge optical correlator is used as a comparator in this system. In our case, scanned microchip patterns are compared with reference microchip patterns stored in the database.

II. Microchips Pattern Recognition System

The microchip pattern recognitions system (Fig. 1.) is designed to detect microchip from the input scene based on given criteria and then compare the pattern with reference microchip pattern from the experimental database. A program which is created in C# programming language with using Aforge.NET library is used to detect the patterns.

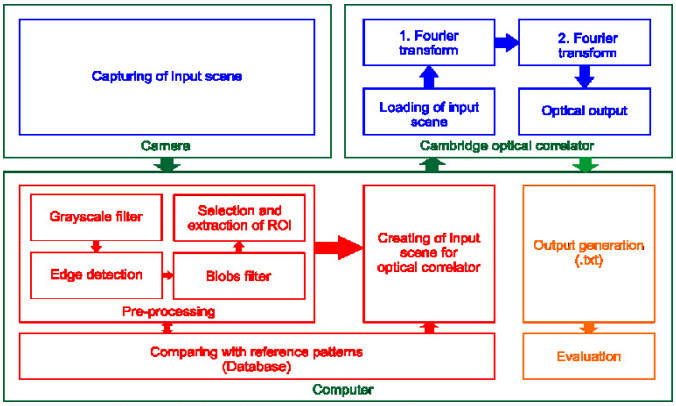

Fig. 1. Procedure of microchip pattern recognition system.

III. Pre-processing

The main task of the Pre-processing is to adjust the input image obtained by the camera for the purpose of obtaining necessary information microchip pattern. It is realized by the software for detection of the microchip pattern, which must quickly and clearly determine the region of interest (ROI) [6][7].

The first step is setting the resolution of the input image (Fig. 2 (a)) to 800x478 pixels, so the functions used in the program detect the microchip pattern as quickly as possible. Subsequently, Grayscale filter is applied by using the function "Grayscale()" to convert the multi-level to the grayscale image. This image carries brightness information only, no information about a colour (Fig. 2. (b)). Sobel detector (Fig. 2. (c)) was used for edge detection by using the function "SobelEdgeDetector()" [6][8][9]. This function converts image to black and white image, which get files of closed curves. These files of curves represent a range of areas and objects. After edge detection, an image contains unwanted objects or areas (blobs) that are not a part of the microchip pattern. The function "BlobsFiltering()" is applied to remove blobs that are smaller than 75x75 and bigger than 150x150 pixels (Fig. 2. (d)) [6][10]. Next step is selecting and defining the region of interest which means the place where microchip pattern might be located. The algorithm "BlobCounter()" is applied to the image – it gradually passes line by line and returns an array of rectangles that bound the field of blobs (Fig. 2. (e)). Last step is extraction of the selected region of interest which represents pattern (Fig. 2. (f)). The found microchip pattern are compared with reference microchip pattern using Cambridge optical correlator [11].

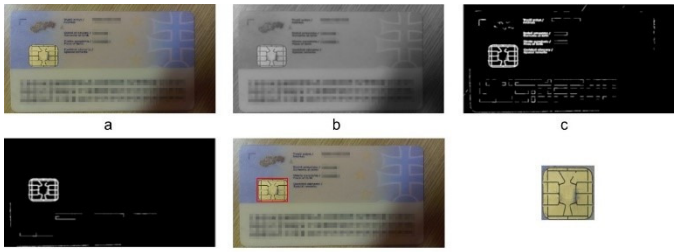

Fig. 2. Input image (a), grayscale (b), edge detection (c), blobs filter (d), selection of region of interest (e), extracted microchips pattern (f).

IV. Results and Conclusion

The captured images of different types of microchip pattern were analyzed by created MPRS based on Cambridge optical correlator. Fig. 3. is shown reference microchip pattern stored in the reference database.

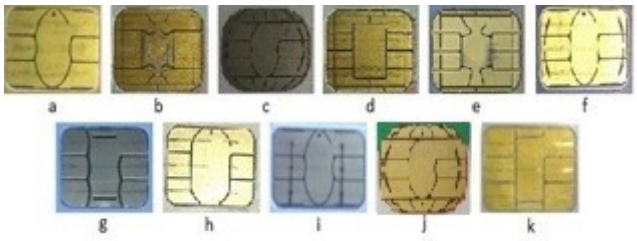

Fig. 3. Reference microchip pattern..

The optical output of Cambridge optical correlator contains correlation peaks and their size might be in within range <0;255> where value "255" refers to total match and value "0" refers to mismatch [2][3]. The equation (1) means percentage match between images situated in the input scene, where I is arithmetic mean, I_1 and I_2 are intensities of the correlation peaks:

$$Match(\%) = I / 255 * 100, \quad (1)$$

$$I = (I_1 + I_2) / 2. \quad (2)$$

The reference database contains 11 microchip patterns. 100 reference measurements were made to obtain thresholds for each of microchip patterns. Threshold can be considered as the average value of intensity of correlation peaks. The resulting thresholds are shown in the Fig. 4.

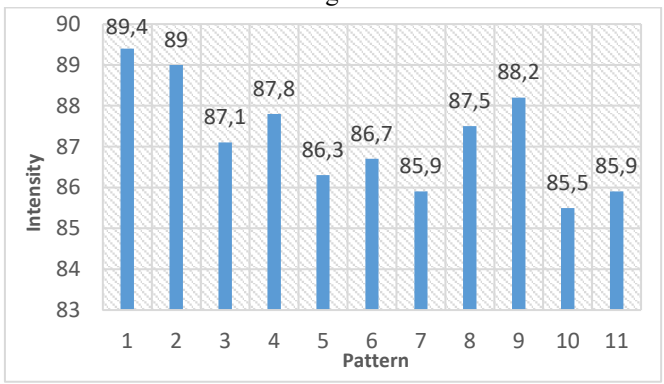

Fig. 4. Resulting threshold of 11 measurements.

It was decided that if value of percentage match is greater than 85 %, the extracted and reference microchip pattern are considered as the same. 66 measurements were made, in which the pattern comparison was performed. The results of percentage value of intensity of extracted and reference microchip pattern are shown in Fig. 5. As mentioned above, the maximum intensity value is 255, e.g. exact match of compared microchip pattern. The average intensity of correlation was 89.58 what is 35.13%. Some experiments had value of intensity in range 70 - 81% but compared images was not the same.

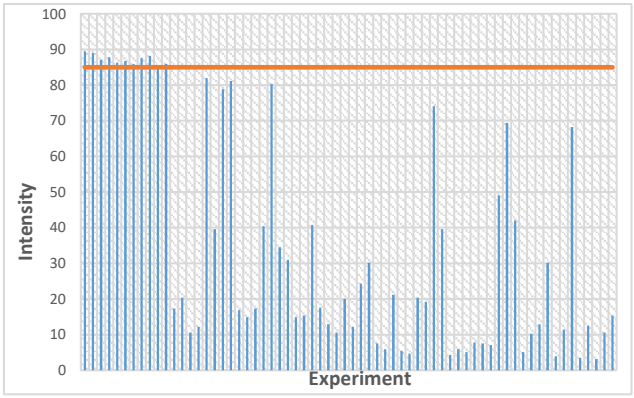

Fig. 5 Resulting intensities.

The input scene (ID cards, credit cards and SIM cards) was obtained by HD colour camera. The surface of these cards might be polluted or distorted. So, all of that had significant impact on detection and recognition.

Acknowledgment

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Overview of 3D Image Classification using Deep Generative Models

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***Abstract*—This paper is a brief overview of a selection of current 3D image classification techniques, particularly those using generative modelling. It also summarizes the current state of our research in which we compare different modalities of image data in the context of classification by convolutional neural networks. Finally we propose our future research goals and outline the next steps towards them.**

***Keywords*—computer vision, image classification, deep learning, convolutional neural networks, generative modelling, GAN**

I. Introduction

With the rise of deep neural networks, the interest in their application in 2D and 3D image classification has grown significantly. The de-facto standard architecture used for this task - deep convolutional neural network - has proven very successful, especially with 2D images. 3D classification, while slightly less common, has also been gaining more attention. While there is some overlap (notably convolutional neural networks), classification of 3D images generally requires a slightly different approach.

In the last year a lot of attention has focused on generative models. While classification might not be their primary focus, researchers have proposed many supervised and semi-supervised generative architectures achieving very interesting results in this area. In some benchmarks, generative classifiers even outperformed the state of the art. We see great potential in this approach and would like to focus our efforts on applying it on 3D image classification.

II. Related work

Currently, most of the techniques used for 3D object classification could be categorized into two most prominent groups: projection-based and 3D convolution-based techniques. Generative modelling is a methodology that usually uses convolution-based architectures and will be described in it's own subsection.

A. 3D image classification

ModelNet [1] (a 3D classification benchmark) provides an interesting overview of the current state of research in the area of 3D shape classification. The dataset contains 662 classes of labeled CAD models and the competing methods are a mix of both projection and 3D convolution-based techniques (compared in [2]).

Convolutional architectures (e.g. ShapeNets [1], VoxNet [3]) operate with voxel representation of the models. These models are based on a 3D convolutional neural network and work similarly to 2D convolutional classifiers. The main weakness of convolution is it's hard-to-achieve rotational invariance. Authors of these models solve this by augmenting the training data and voting during the forward pass.

Projection-based techniques like MV-CNN [4], DeepPano [5] or GIFT [6] generate several projections of the three-dimensional object model and classify these 2D images to determine its class. Some of these methods provide additional benefit in terms of determining the next best view of the object which is particularly useful for active object classification task in robotics [7].

Other methods (e.g. FusionNet [8]) achieve good results by combining both representation of 3D objects - voxel grids and 2D projections.

B. Classification using generative models

Generative modelling and especially GANs (Generative Adversarial Networks) gained a lot of traction during the last year. Apart from their wide spectrum of other interesting applications, these architectures have shown great potential in the classification tasks.

Currently the most successful model in ModelNet benchmark is called VRN (Voxception-ResNet) [9] which is based on a generative approach using voxel-based variational autoencoders. Combining the benefits of ResNet and Voxception architectures, authors developed a powerful generative model which, thanks to its decoder-encoder pair, is able to both generate and classify 3D shapes. In ModelNet10 benchmark, VRN achieved first place with 97.14% accuracy. Authors also presented a user interface for exploring the latent space and visualize the interpolation between objects and classes.

Another example is a GAN modification called SGAN (Semi-Supervised GAN) [10] which trains the discriminator to predict N+1 classes (N real classes and a "fake" class). This approach has proven successful in classification task especially with small training sets and also achieved improved quality of generated samples compared to the traditional GAN.

BiGAN (Bidirectional GAN) [11] is another GAN modification which allows classification by employing an architecture similar to autoencoders. By training the encoder at the same time as the generator-discriminator pair and minimizing the reconstruction loss, it approximates the inverse of the generator

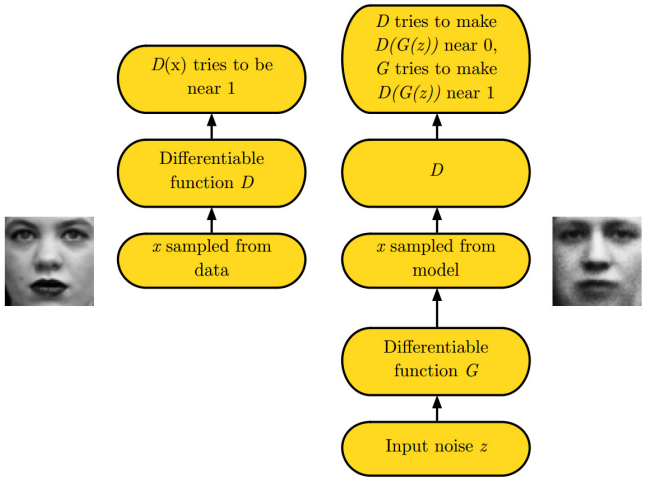

Fig. 1. Structure of a generative adversarial network (GAN). [12]

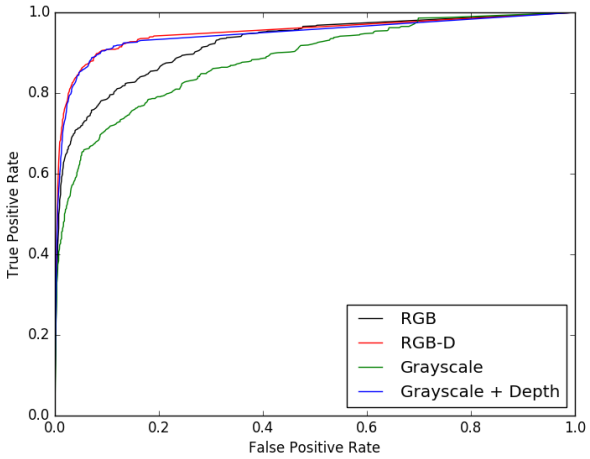

Fig. 2. ROC curve comparison of model precision using various input data modalities.

function which can then be used for extraction of feature vectors.

III. Generative models and GANs

The basic function of generative model is to approximate the real probability distribution of a system and generate new samples that are very similar to the real ones. These models can be explicit (provide explicit p.d.f.) or implicit (can only generate new samples). The generator takes a vector $\boldsymbol{z}$ as an input from which it generates a new sample. After training, this vector represents a latent representation of the sample and essentially becomes a feature vector. Bi-directional generative architectures (such as VAEs) can then extract this vector from an unlabeled sample and use it for its classification.

An example of this approach is a Generative Adversarial Network (GAN). This network consists of two parts - generator and discriminator (see Fig. 1). These two parts (players) compete in a game where the discriminator is trained to distinguish real and fake samples and at the same time, the generator tries to fool the discriminator and make it classify the generated samples as real. The training is performed by simultaneous SGD (updating generator and discriminator in one step). [12]

IV. Current research

In our current research, we focused on the topic of investigating the benefit of additional 3D information in the task of image classification. While the added value this modality is intuitive, we decided to quantify this improvement by performing an experiment, comparing grayscale, RGB and RGB-D image representations when classified by a convolutional network. We constructed a simple model which we trained on the CIN-DB dataset [13].

The model we chose for the experiment was a neural network consisting of two convolutional layers, a fully connected hidden layer and a softmax output layer. We intentionally chose a simple model to better emphasize the differences between the modalities.

Our results are similar to [13] although the type of used classifier network is different, which further confirms the intuitive hypothesis. An interesting observation was that the addition of color information brought much lesser benefit than depth and when depth was available, the benefit of color information was almost insignificant. ROC curves for different modalities are shown in Figure 2. The paper is currently being prepared and will soon be submitted for publishing.

V. Future work

As noted in [14], our goal is to contribute in the area of 3D image classification in the domain of mobile and service robotics. During the last year, we identified the area (semi-supervised generative modelling), which we believe has the potential to further improve the accuracy of 3D classification the mentioned domain.

The next steps of our research (detailed in [2]) are to investigate the weak spots of generative modelling-based classification of 3D imaging and to find possible areas of improvement. One of the most important research frontiers of GANs particularly is non-convergence (or oscillations) and particularly mode collapse, where the generator converges or cycles between states where it models only one part of real distribution and therefore generates the same output regardless of it's input. Another area that we want to focus on is semi-supervised training of generative models where we see opportunities in inventing new architectures and possibly using different types of networks or mechanisms for generators and discriminators. [12]

In the area of practical contribution, we are planning to create a tool for transforming data between 3D polygonal mesh (CAD models) and voxel formats. This is required to use data from some publicly available 3D classification datasets and benchmarks (specifically ModelNet [1]) with convolution-based models. Custom conversion tool will allow us to experiment with various resolutions and voxelization methods.

Acknowledgment

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PLC based universal hardware in the loop workplace

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***Abstract*— The article deals with design and implementation of universal Hardware in the Loop workplace (HIL) for the modeling and control of continuous or discrete dynamical systems. The whole concept is based on the requirements of the widest workplace universality and the requirement to use standardized, commercially available devices during its implementation. In order to meet these requirements, both subsystems of the HIL workplace (testing and simulation) were built on basis of standardly available Programmable Logic Controllers. The workplace is mainly being used for solving tasks related to electric drives, mechatronics, robotics and technological plant control.**

***Keywords*—hardware-in-the-loop (HIL), programmable logic controller (PLC), dynamic system**

I. Introduction

Verification solutions to research problems of different type and complexity of the field of industrial systems is often required in view of their complexity laboratory equipped with appropriate facilities or specific physical models of these systems. Such devices are often in view of their specificity technically and financially demanding and useful only for a narrow class of solving problems. Therefore, it is appropriate to have for the purposes of research, as well as education-devices which are universally applicable to a wide range of tasks, and the results that can be obtained by using them, it can be applied with a high probability and in engineering practice. [1]

This technology is extensively used in the aerospace, automotive and rail transportation industries. The benefits of using HILS testing are four folds: first, the controller can be tested even before the actual plant that it will control (for example, an engine, motor or transmission) is built or available; second, the risk of damaging the plant is eliminated thus reducing cost and risk; third, fault conditions can easily be created; and fourth, the field condition can be replicated with given operation condition and analyse the abnormalities. HILS testing has been very successfully used for testing mechanical systems which require lower sample rates.

The literature currently presented several concepts HIL workplaces. There are two main types of hardware used today to make HIL workplace: multi-core CPUs and FPGAs, only a few concepts are built on PLCs [2]-[5].

A new concept of hardware-in-the-loop (HIL) simulation workplace that serves as an effective tool for education and research tasks related to modelling and control of technological dynamic systems is designed and discussed in this paper. The workplace concept is based on generally available and employed hardware (Programmable Logic Controller) and software means (MATLAB), configured to enable work on practically any type of both continuous and discrete systems. Furthermore, this concept, hardware of that is built on PLCs, enables standardized remote access over the internet through tools used in the Windows operating system.

A case study involving a DC drive included in the paper also demonstrates the simplicity and effectiveness of the HIL simulation workplace. [4]

II. Concept of HIL workplace

It is with the above requirements in view that the workplace concept illustrated in Fig. 1 was designed.

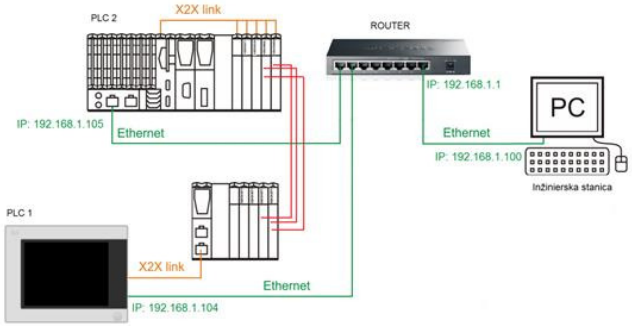

Fig. 1. The involvement of a particular workplace HIL

In compliance with the concept specified above, an HIL simulation workplace was built having the following parameters:

1. Standard PC i3-2120 CPU 3.3GHz, 4GB RAM with OS Windows 7 Professional. Matlab version R2012a with B&R Automation Studio toolbox for direct transfer of block diagrams from Matlab to the PLC from B@R was installed on the PC. For PLC programming, software package *B@R Automation Studio* version 4.2 with added libraries *brsystem* and *sys_lib*.
2. PLC for technological process simulation by B@R type PP500 with operator display 5PP520 1214-00 TFT SVGA 12.1″. For more simple process models the PLC enables reaching sample time as short as 1ms.
3. PLC for technological process control by B@R, type X20 CP 1484-1.

III. Case study – HIL simulation of a DC drive control

As an example of the use of the HIL simulation workplace for educational purposes we present the simulation of control of the angular speed of an electric drive with DC motor.

On basis of state discrete dynamic equations of DC drive we created a block diagram of the DC motor in Matlab/Simulink, which can be directly converted into the PLC using the Automation Studio Toolbox by B&R installed in Simulink (Fig. 2). In this way, any dynamic system model created in Simulink can be implemented in the relevant PLC without detailed knowledge about its programming environment.

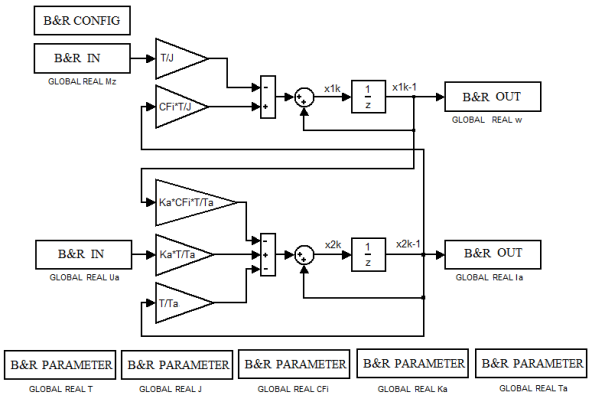

Fig. 2 Block diagram of DC drive in discrete form prepared for conversion into the PLC

For current and speed control of the DC drive we chose a discrete PI controller.

The parameters of DC motor and controllers are specified in the Appendix. The structure of the controllers for current and speed control of the DC drive implemented in the PLC is illustrated in Fig.3.

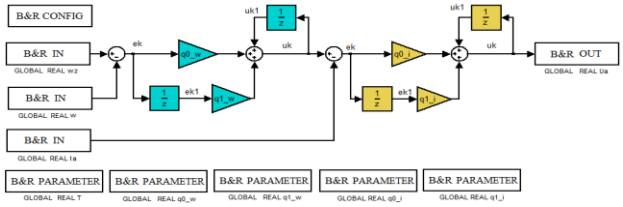

Fig. 3 Block diagram of PI controller for both current and speed loop of the DC drive

Verify the correctness of the solution by comparing the responses of the relevant quantities acquired from the simulation (Fig. 4) and those acquired from the HIL workplace (Fig. 5).

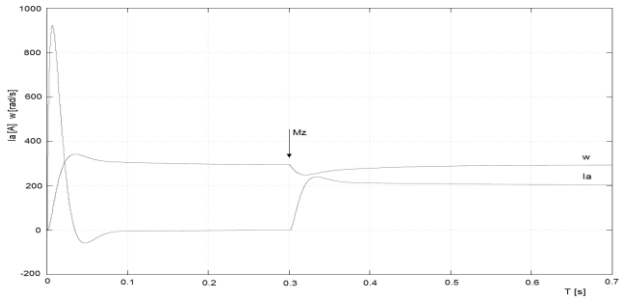

Fig. 4 Responses of drive under control to step change in desired speed (w_{des}=270 rads^{-1}) and load torque (M_z=140 Nm)

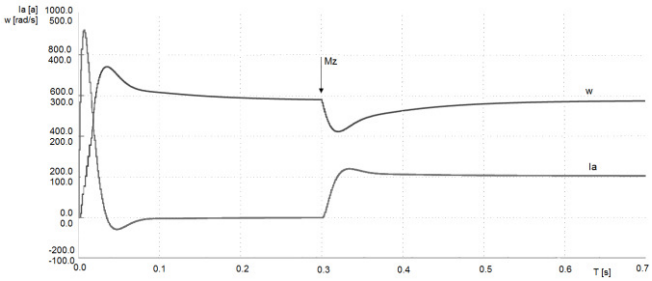

Fig. 5 Responses of controlled drive from HIL simulation workplace to step change of desired speed (w_{des}=270 rads^{-1}) and load torque (M_z=140 Nm)

Comparison of plots of output quantities from Fig. 4 and Fig. 5 shows that the dynamics of DC drive control is in both cases practically the same and therefore the control PLC can be directly interfaced with the real DC drive.

IV. Conclusion

The paper describes the concept and implementation of a universal HIL simulation workplace. From a pedagogical point of view is important solutions variability of the duties of the proposed concept HIL workplace built on the basis of two PLC allows. From the hardware point of view is a simple change in the number and types of standardized PLC inputs and outputs. From the software point of view it is of course necessary amendments to the relevant program in the PLC. Features of the concept developed HIL workshops are verified article on the example of drive control with DC motor. The achieved results confirmed the functionality of the concept developed HIL workplace that is sure to find its use in teaching and research in the process of modeling and control of various types of dynamic systems.

Appendix

DC motor: n_n=2800 ot/min^{-1}, Pn=2,3kW, M_n=146 Nm, I_n=12,3 A, J=0,0315 kgm^2, U_{aN}=220V, R_a=1,6 Ω, L_a=8,8 mH, cϕ = 0,7 Vs, K_a=0,625 Ω^{-1}, T_a=0,0055 s, M_z = 140 Nm

Parameters for discrete PI controllers were calculated based on KSO (speed loop) and KOM (current loop) method: current loop: q_{0I}=2, q_{1I}=1,8 speed loop: q_{0w}=5, q_{1w}=4,95

Acknowledgment

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Pattern Recognition in the JEM-EUSO Experiment

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***Abstract*—The aim of the JEM-EUSO experiment is to find sources of the ultra high energy cosmic rays (UHECR) by observation of air showers created by interactions of UHECR particles with the Earth's atmosphere. The showers will be observed as a spot of light moving through the JEM-EUSO detector field of view. Therefore the task is to precisely recognize properties of a primary particle from observation of an air shower. This paper reports about preparation work towards developing a more detailed approach of estimating the detector exposure, enhancing and redesigning event reconstruction algorithms, and exploring tsunami wave detection with EUSO-class experiments.**

***Keywords*—JEM-EUSO, UHECR, pattern recognition, exposure estimation**

I. Introduction

Japanese Experiment Module - Extreme Universe Space Observatory (JEM-EUSO) [1] is designed to be installed onboard of the International Space Station (ISS) on the Exposed Facility of the Japanese Experiment Module. The innovative instrument will detect Ultra High Energy Cosmic Ray (UHECR) particles above and around the Greisen-Zatsepin-Kuzmin cut-off, by imaging in UV spectrum with very high temporal resolution. The aim of the experiment is to observe extensive air showers (EAS) caused by UHECR particles, and thus initiate new field of astronomy that uses the extreme energy particle channel. Challenge of UHECR detection is their very low primary particle flux. Therefore there is a great need to design methods that not only provide high precision but also can recognize primary particle properties from small amount of the data in a noisy environment.

The event detection and classification relies on applied event reconstruction techniques. All these tasks are connected to the image and video processing field because raw data itself are similar to classical image and video recordings. For these techniques to work properly, the input data need to be properly preprocessed, ideally filtering noise from measurements and discarding data without events of interest observed.

The JEM-EUSO and other pathfinder EUSO-class detectors provide additional capabilities besides the primary goal of the mission. One of such applications considered is possibility of tsunami detection via observation of the UV airglow perturbations. To detect and reconstruct direction of such events different approach, when compared to UHECR detection, is required.

II. Research Problem and Its Initial Status

To validate feasibility of the experiment, the probability of an event detection and reconstruction needs to be determined. However preset studies [2] has not connected the exposure calculation to event reconstruction performances, which requires simulation of an air shower in every possible observation scenario during duration of the mission, followed by the event reconstruction and evaluation of the true and reconstructed event parameters.

The event reconstruction techniques presently in consideration depend on fitting recorded data to the existing mathematical models of the physical world. All of the present approaches [3] for the event reconstruction in the JEM-EUSO view it as strictly handwritten pattern recognition algorithms based on the highly detailed expert knowledge and intuition about the input data.

Deep learning methods are arguably the best performing tool for the pattern recognition and especially the computer vision, this is demonstrated by a fact that all winning competitors of the yearly ImageNet challenge [4] utilize approaches based on deep neural networks, usually building on principles of convolutional neural networks (CNN) [5]. In comparison to multilayer perceptron approaches, which are suited for classification from extracted features, a representative learning approach like CNN learns features during training. Performances displayed by the CNNs motivate to explore this pattern recognition method in less typical applications of computer vision. Several studies [6], [7], [8], [9] used CNN in high energy physics and astrophysics mainly for classification purposes. However we have not found studies that would apply CNN for air shower reconstruction.

Use of the machine learning for the event reconstruction would be an alternative paradigm to the existing method. Results of such study might be generalized and applied for different experiments in the field. Possibly very interesting result produced by the research would by a comparison of expertly selected features and features learned by the network.

III. Progress in the Research Area

Our work is focused on the following four directions:

1) Exposure evaluation and extension of the definition to include reconstruction performance, and relate the exposure to sources of the primary particles.
2) Development of air shower segmentation methods utilized in the current process of the event reconstruction.
3) Event reconstruction by the machine learning algorithms trained on the simulated events.
4) Tsunami detection via EUSO-class detectors.

The first three directions are tied to the same dataset of the UHECR and detector simulations. And the last - tsunami

detection - utilizes dataset of observations from the JEM-EUSO pathfinder experiments.

A. Exposure estimation framework

Our form of the exposure is calculated as a product of the detector duty cycle factors and geometrical aperture. If the aperture is related to a source, then this equation also contains factor of source visibility affected by the relative positions of Sun, Earth, and Moon. A cumulative form of the equation integrates this value over measurement duration, over range of primary particle energies and arrival directions. The geometrical aperture expresses probability of event detection over area of the focal surface and primary particle arrival directions. Aperture definition will be extended with event reconstructability variable, that is considered to have multiple possible definitions, for instance probability (or fraction) of events reconstructed within the mission requirements. This is mostly dependent of particle primary energy, position on the focal surface, background intensity, and arrival direction, thus the reconstructability can be expressed as a function of these parameters. Correct modeling of the background intensity is non-trivial task because of many contributing factors and insufficient dataset of suitable measurements. Impact of different background intensities on the reconstruction precision has not been studied sufficiently, especially including the most recent versions of airglow models [10].

Goal of our work related to the exposure estimation is to create a system that can provide near real time results for any provided UHECR source particle flux, including variations of multiple sources and isotropic arrival. Figure 1 illustrates its basic structure and data flow. The system will allow to validate the detector capability to observe expected sources. Another possible application is search for possible UHECR sources comparing modeled and observed particle flux.

Dataset of simulated and reconstructed events makes possible to determine restructurability in near real time. It is also essential for our next goal, that is to train CNN to handle event reconstruction. To achieve this goal, a massive dataset of UHECR air showers recorded on focal surface is necessary.

UHECR and detector simulations are done by ESAF framework [11]. First testing simulation and reconstruction run has produced 136 000 simulated events. Data are divided by 4 particle arrival zenith angles, and 17 primary particle energies. These parameters have the most significant influence on a simulation duration and shower reconstructability. Processing time is most significantly affected by the duration of the simulation. Measured time of simulations can be used to extrapolate duration of a more massive simulation. Analysis has shown that a mean value of simulation duration as a function of an primary energy is well described by a square root function, and also a linear function for higher energies depending on zenith angle (processing time for 75° shower rises only linearly considering values range of the dataset). On the other hand, mean simulation duration raises exponentially with an increasing zenith angle. This data has been used to approximate total simulation duration of planned analysis. Considering 10 000 events for every combination of primary energy (27 values), zenith angle (28 values), and UV background intensity (at least 10 values), using tested hardware the simulation is expected to take approximately **100 days on 100 processor cores**. Which can be done by use of a computational cluster at the Institute of Experimental Physics of Slovak Academy of Sciences. The simulation duration is expected to be decreased by storing and reusing results of intermediate common steps. Especially reusing photomultiplier hits would reduce the need to run complete simulations for different UV background levels to a task of merging photo-electron hits data with Poisson noise and application of trigger algorithms to the data.

B. Air shower segmentation methods

We have analyzed angular reconstruction precision dependence to a segmentation method and intensity of background noise in [12], then the study was extended in [13]. Another important factor is intensity of shower feature signal. Figure 2 shows angular reconstruction precision for air showers with different primary energies. Compared segmentation methods are Hough transform 2 (HT2) and Peak and window searching technique (PWISE). The HT2 method is described in [13] and PWISE precision measurements have been taken from [14]. Implemented Hough transform methods fit signal to a line model in X-time, Y-time planes, or alternatively in 3D space X-Y-time. Another simple implementation using RANSAC method has been also tested and comparable precision to Hough methods has been observed. This demonstrates that when signal-to-noise ratio is low, methods that select data based on spatial attributes have generally superior performance to methods that only perform some form of thresholding based on pixel-time intensity distribution.

GUI application called *PattRecoViz* has been created that allows more convenient development and output visualization of feature segmentation methods on the detector focal surface. This Qt framework-based application links ESAF framework shared libraries, therefore same source code can be used inside this and event reconstruction applications. Architecture of the application separates pixel map visualization and input file parsing, which are accessed through an universal interface, thus there is also possibility of Offline framework [15] integration.

C. Tsunami detection methods

Tsunami detection techniques are being developed using simulated atmospheric gravity wave events observed by the Mini-EUSO detector using a wave package and airy functions [16]. At present stage, methods focus on correct extraction of wave orientation from a single image, which is then followed by reconstruction of tsunami wave characteristics from selected signals. Reconstruction precision is evaluated for different wave types.

IV. Conclusion and Plans for the Future

Our work has been so far focused on preparation of utilities for a massive data analysis handling terabytes of simulated events. Published papers focused on performance analysis of current Hough transform-based algorithms. More definitive algorithm comparison and implications of segmentation algorithm influence on reconstruction precision will be provided by comparing resulting detector exposures.

Next step in our work is to utilize developed automated ESAF simulation, reconstruction and analysis system (*AESRA*) to create first version of a dataset which can be used for purposes of exposure estimation and convolutional neural network training.

The focus in the development of the segmentation methods will be on variable thresholding methods, attempting to minimize threshold values required for the successful location of the shower feature. Possible avenue is also to consider more advanced shower parametrization instead of a simple line, taking into account actual expected shape and pixel intensity of a shower. The event reconstruction methods will be tested using real shower observations by EUSO-SPB detector, that is to fly on a stratospheric balloon in spring 2017. We expect this workflow to greatly benefit from capabilities provided by the *PattRecoViz* application. The application and algorithms are also planned to be extended as a part of student diploma theses.

Tsunami detection techniques will be tested using real data from flight of the Mini-EUSO detector in late winter 2017 or early spring 2018.

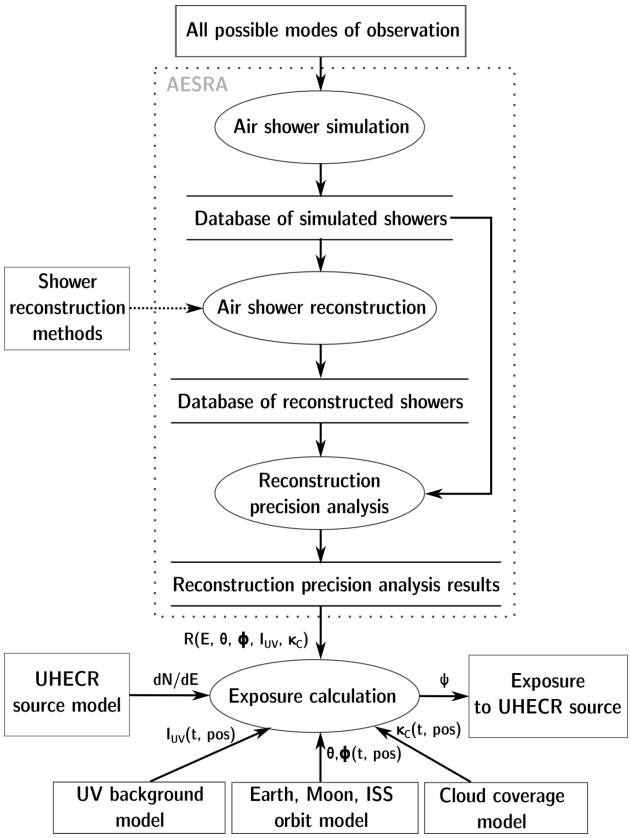

Fig. 1. Data flow model of the exposure analysis system.

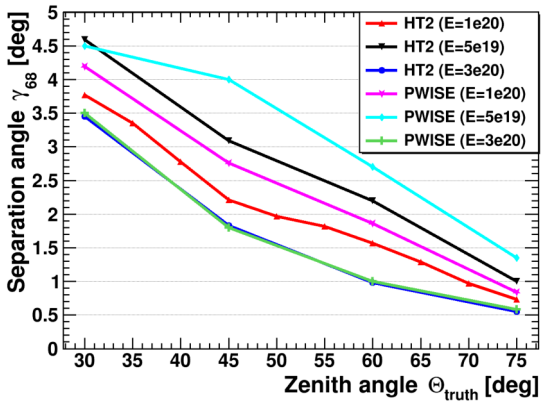

Fig. 2. Angular reconstruction precision as a function of zenith angle for different primary energies and nominal UV background intensity.

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Predictive Data Mining Models for Data Analysis in a Logistics Company

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***Abstract*—Decision support system in the logistics can provide managers of logistics companies valuable information needed to make effective decisions. One of the key and often solved tasks in logistics company are not only the question of low fuel economy, but also decisions about the assignment of truck drivers to planned routes. The aim of the article is to identify the combination of factors that have a key effect on fuel consumption. This paper focuses on data analysis to improve decision-making in the selected logistics process - the selection of truck drivers for planned routes. A questionnaire survey shows, that in logistics companies and transport companies often miss information system that would facilitate assigning truck drivers on planned routes.**

***Keywords*—data analysis, average fuel consumption, Naive Bayes classifiers, decision support system**

I. Introduction

Data analysis and logistics are closely related. Logistics companies often manage a large flow of goods while creating a lot of data. This data have the potential for new business models. Inventory management, shipment tracking, and even positioning the sensors in vehicles, all these activities provide large amounts of data [1] [2]. For logistics companies are difficult to perform timely and accurate decisions for operational logistics activities [3]. The technology of data mining and statistical analysis can help to understand customer behavior and carry out an appropriate strategy, which can reduce the risk resulting from wrong decisions [4].

The aim of this work is to apply predictive data mining techniques, thanks to which we can identify the key factors that influence the average fuel consumption. This paper identifies best practices and driving styles of truck drivers that can help in the decision about the assignment of drivers to trucks on planned routes.

II. The Current State of the Problem

Recently, several research studies have shown the benefits of using big data techniques in logistics and supply chain management.

One of the objectives described in the article [5] was to develop a model for prediction of the fuel consumption for heavy vehicles for a given route. For predicting the average fuel consumption, the authors have used machine learning methods based on a number of variables related to the route, driving behavior, vehicle specification, road characteristics and weather data. The model should provide an estimate of the fuel consumption for a given vehicle, characterized by a given set of attributes, for a given road segment with certain properties.

Next case study [6] deals with the influence of the driving style of each truck driver on fuel consumption. Investigators decided to use the technique Naive Bayes to identify key attributes, which can have a major impact on fuel consumption. The authors concluded, that attributes such as clutch usage, time percentage of engine rotation in yellow band and time percentage of engine idle rotation have an impact on reducing fuel consumption. Data about the weather have minimal impact on average fuel consumption. With appropriate driving style, the fuel consumption can be reduced by 3-5 liters per 100 kilometers, which is 20-40 € per day and 1.5 million Euros per year.

III. The Actual Results

The main objective of our research is creating system for support decision about truck driver selection for a specific route. For this reason, research was conducted among logistics companies.

A. Questionnaires

More than 300 logistics companies and transport companies was interviewed via e-mail. One of the questions was whether they would imagine a system that suggests assignment of truck drivers to particular routes. 10% of respondents do not know such a system, 40% would not use such a system and 50% of respondents would like to use such a system, some of them tested such a system already and plan to deploy it. Moreover, by means of questionnaires, we have found that over 88% of companies analyze the driving style of their truck drivers, whereas about 46% of them use for such an analysis a software program.

In Figure 1 we can see the composition of the answers to the next question: How do you assign the truck drivers to a specific driving route?

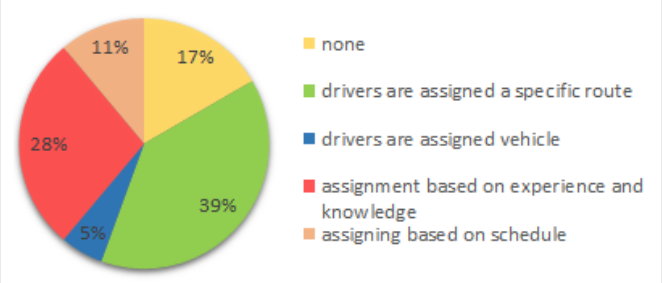

Fig. 1. Answers to the question obtained through the questionnaire survey

B. Model Design

Through initial analysis published in [7] [8], we continue our further research towards identification of key factors affecting fuel consumption.

Data preparation (data selection, data cleansing, data integration, design data, data formatting) was done through programs MATLAB and R. The proposed model was implemented with software tools RapidMiner and Visual Studio. Based on Naive Bayesian Classifier we determined which attributes have the greatest impact on the fuel consumption.

C. The results

The accuracy of created model can be seen in the confusion matrix in Table 1. The highest prediction accuracy has the first and the last class.

TABLE I
CLASSIFICATION MATRIX

accuracy: 60.85% +/- 48.81% (mikro: 60.85%)

	true to 27	true from 28 to 29	true over 30	class precision
pred. to 27	610	138	266	60.16%
pred. from 28 to 29	64	30	111	14.63%
pred. over 30	212	126	785	69.90%
class recall	68.85%	10.20%	67.56%	

The results shown in Table 2 represent key factors influencing average fuel consumption. For example, we can say that if the truck driver will use cruise control more efficiently, with probability 89.2% he will achieve lower fuel consumption.

TABLE II
KEY FACTORS INFLUENCING AVERAGE FUEL CONSUMPTION

Attribute	Parameter	to 27 ↓
Within Economy	value=Good	0.958
Top Gear	value=Good	0.910
Cruise control	value=Good	0.892
Coasting	value=Good	0.752
Brake/stop relation	value=Good	0.709
Overspeed	value=Good	0.685
Above Economy	value=Good	0.637

On the basis of analysis described in [7], we can create model of delivery route. The created model can predict the probability of a low average consumption for individual truck drivers. For example, on the route Kiel (Germany) – Akershus (Norway), Driver_C with probability 74,1% used up 27 l/100 km, while Driver_H on the same route with probability 69,4%, used up more than 29 l/100km.

D. Recommendations

Based on the conducted experiments, we have gained knowledge of the savings in fuel consumption. Recommendations that would lead to a reduction in fuel consumption are as follows:

- proper brake usage,
- effective use of cruise control,
- optimal engine usage,
- maximizing savings drive
- improve above economy.

IV. CONCLUSION

Thanks to the predictive data mining, we identified the main factors, which affect the average fuel consumption. On the basis of our results, we designed recommendations for truck drivers. These recommendations may help the truck driver to lower fuel consumption. Finally, we showed how such results can influence the decision process of assigning truck drivers to planned routes.

V. FUTURE WORK

Future research will focus on an extension to create a model for other factors to support decisions on the selection of truck drivers. Based on the requirements of the owner of a logistics company, interviews with truck drivers, existing analysis, we will design a multi-criteria decision-making model. The main goal of further work will be to design and develop decision support system for truck drivers' assignment to planned routes. With the consent of the owner of this company, the model we will test and evaluate the extent to which this system is beneficial for the selected logistics company.

ACKNOWLEDGMENT

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Predictive Maintenance Based on Industry 4.0 with the Help of IT Technologies

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***Abstract*—In the last few years Industry 4.0 has become a part of industrial revolutions, the fourth of its kind. It describes a comprehensive system of monitoring and analyzing all the aspects in the organizations with the help of many modern approaches for better data processing (e.g. information sharing through clouds, Internet of Things, etc.). This paper describes a brief history of the Industry 4.0, smart factories as organizations that follow the Industry 4.0 principles and its Cyber-Physical Systems, which are essential to build such organizations. Also, it gives an insight for a maintenance management and the best approach of predictive maintenance in such environment. At the end of the paper we analyzed various platforms for developing our new application based on the mentioned principles and strategies.**

***Keywords*—Industry 4.0, maintenance management, predictive maintenance, statistics of platforms**

I. INDUSTRY 4.0

Industry 4.0 is the current trend of automation and data exchange in manufacturing technologies. It includes cyber-physical systems, Internet of Things and cloud computing.

A. History of the 4th Industrial Revolution

Development of the industry is characterized by stages that change over time, depending on progress of the new technologies development and use of obtained energy. The first industrial revolution originated with the simple mechanical devices powered by steam, the second one - use of electricity and related mass manufacture production, the third one - based on automation capabilities of mass data processing, the use of electronic systems and computer equipment (so-called digital revolution). Brief chronological succession of the industrial revolutions is shown in Fig. 1.

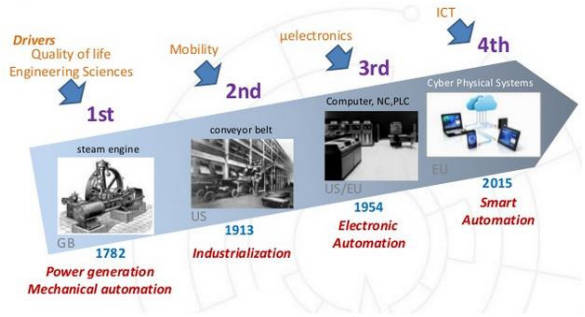

Fig. 1. Historical development of the 4th industrial revolution [2].

Options for the processes management from input to output are historically known within the so-called Logistics, which originated in a military sphere and its development increased significantly after World War the Second. Logistics as a management tool is linking information, material, human and energy flows in order to ensure "the right product - at the right quality - in the right quantities - for the right price - at the right place."

Industry 4.0 appeared for the first time as a result of the German Government project (High-Tech Strategy, in German: Bundesministerium für Bildung und Forschung – BMBF, shown in Fig. 2), in pursuit of full automation industry. Currently, these concepts are similar in China, Japan and the US, e.g. project called "Smart Manufacturing Leadership Coalition - SMLC" [1].

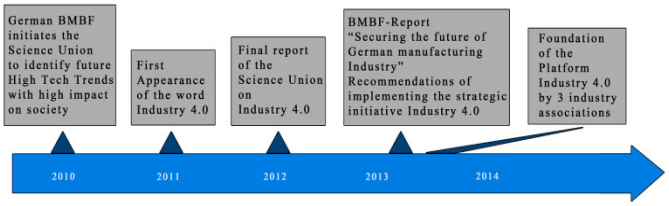

Fig. 2. Formation of the Industry 4.0 concept in Germany [2].

In "National Initiative Industry 4.0" published under the Ministry of Industry and Trade of Czech Republic, under the auspices of prof. Marika [1], it says "phenomenon today is linking the Internet of Things, services and people (Internet of Things - IoT, Internet of Services - IoS and Internet of People - IoP) and the related huge volume of data generated in communication between "machine to machine", "man to machine" or "man to man". Industry 4.0 transforms the production of separated and automated workstations to fully integrated and automated continuously optimized production environment."

A prerequisite of such environment is a development of global networks, which link devices with the environment, through the so-called. "Cyber-Physical Systems" - CPS, and these systems are the functioning cornerstone of the Smart Factories - SF.

Kagan Pitman on the website for the media industry [3] declares that the Industry 4.0 is a connection of new technologies based on IoT, with automation and technology

of clouds, where information flows are very important.

John Fleming, a member of the Manufacturing Leadership [3], believes that this initiative will link digitalization with the experience of workers: "Our future CPS environment will be based on the merging of products, chain suppliers and businesses". Fleming wants to create certain procedures (so-called "roadmaps"), which would be led by experts, who could guarantee full use of IoT in such way that there would be key indicators like safety, quality and cost-effectiveness protected. His challenge brings a hidden concern, whether the vertical and horizontal integration to the comprehensive digitalization will bring the expected results for creating "smart products" meeting all customers requirements [1, 3].

B. The Elements and Principles of the 4th Industrial Revolution

Smart factory links physical and virtual environments through the CPS. The result is a fusion of the technical environment with the business environment (Fig. 3) [4].

The modular structure of smart factories is composed of these elements:

- Cyber-Physical System,
- physical processes,
- Internet of Things (IoT),
- communication connections.

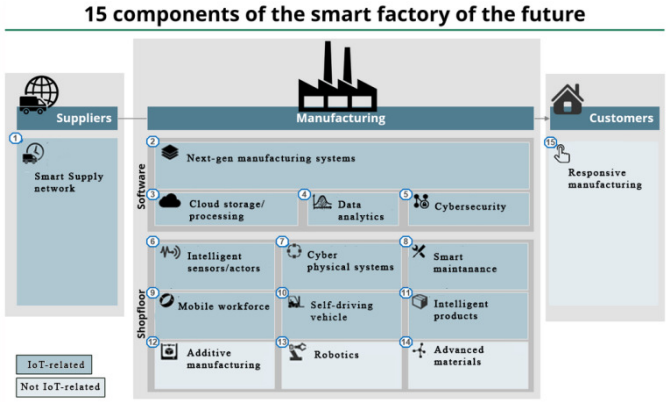

Fig. 3. Elements of a smart factory [4].

The result of these connections, virtual and real technical environment using the latest communications technology is more favorable (humane) working environment, it ensures customer satisfaction by delivering a product with characteristics that correspond with the custom requirements and taking into an account the changing conditions during its life-cycle. Use of machinery in the context of global optimization is guaranteed by its abilities to do a self-diagnostics and self-repair according to the external requirements.

The essence of the smart factory scheme is a dynamic decision making to ensure fulfillment of the objectives for the "core business" requirements.

When building a smart factory, it needs to take into an account at least these three critical elements:

- poor specification of the core business requirements and a lack of methodological management of their implementation in decision making modules and criteria,
- underestimation of a risk assessment with regard to internal and external environment of an organization "business environment" management without comparative factors related to the risks,
- predictive maintenance vs. full automation without a knowledge of guiding indicators that monitor a device status, lack of prioritization and their mutual combination methodology compared with critical parameters defined as a cascade model of a process approach based on the defined business objectives.

II. Maintenance Management in Smart Factory

Maintenance management based on Industry 4.0 gets not only a new dimension, but becomes a key factor for the success of a smart factory development. There appears a new trend for its definition, which is called "e-Maintenance (eM)". The question is, how to understand eM, whether it is as a new strategy, concept or just a method of maintenance management by integrating data and the best practices in the maintenance [5, 9]. It can be understood as an online maintenance and is defined as follows (Fig. 4).

- According to API (American Petroleum Institute), eM is online solution for a maintenance management that supports all the maintenance requirements ("an online maintenance management solution that allows you to log, take action, track and report on all your maintenance requests") [7].
- According to Levrat – eM is an emerging concept of monitoring and maintenance management for the devices over the Internet ("e-Maintenance is an emerging concept generally defined as a maintenance management concept whereby assets are managed and monitored over the Internet") [6].
- According to Holmberg [12]: eM is a synthesis of two basic trends in a nowadays society - rising an importance of maintenance as a key technology and a rapid development of information and communication technologies.

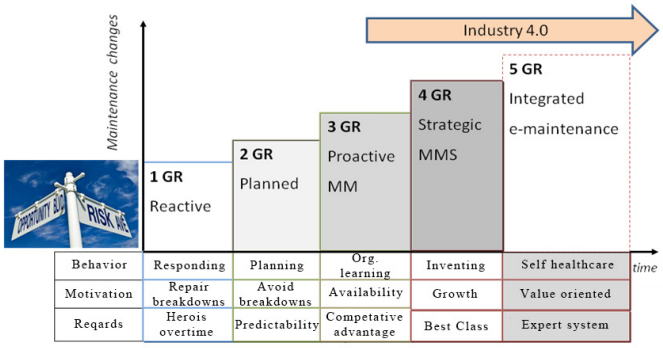

Fig. 4. Development of a maintenance management, from corrective maintenance to eM

Based on the previous reviews, it can be defined as the e-Maintenance Management (eMM) concept of an intelligent maintenance management, using modern information technology-based analysis and assessment of critical equipment or processes capable of collecting appropriate data, analyze them and evaluate relevant information that guarantee an application of such devices algorithms that they would be able to "self-learn healthy behavior." This behavior results from the prediction of required performance and required

maintenance activities, as a result of a continuous process of acquiring knowledge about the devices.

A. The Role of a Predictive Maintenance in eM

Predictive maintenance (maintenance based on the device status) is one of the basic maintenance strategies (it includes: preventive planning, predictive and corrective maintenances) that uses available measuring instruments (methodologies). It can track changes in a device condition by monitoring its physical parameters and prior to the failure occurrence, it plans adequate actions.

Its success in the recent decades is linked to its affordability, but also its technological and methodological developments. Similarly, its full incorporation into an enterprise communication systems is pre-prepared (or already implemented), offline or online monitoring and evaluation.

Mr. Bielesch [9] declares about the predictive maintenance in the Industry 4.0 that the implementation of IT technologies in production control is necessary to speak mainly on advanced and comprehensive self-diagnostic system, which has got an advantage not only in the identifiability, but mainly predictable failures in order to optimize and make correction plans more efficient based on a device status. Except of stress free protection for maintenance workers, there is a consistency of production expected while minimizing potential losses, using new algorithms and mathematical models to assess the current state of devices life nodes.

There are basic methods to predict the remaining life of the monitored components - methods of predictive analysis [10], which are:

- Regression methods – use different forms of statistical analysis from simple linear regression to multicriterial regression (optimization) to predict devices failures.
- Tools for a self-learning – a way of simulating the behavior of a man, who creates diagrams and schemes used for better decision making and later prevent the potential failures based on the monitored data and experiences from the past.

The problem is the collection of failures data (Fig. 5), sufficient knowledge about the root causes and of course, the time and the possibility to avoid a failure, for example: for critical devices (devices that are the most important in the factory) a failure can cause a serious loss of money.

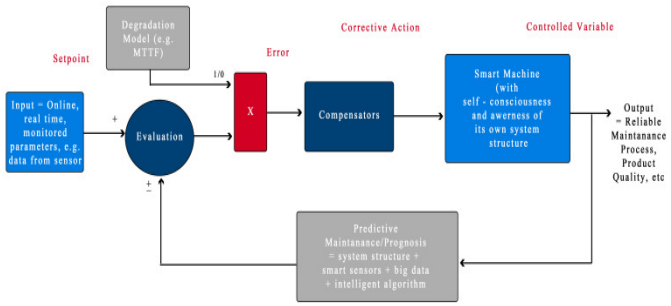

Fig. 5. Forecasting model based on data from the predictive maintenance [11]

It is clear that sophisticated mathematical models are a necessity for use within the predictive maintenance in smart factories.

III. Analysis of Trends on Various Platforms

The use of computer devices in the last eight years has dramatically changed thanks to smart phones, which contributed to the use of different Operating Systems – OS on the basis of what kind of device it is. In the next two subsections there are statistics of the mobile, desktop and web platforms, which are widely used nowadays.

A. Mobile Devices Trends

The most used mobile operating systems nowadays are Android, iOS and Windows Phone [12]. In the next figure (Fig. 6) you can see a market share of mobile devices with a different OS.

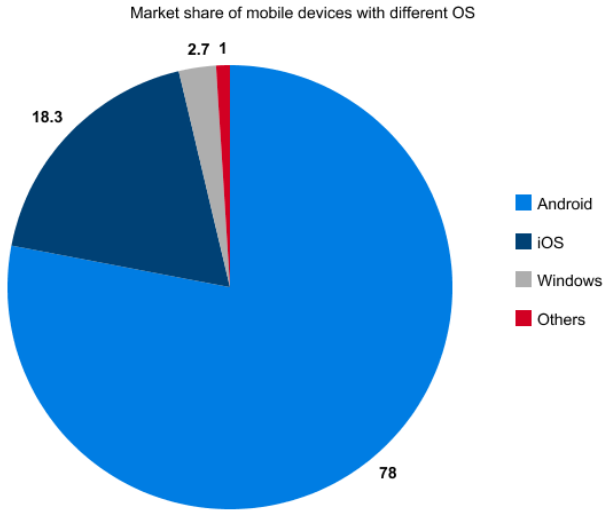

Fig. 6. Percentage market share of mobile devices with different OS [12]

The following table (Table. 1) shows an average price for mobile devices with various operating systems:

TABLE I
THE AVERAGE COST OF MOBILE DEVICES [13]

OS	Price average in 2014	Expected price average in 2018
iOS	$657	$604
Android	$254	$215
Windows	$265	$214
Others	$314	$267

Market share in a relation to the operating system for mobile devices until 2020 is shown in the figure below (Fig. 7).

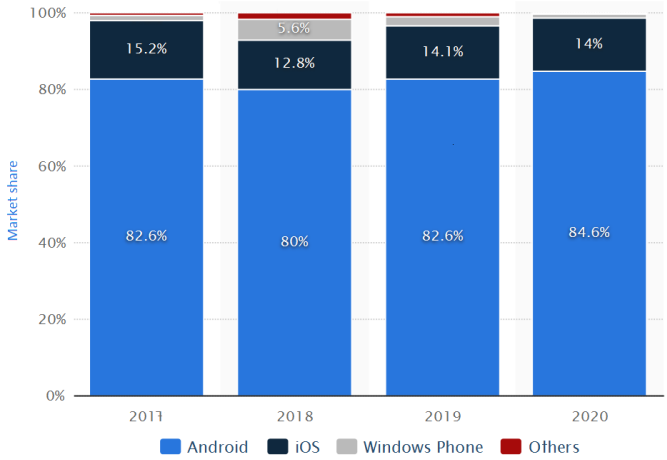

Fig. 7. Forecast of a market share for mobile devices with a different OS [14]

From these analyzes and statistical data, we concluded that the best option is to use the Android operating system for developing our desired application, because of its low cost, usability and mainly because it is the most widely used operating system for mobile devices today.

B. Desktop Computers and Web Trends

There are many of the operating systems available now worldwide, but only a few of them are favorite to most of the people. In the following figure (Fig. 8), there is a percentage share of Windows, Mac and Linux operating systems, according to which we will make a further decision of making our first version of the application for the best and widely the most used operating system.

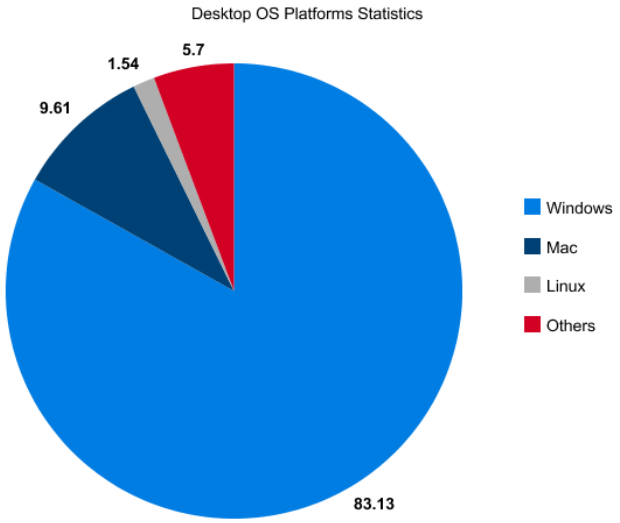

Fig. 8. Desktop OS platforms statistics in percentage share worldwide [15]

According to the statistics for Desktop OS Platforms, it is the best to build a native application for Windows platform.

As it goes for the Web development, it is the easiest way how to access data on all the platforms through the available browsers. According to edUi [16], the best is to use the combination of Polymer and Firebase platforms to build progressive web applications with the use of clouds. This way it will be guaranteed that all the collected data in the process of Internet of Things will be delivered to all the platforms in the real time.

IV. Conclusion

Our vision is to develop a new method for assessing the devices in the organization with a proper algorithm for predictive maintenance analysis so it will be implemented in all the important platforms with one central server side system – cloud. This way all the data will be connected across all the platforms in the real time and it will significantly help with the further decision making in the organizations.

Such tool can efficiently detect any of the failing devices before the failure occurs, which can save a lot of potential income.

In the end, it will be very important to implement the application for all the platforms, which can be easily done with the help of students as part of their final thesis.

Acknowledgment

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Progress in Development of Diagnostic System Based on Hardware and Analytical Redundancy

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***Abstract*—The purpose of this article is to summarize progress made during the last year of PhD study which focuses on fault diagnostics of sensors within distribute control system.**

***Keywords*—mobile robot, robot operating system, fault detection and identification**

I. Introduction

Mobile robotics experiences huge expansion in many different fields such as service robotics, home appliances, industry, free time or military. There are several types of mobile robots like walking or flying robots, but wheeled robots are the most widespread among all, especially the ones with differential driven chassis. The reason of their popularity is because of relatively simple and precise motion control, high efficiency of movement and low computational demands on controller.

Non destructive diagnostics in mobile robotics is used in robots with increased reliability where fault of sensor or actuator can endanger human life or in exploration robots with limited maintenance possibilities.

The main motivation for this work is to develop diagnostic system based on hardware and analytical redundancy to determine fault of the sensors or unusual state of the mobile robot.

In first part the progress during first three years of PhD study is summarized. Second part of the article is devoted to describe advances made in the last year.

II. Previous work

In first year we presented techniques for Multisensor data fusion (MSDF) using linear Kalman Filter (KF) and Extended Kalman Filter (KF) which combine data from multiple sensors to obtain more precise and robust result [1].

In second year the multilayer diagnostic system within distributed control system was described, which covers tasks from data collection, trough data preprocessing to Fault Detection and Isolation (FDI), ending with localization using MSDF [2].

In third year the multilayer motion control system for mobile robots with differential drive was introduced, which is the radix for all future work on mobile robots developed at our department [3]. This control system was described in more detail in [4].

III. Progress during last year of study

During last year of study there have been multiple advances in development of control system and diagnostic system for differential wheeled mobile robots.

A. Creation of ROS packages for mobile robots

In last year there were developed multiple ROS packages to control motion of mobile robots, collect data from sensors, actuators and subsystems of the robot and to determine position of the robot based on image processing from stationary camera.

These software packages were tested on desktop computer connected to MR using Bluetooth interface and on minicomputer Raspberry Pi placed directly on MR and connecter to control board using UART interface.

B. Development of sensor board

There was developed sensor board and its program library for mobile robots which contain 9-axis Inertial Measurement Unit (IMU) consisting of 3-axis accelerometer, gyroscope and magnetometer. This sensor board is connected to main control board using expansion connector via Serial Peripheral interface (SPI). The data collection from IMU sensor is implemented in Hardware Abstracion Layer (HAL) and uses Direct Memory Access (DMA) controller to read data from sensor.

C. Data collection from mobile robots

For the offline data analysis the data from sensors and actuator were collected in various scenarios. The collected data will be used for development and validation of diagnostic system described in [2].

Data collection was performed using ROS packages and consists of data from IMU sensor, motor regulators and external camera system. Sample set of collected data during one run is shown in Fig. 1.

This graph shows calculated heading angle gathered from multiple sources such as gyroscope, magnetometer, odometry, dynamic model and global camera system.

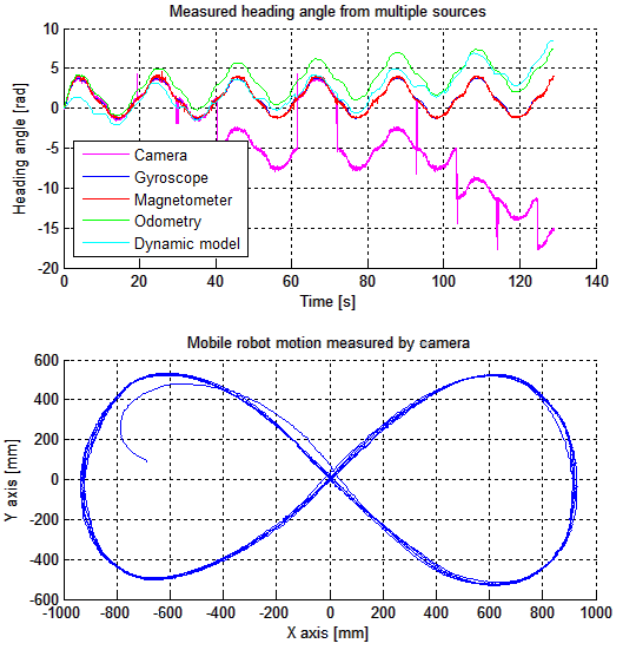

Fig. 1. Chart of measured data from multiple sensors (top) and position of mobile robot measured by camera (bottom).

D. Developed mobile robots with differential chassis

To test algorithms of designed control system and diagnostic system, the two mobile robots with differential driven chassis was developed. Both of them are controlled using the same type of control board and control system to prove the versatility of designed control algorithms. Photo of these mobile robots is shown in Fig. 2.

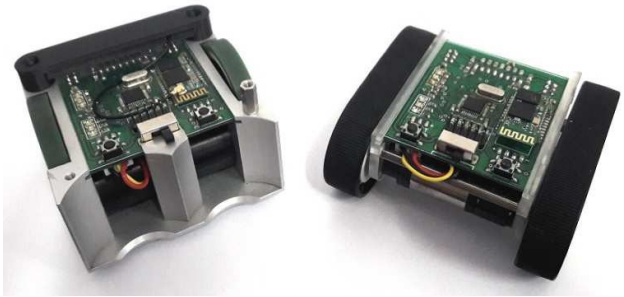

Fig. 2. Differential driven mobile robot for robotic soccer of category MiroSot (left) and tracked mobile robot TrackBot (right).

E. Sample applications based on developed mobile robots

During last year several applications were created which use developed mobile robots to solve different tasks such as:

1. Robotic soccer of MirosSot category. Multiple mobile robots are controlled by central computer which reads robots position based on data from image processing. Whole control system on the side of computer is covered by ROS, using custom made packages.
2. Maze solving using image processing. In this application the MiroSot mobile robot was used which was extended by minicomputer Raspberry Pi and camera.
3. Line following using image processing. For this application, there was used TrackBot MR with Raspberry Pi extension and onboard camera.
4. Remote teleoperation using ROS system. This application uses both MR with Raspberry Pi extension and onboard camera. Remote computer connects to Raspberry Pi using Wi-Fi and can receive image from camera and control motion of the MR.

Picture of MR in these applications is shown in Fig. 3.

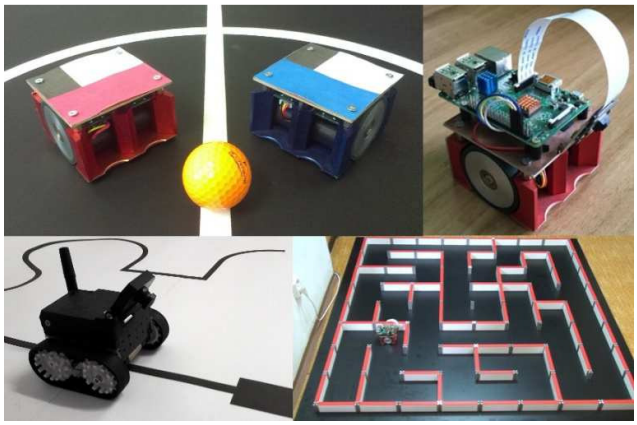

Fig. 3. Sample applications based on developed mobile robots.

F. Participation on CERN project

Our research group is also working on Experiment ALICE on LHC in CERN: Study of strongly interacting matter at extreme energy densities.

IV. Plans for Future Work

Next and final step of author's PhD study will be to test designed algorithms of diagnostics and localization of mobile robots on data gathered from mobile robots.

Acknowledgment

This publication arose thanks to the support of the Operational Programme Research and development for the project "Centre of Information and Communication Technologies for Knowledge Systems" (ITMS code 26220120020), co-financed by the European Regional Development Fund (20%), by the Research and Development Operational Program for project: University Science Park Technicom for innovative applications with knowledge technology support – 2nd phase, ITMS code 313011D232, co-financed by the ERDF (40%), grant TUKE FEI-2015-33: Research Laboratory of Nonlinear Underactuated Systems (30%) and also this publications also arose thanks to grant KEGA - 001TUKE-4/2015 (10%).

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Protocol based evaluation methods for comparison different mobility models in MANET

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***Abstract*—In this paper are compared and described different mobility models based on random movements of mobile nodes and movement with social relations among nodes. Ability to transfer data through Mobile AdHoc Network (MANET), where mobile devices have different pattern of mobility (random or social) is verified based on application four routing protocols usable in MANET environment – Dynamic Source Routing (DSR), Unlimited DSR (U-DSR), Social Based Opportunistic Routing (SBOR) and SBOR with social aspect (SBOR-sa). Some of them are social dependent and some of them are social independent. Comparison of mobility models with routing protocol vas simulated in Matlab environment.**

***Keywords*—Mobile AdHoc Network, mobility models, reactive routing protocols, opportunistic routing protocols.**

I. Introduction

Communication in MANET networks [1] is provides based on routing protocols which are selected based on types of messages, priority of delivery, speed and density of mobile devices, relations among nodes and another. Many authors use for MANET network random mobility models [2] and applied on it different MANET routing protocols [3], which transfer messages from Source (S) to Destination (D). We want to compare usage social and unsocial mobility models [4] for creation of mobile network. Then we try to use two relations independent (DSR [5], U-DSR) and two relation dependent (SBOR [6], SBOR-sa) routing protocols for every created movement. Finally we want to compare results for each routing protocol and each pattern of mobility.

II. Mobility Models

Mobile AdHoc Network is consist of mobile devices (smartphones, tablets …) which are moved in some geographical area based on different mobility models. Three mobility models were used for the aim of research. First, Random Walk mobility model [2] which is a simple mobility model based on random directions and speeds. Second, Matis mobility model [6], which is other type of random mobility model, where is selected mobile nodes' speed and direction of movement for each mobile nodes. Third, Social based mobility model (SSBM) [4], which is constructed based on assumptions, that the people have same habits during the day, which are repeated.

III. Evaluation Methods for Mobility models

Many evaluation methods are possible to use for verification and comparison mobility models like protocol dependent and independent methods. Protocol dependant (Average number of transfers, Average End-to-End delay, Packet Delivery Fraction, Average Throughput, Routing overhead, Packet Loss) and protocol independent evaluation methods (Degree of Spatial Dependence, Degree of Temporal Dependence, Relative Speed) are known for verification, which mobility model is better to use [4]. Four routing protocols was used for verification protocol dependent evaluation method.

A. DSR

First routing protocol is standard DSR (Dynamic Source Routing) routing protocol based on RFC 4728 [5], which is simple and efficient, on-demand routing protocol designed for usage in multi-hop wireless ad-hoc networks. The protocol is composed from two main mechanisms of "Route Discovery" and "Route Maintenance", which allow discovering path from S to D. Path finding was limited on two attempts for one message, first time at the start of communication and second time during maintenance process.

B. U-DSR

Second routing protocol U-DSR (Unlimited Dynamic Source Routing) is like previous routing protocol DSR. The main differences is in number of path finding, where the attempts to find a path between S and D was unlimited.

C. SBOR

Other type of routing in MANET environment is based on opportunistic transfers with or without social relations among nodes. For our comparison was used SBOR (Social based Opportunistic Routing). This method can assume a flooding based routing for sending "extended RREQ packet (E-RREQ)" and direct transfer of single copy forwarding based schema for sending of data with social determining. The selection of the next hop neighbour from potential nodes is provided by probability of delivery. This probability was calculated from contact history among nodes. SBOR is well solutions, in situations, where is impossible to established E2E path.

D. SBOR-sa

SBOR-sa is almost the same routing solution like SBOR, but the main differences between them is in probability of delivery.

Standard probability of delivery calculated from contact history is recalculated by social aspect given from knowledges about nodes origin and division to the groups of interest.

IV. Simulations and Results

In this paper are described three main simulation results for three mobility models (Random Walk, Matis and SSBMM), where was running four routing protocols (DSR, U-DSR, SBOR and SBOR-sa).

A. Average number of transfers

First result on Fig. 1 displays average number of transfers for successfully delivered messages on the left axes. Right axes displayed average delivery time for successfully delivered messages. The result is depending on radio range.

DSR routing protocol never reached completely full transfer of message. By using U-DSR routing, which worked independently from social relations, it works much better due to unlimited number of path finding for one message then standard DSR routing protocol. Results about reactive routing protocol, DSR and U-DSR was similar for both random mobility models, but for SSBMM got higher average number of transfer but lower average time of delivery.

SBOR routing worked based on social relations – contact history. When some random mobility model was used, a number of transfers were higher than by usage of social mobility model, because mobile nodes weren't move based on social patterns and the probability of delivery among nodes was confused for social routing.

SBOR-sa routing got worse results for random mobility models because social aspect degrade transfer decisions. When SSBMM was used, SBOR-sa got a little better results.

B. Average number of transfers

Second result on Fig. 2 displays average end-to-end (E2E) delay for successful attempts, which is depended on radio range. Given results are for four routing protocols (DSR, U-DSR, SBOR and SBOR-sa), each for three mobility models (Random Walk, Matis and SSBMM), which are usage in MANET environment.

DSR routing protocol got infinity average E2E delay, because it wasn't totally successful in each simulation. U-DSR got lower E2E delay than SBOR and SBOR-sa, but social routing methods were more successful by lower radio range, than U-DSR. When the probability of delivery was adopted by social aspect for SBOR-sa routing protocol, the average E2E delay was higher for unsocial movement and lower for social movements.

V. Conclusion and Future Work

In this paper was compared different mobility models on which four routing protocols, social dependent and independent was applied. Transfer of messages was the most efficient, when social based routing protocol was used in MANET environment with social relation among nodes. We want to focus on more complex social mobility models in the future

Acknowledgment

This work was performed in the framework of research project VEGA 1/0075/15, funded by the ministry of education of Slovak Republic and COST Action CA15127 ("Resilient communication services protecting enduser applications from disaster-based failures – RECODIS") supported by COST (European Cooperation in Science and Technology).

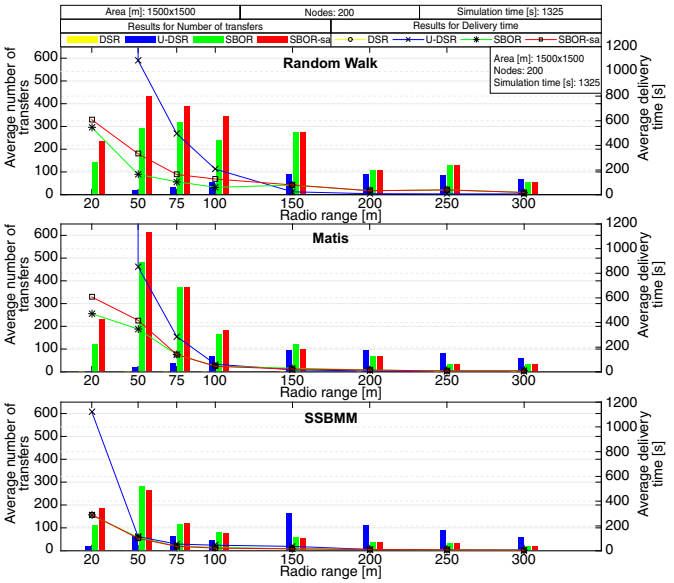

Fig. 1 Average number of transfers for four routing methods (DSR, U-DSR, SBOR, SBOR-sa) applied to three mobility models (Random Walk, Matis, SSBMM) with time of delivery only for successful simulations

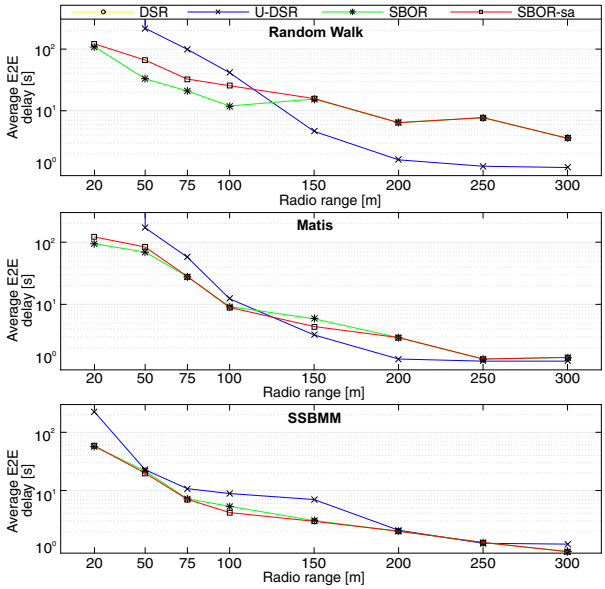

Fig. 2 Average E2E delay for four routing methods (DSR, U-DSR, SBOR and SBOR-sa) and three mobility models (Random Walk, Matis and SSBMM) depending on radio range only for successful simulations

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Reasoning About Arbitrary Domains Using Formal Modelling and Subsequent (Semi-)Automatic Synthesis of Their Properties

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***Abstract*—Programming can be viewed as a process of finding an appropriate model of a part of the real world and implementing it. There are various modelling tools for the said purposes, ranging from programming languages to proof assistants. As it turns out, large parts of the method can be automated to one extent or another. The field of automated reasoning aims to exploit fundamental properties of logic in order to derive conclusions from a set of known facts, much like what human beings do using their intelligence and creativity. This paper is an overview of the entire process of deriving useful conclusions from hypotheses, beginning with modelling rooted in formal logic, also describing connections to computation and practical software engineering, ending with procedures capable of reasoning about arbitrary domains of knowledge. An outline of various possible areas to explore is given as well.**

‘ ***Keywords*—Automated reasoning, Formal logic, Formal modelling, Theorem proving, Type theory**

I. Introduction

Correspondence between formal mathematical logic and type theory has been a subject of research for many a decade now. The idea is to relate logical propositions (under their intuitionistic / constructivist interpretations) to types[1], suggesting that reasoning itself (which is modelled by mathematical logic) is reflected in computer programs we write; very unsurprising, yet worth explicitly stating. This correspondence is often called Curry-Howard isomorphism, named after Haskell Curry and William Alvin Howard.

Once a proposition is formalized and encoded as a type, its proof then correlates with a program of the corresponding type, which in general is a function type with its domain representing assumptions and codomain being whatever it is we are trying to prove / return. In other words, functions can be looked at as mechanisms transforming their arguments into return types, which also happens to correspond with proofs being series of logically sound transformations of assumptions, reaching a conclusion.

While the term "automated reasoning" is a more general term, we are mostly interested in its applications in the area of theorem proving. In this sense, automated reasoning is concerned with ways of automatically finding sequences of transformations that allow us to come to a conclusion given a set of hypotheses.

II. Formal basis, expressing propositions, tools

Just like many proof systems exist (distinguished by their syntax, structure, axioms, reasoning rules, etc.); for example Gentzen’s Sequent calculus[2] or Hilbert’s deduction calculus[3], there are also multiple ways of encoding propositions using formal languages and tools associated with them.

A. Compilers of high level languages with semantic analysis

Commonly used programming languages

Mainstream statically typed programming languages (Java, Delphi, C++) and their associated compilers are in some sense primitive tools for dealing with propositional attitude towards types.

They are capable of deciding whether a given program is a possible proof of its corresponding proposition (type), which is reflected in whether type checking passes or fails. Sadly, for the most part, their type systems are rarely expressive enough to represent propositions we might be actually interested in (where a somewhat primitive parametric system F[4] (modelled after propositional logic) and its derivatives of similar expressiveness are already considered "very strong" despite their primitive nature) and since the compilation process is their only way to take a propositional attitude towards types, they are not very interesting.

Programming languages with expressive type systems utilizing dependent types

There are however programming languages equipped with very expressive type systems, which is generally analogous to being able to represent dependent types, which are a reflection of predicate logic capable of expressing quantifiers.

These allow us to express arbitrary properties required of functionality they restrict, making it possible to describe specifications in great detail. Type checking becomes tricky as arbitrary computation can take place directly within types. Similar to languages with less expressive type systems, successful compilation then ensures that a term of type T is a proof of a proposition T, a fact following from the Curry-Howard correspondence.

The programming languages Idris[5] and Agda[6] are among the most relevant proponents of dependent types.

B. Model checkers

Model checkers represent a system as a set of states along with transitions that describe the way states change based on inputs. A notion similar to finite state automatons.

Properties to prove are then expressed in an assertion language. These vary based on chosen model checking approach, however various temporal logics[7] are often good candidates.

Based on the assertion language and modelling framework they choose, there is many a candidate to list; [8] or [9] are but few to mention.

A note on model checkers in general. While verifying properties requires no human input, their functionality is often very restricted. This is because we have to model systems under an important constraint that only "reasonably small" number of states can be represented while interesting real-world systems can often be in an astronomically many possible states (as model checking often amounts to exhaustively verifying each and every state). This restriction can be sometimes partially lifted as some properties can be verified without having to resort to checking every possible state. Given their bounded nature, we shall not pay much attention to this approach and rather focus on systems based on definitions in logic calculi, which are to be discussed shortly. All of this said, the approach of model checking is by no means useless and is subject of vivid research and also used in industry for real world applications.

C. Theorem provers

Tools such as Coq[10] and HOL[11] have high degree of affinity for propositional attitude towards types. As a matter of fact, they are (automated) theorem provers / proof assistants that happen to be programming languages by a remarkable accident. Naturally, "propositional attitude" is not restricted to "propositional logic"; for example, Coq uses Martin Löf's type theoretical basis (enriched to calculus of inductive constructions) as its logical framework.

While programming languages offer better support for convenient language constructs and common out of the box functionality (for example I/O), proof assistants focus on ease of their use with regards to both modelling domains and proving properties about created models.

This approach can be viewed as "proof-first" as opposed to "program-first" that Idris or Agda use. This is also reflected in the way programs (proofs) are structured and written.

Both model checking and theorem proving naturally facilitate software validation, given their ability to express and subsequently validate properties of interest; in this case pertaining to software.

III. Example: Natural numbers, their addition and neutrality of zero from right with respect to addition

A. Idris

First let us create a set representing natural numbers in Idris.

```
data Natural : Type where
       Zero : Natural
       Succ : Natural -> Natural
```

This inductive construction is based on Peano axioms[12].

Now we create a useful definition, a very common operation on natural numbers: addition.

```
(+) : Natural -> Natural -> Natural
(+) Zero y     = y
(+) (Succ x) y = Succ (x + y)
```

Finally a proposition to prove:

$$\forall n \in \mathbb{N}, n + 0 = n$$

In Idris:

```
n_plus_zero_is_n :
       (n : Natural) -> n + Zero = n
```

We can finally demonstrate the (relative, more on the topic later) clumsiness of writing proofs in a programming language.

A mathematical proof of the proposition is quite simple. We shall proceed by structural induction (which in this case happens to correspond to the standard mathematical induction, as the structure is natural numbers) on n. Assume there is no counterexample smaller than k, such that $k + 0 = k$.

We first need to show the property holds for $n + 0 = n$ where $n = 0$. Performing substitution, we get $0 + 0 = 0$ and by definition of $(+)$, we get $0 = 0$.

Now we need to show that successor preserves the property; that is, show $(k + 1) + 0 = k + 1$. By definition of $(+)$ we get $(k + 0) + 1 = k + 1$ and from our inductive assumption, we get $k + 1 = k + 1$, which is trivially true and concludes the proof.

This exact thought process is possible in Idris and is written by constructing a proof term, that is, a functional program of the required type (that is, n_plus_zero_is_n).

We proceed as follows:

```
n_plus_zero_is_n :
       (n : Natural) -> n + Zero = n
-- base case
n_plus_zero_is_n Zero
       = Refl
```

The base case simply states that if the argument is zero, construct equality with its only constructor Refl. (Of course, the only way to construct an object of equality is to provide two equivalent objects). Idris can perform symbolic computation and as such can reduce $0 + 0$ to 0 and from it, we have syntactic equality.

```
-- ...
-- inductive case
n_plus_zero_is_n (Succ k) =
    let step = n_plus_zero_is_n k
       in rewrite step
              in Refl
```

The inductive case is a little bit difficult to read. We first invoke the function recursively on k, which is an immediate smaller constituent of $Succ$, that is, we are guaranteed to eventually terminate given a base case exists. This corresponds with the inductive hypothesis stating that there is indeed no case for which the property does not hold up to an arbitrary k.

Now we ask Idris to rewrite using the inductive hypothesis; a step corresponding with what is generally simply referred to as "use the inductive hypothesis".

Notice that because of implicit computation that Idris performs, the step saying "by definition of $(+)$, we get..." is

absent. Lastly, after using the inductive hypothesis, we have two equivalent sides for equality and as such, we can in fact construct a term of the required type.

An interesting thing to notice here is that the function technically does not compute anything interesting. It constructs an object of equality using its Refl constructor.

B. Coq

As already stated, proof assistants streamline the process of writing proofs, allowing us to reason in a way that is very analogous to "standard" reasoning in mathematical (intuitionistic[13]) sense. This amounts to not having to write a proof term of a required type, but rather have it be constructed synthetically from a series of logical operations that mirror "standard" reasoning very closely.

Remark: Detailed explanation shall be omitted for parts that are very similar to Idris

Our set of natural numbers can be defined as follows:

```
Inductive nat : Set :=
  | Zero : nat
  | Succ : nat -> nat.
```

And the definition of addition:

```
Fixpoint plus (m n : nat) : nat :=
  match m with
    | Zero    => n
    | Succ k => Succ (plus k n)
  end.
```

Now on to the interesting part of proving the already stated proposition.

```
Theorem n_plus_zero_is_n :
  forall n : nat,
    plus n Zero = n.
Proof.
  induction n.
  - (* Base case *)
    unfold plus.
    reflexivity.
  - (* Inductive case *)
    simpl.
    rewrite IH.
    reflexivity.
Qed.
```

Even looking at the syntax, the proof looks nothing like a term of some type. It is a series of sound logical steps representing a proof.

We begin the proof by induction on n. An attentive reader might have already guessed that from the part of the proof script that says $induction\ n$. We have two cases to consider, each adorned with a comment explaining which case the respective subproof belongs to. In the base case, we unfold (expand) the definition of plus to reduce the expression (that is, to perform computation). Now we have $0 = 0$, which is trivially true by reflexivity of equality.

The inductive case is equally as simple. First we *simpl*ify the expression (with regards to any and every operation, that is, plus is not mentioned explicitly). Now we use the inductive hypothesis IHn and we again arrive at two syntactically equal terms. Shiny.

Unsurprisingly (and unimportantly), we can also extract a proof term from the proof. It shall be omitted for brevity. An interested reader may use Print command in Coq in order to inspect it (using the definitions provided in the paper).

It should be apparent that proving properties using proof assistants is a lot more streamlined and convenient as opposed to relying on compilers to in some sense accidentally verify validity of proofs.

IV. Automated proof construction, theorem resolution

The idea of automated proof construction has already been touched on in the section describing model checkers. They work automatically once a model is created and desirable properties are stated. This is in contrast with proof assistants that are very powerful but require human insight to function; or do they.

A. General or domain-restricted heuristic procedures and resolution algorithms

The task of automatically constructing proofs might seem daunting. In some sense, where do we even start. Proofs in general are often looked at as flashes of insight somehow made formal with a dose of ingenuity and creativity.

As we have seen an example of, a proof can be described by a proof script. A proof script is in turn just a series of reasoning primitives (in this context called tactics). Under this interpretation, finding a proof corresponds with finding a sequence of tactics that form a term that type checks for a given type. This also implies that we get a program "for free".

There are many criteria that can be used to distinguish between various strategies of generating proofs. Two of the most pertinent ones are generality of approach and nature of process used with regards to termination and certainty of finding a correct result.

On one hand, we have resolution procedures. These are often tailored to a very particular domain (by assembling a collection of useful facts about the domain under inspection) and are at least guaranteed to terminate and potentially (hopefully) find a solution if one exists.

For example, the Omega algorithm[14] (implemented in many proof assistants) solves any goal in Presburger arithmetic[15]. Simply put, a system with equalities and inequalities involving operations on natural or whole numbers.

As a very simple example in Coq, consider the following proposition: $\forall n \in \mathbb{N}, n < n + 1$

That is:

```
Theorem obvious : forall n, n < n + 1.
Proof.
  intros.
  omega.
Qed.
```

Or even more specifically, the Coq proof assistant also supports simplification of terms with various restrictions; *ring* tactic offers automatic associative commutative rewriting (think multiplication), *field* allows us to also add division giving up the associative property, or *fourier* tactic solving problems involving inequalities on real numbers. Overview of tactics can be found in Coq reference manual[10].

On the other hand we have heuristic procedures. These are not guaranteed to terminate nor are they under any obligation to give us useful information when the procedure fails. However, they can be applied to broader categories of problems. They work by using various heuristic approaches that are modelled to capture human intuition; be it in general sense or applied to a particular set of problems. For example, a proof of implication almost always begins with assuming its antecedent and a proof of universal quantification often starts by assuming an arbitrary element.

There are various domains (that vary in generality) where this approach is employed. For instance automated proofs regarding metric spaces[16], tarskian geometry[17] or termination of computer programs with pointer arithmetic[18].

There are also extremely general heuristic approaches that take advantage of the nature of logic (for example by applying modus ponens). Coq comes equipped with *auto* tactic, which tries to find a proof by exploring every possible function application by force. There is also its extension *eauto*, which can also deal with existential quantification by attempting to solve unification after an operation that leaves existential variables is used.

Isabelle[19] takes the entire approach one step further and employs "a" **sledgehammer**. This is a procedure that collects lemmas even remotely useful for the problem in question and uses them as hints for various resolution algorithms and heuristic procedures. It is very bruteforce (hence the name), but surprisingly effective.

V. Onwards we shall go

There is many an interesting domain where automated proof synthesis (and by extension, automated program construction) could be of great value and has yet to be explored. The author is interested in synthesizing proofs about topologies and their application in type theory, within the excellent arising area homotopy type theory[20], which explains deep links between logic, topology, type theory and also their categorical interpretations. Developing advanced heuristics for reasoning in broader terms (with implications in dependently typed functional programming) is also of great interest to the author.

An another venue to explore is utilizing games (as a medium) and have players solve logical problems within games, while their progress would correspond with synthesis of proofs. This could be done by restricting game environments in a way that would align with validity of operations within a proof assistant (an existing prototype has already been developed).

VI. Conclusion

Formalization of systems and automated reasoning about their properties is an area of research of great breadth with implications in several domains ranging from software verification to artificial intelligence. The author is interested mainly in the process itself but also in its use in development of software, for instance pertaining to formal specification and validation. Given the broad applicability of the approach, there is a vast array of tangents to explore and consider, and the paper provides an overview of a particular subset of the area that author considers most pertinent with regards to his interests.

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Recent Progress in Development of Diffusion Algorithm for Chaotic Ciphers

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***Abstract*—This paper deals with description of diffusion algorithms used in chaotic ciphers and their architecture. Each of used operations is examined in detail. The paper also mentions two attacks, which are usually used for evaluating effect of diffusion algorithms. Finally, the impact done by mentioned techniques is presented by comparison of two chaotic ciphers.**

***Keywords*—attacks, chaotic cipher, diffusion, encryption.**

I. Introduction

Chaotic ciphers were introducted in late 1980s as one of new applications for scientific field of chaos [1]. Nowadays commonly used architecture of chaotic ciphers for images was described in late 1990s [2]. Chaotic ciphers, which follow this approach process data in two stages – first is known as confusion while second one as diffusion. *Confusion* step is used for rearranging image pixels, which is useful for minimalization of image pixels correlation. *Diffusion* performs calculation of new pixel values, which could prevent attacks such as statistical, or differential attack.

Diffusion algorithms use several mathematical operations for achieving sufficient results. Some of the operations can depend on parameter, which is included in a key provided by user. In some cases, the order of uses operations can impact values computed after diffusion.

II. Used operations

Pixel values computed by diffusion algorithm should be elements of the same set as the original pixel values. This feature can be achieved by usage of *modular arithmetic*. Nearest value, which is greater than maximal possible value is taken as modulus and resulting values are calculated as remainders after division by this modulus. In case that calculated value would be equal to 276 and maximal possible value is 255, the remainder would be $276 \ (mod\ 256) = 20$.

Unpredictability of set of calculated values can be achieved by usage of a chaotic map, or pseudo–random number generator (PRNG). This step is crucial for minimalization of correlation between sets of pixel intensities before and after the encryption. Intensity of currently processed pixel could be modified in many ways, the number from chaotic map or PRNG could be added to it or these two numbers could be combined bitwise (operation known as eXclusive OR, XOR).

Each original image should produce different encrypted image. *Chaining* is the solution for ensuring that even not significant differences in pixel intensities cause big differences after encryption. Chaining uses several previously computed values in calculations done for actual image pixel. If the difference of intensities is present in already computed value, it will spread to all following values. Spreading the difference into pixels, which are computed prior to first apperance of the difference requires two or more iterations of chaining. However, the rising number of iterations causes higher computational difficulty.

III. Performance evaluation

Two commonly used groups of attacks, which determine performance of chaotic ciphers and thus also performance of their diffusion algorithms are statistical and differential attacks. In addition to them, the key space and sensitivity is investigated or computational time analysis is done.

A. Statistical attacks

This type of attacks tries to find some correlation between original image and its encrypted version [3]. Simple examples of statistical attacks on pairs of original and encrypted images include comparison of histograms, or scatter plots depicting correlation of adjacent pixels. The second case uses randomly chosen pairs of adjacent image pixels. Correlation coefficients could be also included as an indicator of robustness against statistical attacks.

B. Differential attacks

Differential attacks use two nearly similar input images, which are encrypted. Diffusion algorithm could be considered as robust against differential attacks if it causes unpredictable differences between encrypted images. Metrics, which could be used for evaluation of robustness against this type of attacks are known as *Number of Pixels Changing Rate* (NPCR) and *Unified Average Changing Intesity* (UACI) [4]. NPCR and UACI are calculated by (1) and (2) respectively:

$$NPCR_{[\%]} = \frac{100}{hw} \sum_{l=1}^{h} \sum_{k=1}^{w} D_{l,k}, \tag{1}$$

$$UACI_{[\%]} = \frac{100}{hw} \sum_{l=1}^{h} \sum_{k=1}^{w} \frac{|O_{l,k} - E_{l,k}|}{2^C - 1}, \tag{2}$$

where h and w are image height and width, l and k are indices for line and column of image pixel, O is the original

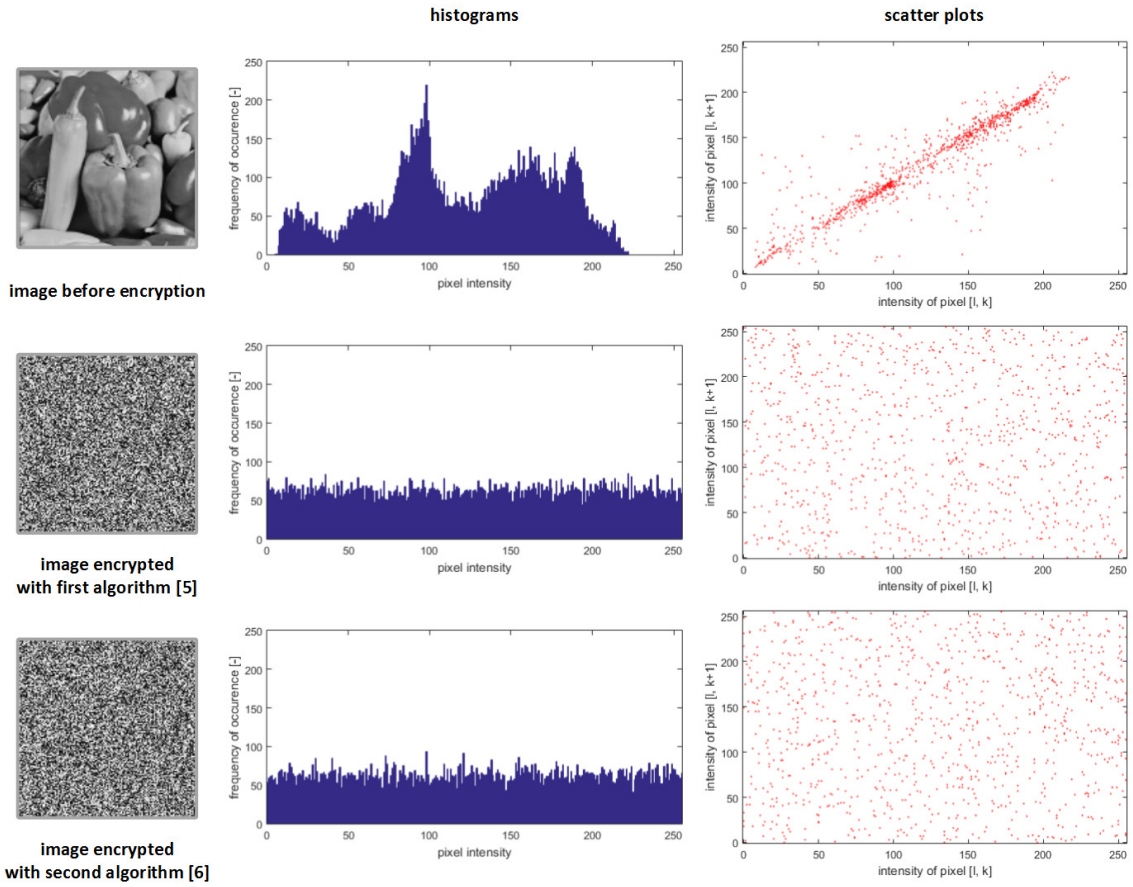

Fig. 1. Used image, its histograms and scatter plots before and after encryption.

image, E is its encrypted version, D is the difference matrix; $D_{l,k} = 1$ if $O_{l,k} \neq E_{l,k}$, otherwise $D_{l,k} = 0$ and C is color depth of image.

IV. Experimental results

The advantages of above mentioned techniques are visible by comparison of multiple diffusion algorithms. Algorithm presented in [5] combines bits of input values and maps them by Harper's map. Second algorithm, described in [6] uses properties of logisitic map and XOR operation for changing pixel intensities. Both approaches use two iterations of their diffusion algorithms.

First column of Fig. 1 displays images before and after encryption. Resolution of original image is 128x128 pixels and it is grayscale. First encryption algorithm [5] used key n_{Ic}, n_{Id} = 4, k_c, l_c, k_d and l_d = 4. Second algorithm [6] had its parameters set as r_x, r_y and r_z = 3.99. Histograms of images before and after encryption are shown in second column. Scatter plots of correlation between 1000 randomly chosen pairs of horizonally adjacent image pixels are illustrated in third column of Fig. 1. NPCR and UACI was examined by performing 100 repeated measurements. Mean, maximal and minimal values for both approaches are given in Tab. 1.

TABLE I
Values of NPCR and UACI

algorithm	parameter	maximal	mean	minimal
[5]	$NPCR_{[\%]}$	99.8779	99.444	98.9075
	$UACI_{[\%]}$	34.3216	33.8068	33.268
[6]	$NPCR_{[\%]}$	99.115	97.9218	96.8933
	$UACI_{[\%]}$	33.9841	33.6522	33.2486

V. Conclusion

Results given in Tab. 1 and Fig. 1 illustrate effect of operations done during diffusion algorithms. Difference in mean values of NPCR can be caused by higher amount of operations done in [5]. The second reason is implementation of bit shuffling. Some of the rearranged bits are also negated. Possible way for reaching even better results is usage of fixed length code, which would encode blocks of encrypted bits.

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Research of energy storages utilization in electric power system

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***Abstract*—This paper deals with research of energy storage devices in electrical power system. It is summarization of work during last year of post gradual study. Short introduction into main research issues of this area, present status, solved research tasks and published articles are presented here. Proposal of future research tasks is also presented. This work involves design and modeling of hybrid generation electric power systems, which utilizes some kind of energy storage for accumulation of energy in various forms; testing of various scenarios; sizing optimization of each component; design of system control, long time measurement of such systems, comparison of models with measured values and evaluation of tested scenarios.**

***Keywords*—accumulation of electricity, energy storage, hybrid system, sizing optimization**

I. INTRODUCTION

In recent years, a lot of changes in electric power system can be observed. For example, on the production side power generation from renewable energy sources records tremendous growth at all voltage levels. This happens because conventional power plants combust fossil fuels and this process cause a production of carbon dioxide and other emissions and also fossil fuels are more and more depleted. So they are gradually replaced by renewables. On the other hand, demand-side improves energy efficiency, but number of electric vehicles rises, causing increased demand for electricity. These facts bring some concerns from the viewpoint of maintaining the existing security, quality and reliability of electricity supply [1]. These concerns have a reason arising from the nature of most renewable energy sources types. They have varying, intermittent and hardly predictable output power, which varies according to environmental conditions [2], so with increasing share there is a need for their better integration.

In Slovak republic, the most utilized among worldwide expanded renewable energy sources are photovoltaic power plants due to satisfactory weather conditions and availability of this source. Particularly sources installed in low voltage systems attract attention. In the near future, it is expected even greater acceleration of the deployment at this voltage level [3][3], either in the form of simple rooftop photovoltaics, complex hybrid systems, or medium sized photovoltaic resources suitable for the power supply of whole communities consisting of tens or hundreds of houses.

There are several problems related to this trend, mainly mismatch between production and consumption, power backflow and maintaining voltage in prescribed limits.

Energy storage systems are one of the solutions necessary to integrate renewable energy generation to the existing power networks [4]. They can be utilized at various voltage levels. By their mutual cooperation mainly with photovoltaic power plants or wind farms within hybrid systems they can achieve powerful features instead bringing some problems.

Nowadays, wide scale of devices can be used as energy storages in electric power system (solid and flow batteries, flywheels, hydrogen storages, compressed air energy storages and others) [5][5].

Described situation and related problems are very current nowadays and they are similar both in Slovak republic and most of European countries. Dynamic development together with unknown impact of these changes on present electric power system was sufficient motivation for conducting a research in this field.

II. PRESENT STATUS OF RESEARCH

Based on previous analysis of theoretical background about energy storages and accumulation of electricity as well as options of their utilization in electric power system, mainly in cooperation with renewables, following PhD theses were defined:

1. Analysis of current status of electricity accumulation and renewable energy sources in Slovak republic and in the world.
2. Analysis of cooperation possibilities between renewable energy sources and accumulation facilities in the island operating systems.
3. Design and modeling of island operating system based on renewable sources in cooperation with electricity accumulation.
4. Analysis of grid services providing options by energy storages.
5. Modeling and benefits verification of selected storage functions in electric power system
6. Results analysis and proposal of solutions which can be used in practice.

First two theses lie mainly in analysis of present status, identifying of main issues and directions of research in this field. They were solved during first year of study. Since that time, thesis number three and four have been fully solved, number five and six have been solved only partially yet.

Research work conducted in order to fulfilling these theses is further described in next chapter.

III. TASKS SOLVED IN PREVIOUS YEAR

Most tasks were in certain way associated with modeling of renewable sources in combination with storage device. All of these tasks were performed using Matlab/Simulink environment. Results were published in international conference papers and scientific journals. Major publications are further described in following sections.

A. Design and simulation of hybrid system for public lighting power supply

This paper deals with design and simulation of hybrid system which consists of photovoltaic power plant, battery energy storage and load. It is used for power supply of public lighting based on renewable energy. Parameters of public lighting are inspired by real situation in small Slovak village. Hybrid system was designed and sizing optimization of each element was performed based on public lighting data, typical load curves and weather conditions in a locality. For this purpose, Homer software was used. Subsequently, system was modeled in Matlab/Simulink and its behavior under real conditions during random day in a year was observed to verify design correctness.

Results from both simulations were compared and evaluated. Both simulation results are similar and behavior of the system shows that it was sized properly. Power delivered to the AC bus by hybrid system follows power required by load. The proposed hybrid system fully covers daily consumption of modeled public lighting load. There are not power outages. System consists of 100 kW sized photovoltaic power plant, battery bank creates 180 pieces of 200Ah, 12 V batteries Vision 6FM200D. Power conversion is provided by 12 kW converter [6].

B. Utilization of energy storages in low voltage grids with renewable energy sources

This paper deals with problems which occur in low voltage grid in case of high renewable energy penetration, especially with photovoltaic power plants. Also simple way how to utilize energy storage to address these problems is proposed and simple charge/discharge strategy was designed for energy time shifting and capacity firming. Simulation model in Matlab Simulink was developed and two scenarios based on real data were simulated in order to strategy verification.

Results are discussed and evaluated, and show that the strategy works well for both tested seasons. In winter, time shifting power from low to high tariffs prevails. This could have a positive economic impact. On the contrary, in summer time-shifting of excess energy generated from photovoltaics is the most frequently used, and energy storage simultaneously prevents the power back flow into the superior grid and thus avoids of energy losses arising by transfer of energy to the place of consumption and undesired voltage effects. This means positive impact on power quality, operation flexibility and stability [7].

C. Mathematical model of fast charging station with integrated accumulators

In connection with the development of infrastructure for electric vehicles is in this article presented complex mathematical analysis of operation fast charging station with integrated battery and by promoting of photovoltaic system. The goal of presented simulation of operating conditions was to demonstrate possibilities (advantages and disadvantages) of integrated batteries during operation of fast charging stations and their possible impact on the connection point to the low voltage (LV) electric network. Main advantage is the use of existing commercially available fast charging stations. The disadvantage is the losses increase in each conversion between AC/DC/AC and increased investment costs. Despite this fact, our results indicate that this technical solution is possible and brings other properties, which could lead to improvement of power quality in the connection point.

Partial results of the simulations show that the system can have a positive effect on the stabilization of consumption peaks in the electric network – possible realization of power demand from electric network at more suitable time (excluding time of the maximum peak demand). This property may be potentially used for delaying certain investments in the connection point (grid construction deferral). Consequently, the possibility of connecting fast charging system is realized in the place where a simple connectivity has not been possible due to the negative influence of voltage conditions in the network [8].

IV. FUTURE RESEARCH

Based on the defined theses, it can be seen, that all of these theses were at least partially solved, so future work lies in their further fulfilling, mainly in deep result analysis of performed simulations and another improvements of proposed solutions.

V. CONCLUSION

This paper reviews work during last year of post gradual study. Progress in research according to PhD thesis and major publications are presented.

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Service Oriented Architecture and Data Acquisition with Gay/Mediator

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***Abstract*— This work deals with the industrial data acquisition, remote control and related issues. Intention of this paper is to describe some of the recent approaches. The main components are Serviced Oriented Architecture (SOA) and algorithms inspired by machine learning that are used for building context-based services. Results of this work solve some issues in the remote control with a help of a contextual behavior and an integration of operational and informational technologies in industry.**

***Keywords*— data acquisition, IT, OT, SOA.**

I. Introduction

New industry and IT trends emerge very fast. Most of them has a potential to bring some improvements into the industry. However, the industry identifies requirements such as working fast, effectively and together.

In this paper, I would like to focus on the working together aspect. The end device, network and IT infrastructure are a part of a set, which contains valuable attributes for the working together aspect.

Many end devices have a direct network connectivity or use a gateway (mediator) to transfer data into a centralized system, in the most cases [1],[2]. The centralized data are used for analytics and further task as a prediction, defining bottle necks and other tasks, which are helping to take decisions. This paper is more focus on the data acquisition. However, the entire process of the data acquisition can be complicated, due the heterogeneity of an environment. Today, there exists many commercial products, which solve these problems and one of the recent technologies, which uses SOA is OPC UA. SOA has the integration role. In the meaning of SOA, data are in various form offered via monolithic/composite services to other IT services/consumers placed inside or outside plant infrastructure. In many cases, SOA has its implementation in micro-services or services. Generally, the services improve interoperability and flexibility inside hierarchical ICS (Information and Control System). Improving point of SOA appeared in better interoperability and reliability, where ICS inherits benefits from Cloud computing.

According to the research, publications and research projects, I summarized issues, which can be solved or are partially solved in the field of the remote control and data acquisition [3]. Improvement of the interactive interoperability with devices, device management, interconnection with technological layer and its unification, better quality of monitoring, data consistency and analytics are some of the issues. Another type of problem is diagnostic over embedded systems and security/connectivity issues [4],[5]. I focus on these selected problems in my work:

1. improve data acquisition and integration,
2. how to decrease energy consumption and network overload
3. unified and non-fixed connection to the technological layer.

The selected problems are related with SCADA (Supervisory Control and Data Acquisition) system and remote control [1]. This work deals with a solution for distributed sensor network and data acquisition based on SOA.

This paper consists of short state of the art, known facts, solved tasks, results and some expectations.

II. Initial Status

This year, I divided initial status of selected problems into:

1. ICS trend is to improve integration of Operational (OT) and Information technologies (IT) and get better representation of the physical world. Therefore, I focus on a smart gateway/mediator, which will improve the OT and IT integration [6],[7].

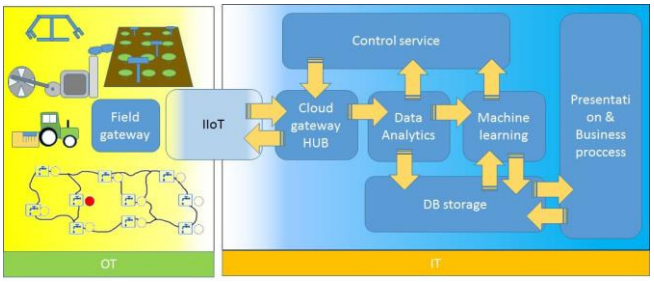

Fig. 1 IT and OT integration based on the cloud services

2. I designed event based methods for the energy consumption and network overload reduction in the previous years [7].
3. CPS interactive topics allow to translate messages from sensor/actuator network and services in the ICS[8], [9].
4. Designed gateway/mediator and its inner representation [9],[10]

III. Solved Tasks in Last Year

Compared to the selected problems and results from previous years, I focused on:

1. Gateway DITA approach (A)
2. Comparison of own and two alternative designed solution (B)

A. Gateway DITA approach

The gateway is a network component, which connects different networks. In my work, I focus on the gateway/mediator (Figure 3), which solves selected issues defined in chapter I. The gateway is designed to OT and IT integration and builds an abstract layer of monitored environment without losing any information nor data. The gateway uses SOA and interaction with cloud ICS services in the cloud. Gateway plays an integration role in the SCADA system. Therefore, the designed gateway is peer-to-peer connected with other gateways to provide stable functionalities [10]. Principal design of gateway is in Figure 3. More about realized parts and functionality is described in[6],[7] and [8].

One of the next designed and evaluated improvement for the gateway/mediator is DITA (Dynamic interference to area). Designed and developed gateway has a contextual behavior and better representation of monitored environment without knowing a sensor network topology. DITA is in the process of review and might be published very soon.

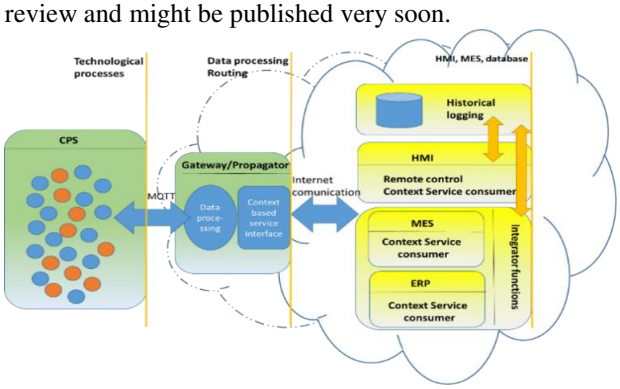

Fig. 2 Symbolic schema of solution without cloud implementation [8]

B. Evaluation

I verified the designed and implemented architecture towards two case studies. Each case represents a division in the laboratory designed plant (Figure 4) [10]. The main commons of division are SOA and cloud. The main differences are different for each division. Division I. – uses a direct connection to PLC and composite services for selected functionalities of SCADA, Division II. - uses monolithic designed and developed services implemented in industrial router eWON. Division III. – uses enterprise service bus and DITA approach. Comparing to other designed and analyzes approaches was Division III. selected as the most suitable.

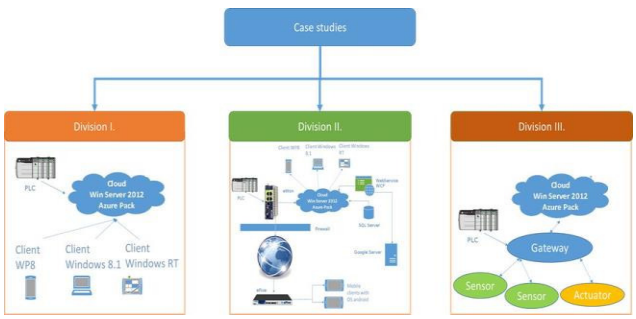

Fig. 3 Three use cases of implementation

Each case is based on the SOA and I selected the quality of services as one of the evaluation indicator. Figure 5 describes quality value for each division in 10 tests, which consists of 10 sets of measurements.

In recent year, I designed a methodology how to evaluate and use the architecture from Division III.

Fig. 4 Division quality of services comparison

IV. Future Work

In the future work, I would like to improve speed of the DITA and continue with improvements.

V. Conclusion

Last year, I designed, implemented and tested DITA approach in the gateway to create an abstraction of a monitored environment. I implemented DITA into the Division III. I compared and evaluated three case studies realized as plant divisions in the laboratory. During the recent year, the problematic was discussed with IT company in Austria and compared with results in founded start up.

Acknowledgment

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Signal Acquisition and Compression: Was Nyquist Wrong?

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***Abstract*— This article deals with compressed sensing as a method of acquisition and compression of certain signals, which can be achieved by a single processing step. Advantages of compressed sensing and current state of this research area are briefly overviewed. Main focus of this article is the summarization of my work done in the last year, concerning mainly but not only compressed sensing. Steps planned for the next year are described in the conclusion.**

***Keywords* — compressed sensing, analog-to-information conversion, stochastic sampling, random modulation and integration**

I. INTRODUCTION

The theoretical foundation for compressed sensing (CS) was published some 10 years ago in [1]. It layed unattended for a few years, until researchers discovered that it could be used for acquisition of certain groups of signals. These signals are called sparse, which means that they compose of only a small number of summed basis functions. Such signals carry only a limited information content, relative to their size when sampled according to the Shannon-Kotelnikov sampling theorem.

According to CS theory, sparse signals can be acquired by taking fewer samples than with a conventional analog to digital converter (ADC) with Nyquist sampling. The original signal can than be reconstructed without any information loss, after transmitting or storing. CS by taking only a few samples performs compression as well as sampling. The performance (achievable compression ratio) of this compression process is comparable to conventional methods, e. g. transform and quantizing. Compression can be realized directly via sampling, without any additional signal processing. Such sampling is called analog to information conversion (AIC). If implemented in the digital domain, CS allows for the same compression ratio with less computing. This makes the CS approach more energy efficient than conventional signal acquisition and compression methods.

II. INITIAL STATUS

The initial status I would describe as "all talk and no work". Although the theoretical aspects of CS have been studied, there is still much work to be done in practical implementation. Only a limited number of people around the world are working on CS. Therefore, very few articles concerning practical use of CS have been published, mostly in the last two or three years [2]. The underlying theoretical principle is understood, but a specific solution has to be found and tailored for each application. This is an inherent property of CS, which makes it a progressive research field with considerable potential in signal acquisition.

The principle and basic methods of implementation of CS I have already described in [3], [4]. I will repeat that there are two methods of AIC that are most practical. One of them is the stochastic sampling, which takes a limited number of samples at random time instants. Thus there is no coherent aliasing effect, reconstruction is possible and compression is performed without any signal processing. The second method is the random modulation and integration, which modulates the input signal by a pseudorandom bit sequence, spreading its spectrum. Modulated signal can then be low-pass filtered and sampled with lower than Nyquist rate, without loosing the information content.

Fig. 1. Venerable academician V. A. kotelnikov feeling uneasy about compressed sensing

The main problem with CS is determining a suitable set of basis functions. The aim is to choose the basis in such way, so all the possible input signals are represented as sparse as possible. This is often not an easy task, e. g. with biomedical or environmental signals. A suitable basis has to be chosen different for each and every application, and very little of this process is so far covered by literature. Another problem is an efficient and robust reconstruction algorithm, that again has to be tailored for every application, according to signal and base properties. Reconstruction leads to optimization problems, which have been discussed in context with CS theory. However, all the work published so far in this area is too abstract and further research is needed to get to real-life applicability.

III. TASKS SOLVED SO FAR

A. Concerning compressed sensing

My research during the previous year was focused on reconstruction algorithms, due to reasons mentioned before. For start I chose to implement an AIC based on stochastic sampling, since it doesn't require any special hardware. Basically any conventional ADC can be converted to stochastic sampling, which is exactly what was done with a National Instruments data acquisition card.

For the purpose of recovery of signals acquired by this AIC, I proposed a time-domain frequency-sparse signal reconstuction algorithm based on differential evolution. This algorithm was evaluated using noisy frequency-sparse test signals by the means of both simulations and experiments. It proved to be exceptionally robust against quantization and uncorrelated noise.

Estimation of the original signal is precise within the order of ppm for frequencies and % for amplitudes and phases of signal components. I proved that frequency sparse signal can be stochastically sampled with peak rate of just 24% of the Nyquist rate. Original signal can then still be precisely reconstructed by the proposed algorithm, while achieving a compression ratio of approximately 100. For these reasons, I dare to put this reconstruction algorithm on the top of my self-praising list. Details I have to keep for myself, since they are currently under review for publishing in a proper magazine.

B. Short-time research activities

Besides compressed sensing, which is the focus of my dissertation, I was involved in other research during the last year. First I worked on enhancement of multiexponential signal decomposition by various preprocessing methods. My contribution was a decomposing algorithm based on simplex optimization method, which was compared with modified Prony method of multiexponential decomposition. These algorithms were then used to evaluate the preprocessing methods proposed by prof. Michaeli. Results were presented at the Radioelektronika conference held in Košice [5]. I would like to thank Ing. Dolinský for taking the burden of presenting our results at the conference, what gave me a day off.

Sort-of continuation of [5] was the investigation of capacitors' dielectric absorption, and it's effect on a dual-slope ADC [6]. We presented the results at IMEKO conference in Budapest. Attending this conference allowed me to meet several people with similar research interests.

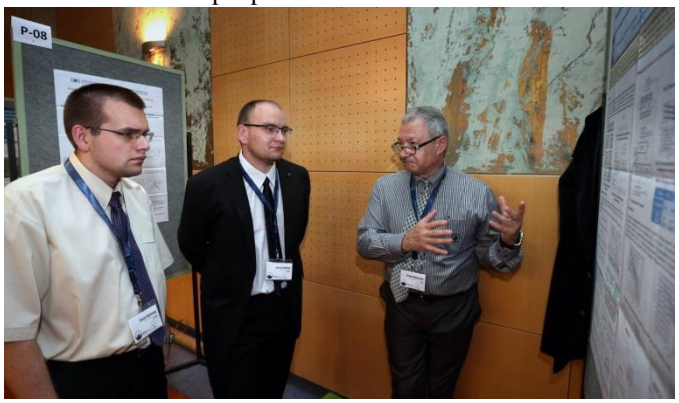

Fig. 2. Discussing dielectric relaxation measurement with Dr. Baltianski

Part of the programme was a refreshing boat trip around the city. Everybody at the conference was mourning the passing of prof. Kollár, long term chairman of the symposium, whom I did not know. The night sail past the parliament building inspired me to some different thoughts. I noticed birds flying in light of reflectors on the top of the building like moths. I spent the whole evening thinking about why are they doing that.

C. Miscellaneous activities

As a PhD student, I have all sorts of engagements besides work on my thesis. First there is teaching, not just our students , but also foreign this year. It involves laboratory exercises, an occasional lecture, and helping and advising students with their projects. These projects sometimes get published as well [7]. Last year I also prepared a significant part of a new subject curriculum, although this subject did not last very long. From time to time I also helped collegues with electronics or measurements, and performed some minor maintenance tasks around the building.

IV. NEXT STEPS

The workplan for the next year has been based on current results. I plan to apply and evaluate the stochastic sampling framework on real-world signals of water parameters. Next there is a random modulation AIC that has been built, but remains to be evaluated using a suitable signal base. Development of additional reconstruction algorithms is currently in progress, subsequently they will be evaluated and compared to each other.

ACKNOWLEDGMENT

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Simplification of High Frequency Soft Switching DC/DC Converters with Active Rectifier with One Switch Development

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***Abstract*—A paper is dedicated to a research process of new generation of high frequency soft switching DC/DC converters. In the paper, first an already solved part of research task is described. Next, a description of currently solved part of research task is done and key research results are presented. At the end, future steps of research and development are proposed.**

***Keywords*—active rectifier, DC/DC converter, snubber, soft switching**

I. Introduction

The DC/DC converters are a fundamental part of switched-mode power supplies. In general, a value of switching frequency is an important parameter of DC/DC converters. The volume and weight of DC/DC converters can be reduced by increasing of switching frequency. Therefore, an effort is to use very high switching frequency. But it is known, that switching losses in transistor switches can be increased also by increasing of switching frequency. Therefore, an application of soft switching techniques to this type of converters is useful and effective. In Fig. 1, simplified idealized time waveforms of soft switching of transistor switch are shown. The soft switching of transistor switches used in DC/DC converter can be partly achieved by using of DC/DC converter with active rectifier with one switch.

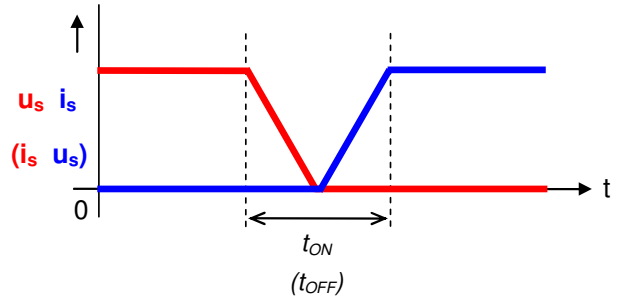

Fig. 1. Idealized time waveforms of soft switching of transistor switch.

II. Already Solved Part of Research Task

The initial experimental entirely soft switching DC/DC converter with active rectifier with one switch topology has been developed. In Fig. 2, a circuit diagram of this topology is shown. The shown topology comprises active lossless snubber (red color in Fig. 2).

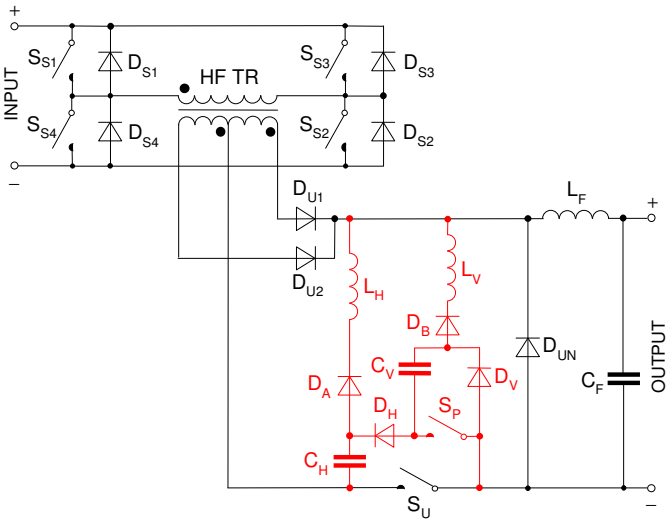

Fig. 2. Circuit diagram of soft switching DC/DC converter with active rectifier with one switch with active lossless snubber.

This topology of soft switching DC/DC converter with active rectifier with one switch with active lossless snubber is controlled by simple pulse width modulation. In Fig. 3, a corresponding control algorithm of this converter topology is shown.

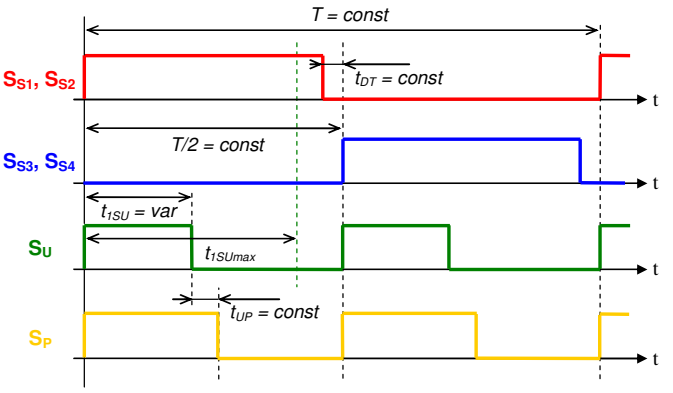

Fig. 3. Control algorithm of soft switching DC/DC converter with active rectifier with one switch with active lossless snubber.

An operation principle of this soft switching DC/DC converter topology was already analyzed. Simplified analytical time waveforms of this converter topology were also already derived. Equivalent circuit diagrams of all period

time intervals were already derived, too. Simulation model and laboratory model of this soft switching DC/DC converter topology were already made and a function of this soft switching DC/DC converter topology was also already verified by many different measurements. From the measurements was obvious that the soft switching of primary transistor switches is achieved in full load range, while the soft switching of secondary transistor switches is not achieved in full load range.

III. Currently Solved Part of Research Task

To resolve this problem, other topologies of secondary side snubber should be proposed and verified. Simultaneously by this way, the complexity of the whole developed soft switching DC/DC converters could be reduced and also other advantages could be achieved. Unfortunately, the development of larger amount of topologies of secondary side snubber is complicated because of the whole DC/DC converter with active rectifier with one switch complexity.

Therefore, for simplification of this development the following simplified converter topology for development purposes was derived. The proposed derivation results from deep analysis of DC/DC converter with active rectifier with one switch operation principle. In Fig. 4, a principled detailed block diagram of DC/DC converter with active rectifier with one switch is shown and in Fig. 5, the principled detailed block diagram of derived simplified converter for development purposes is shown.

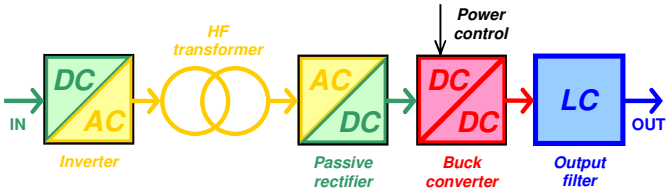

Fig. 4. Principled block diagram of DC/DC converter with active rectifier with one switch.

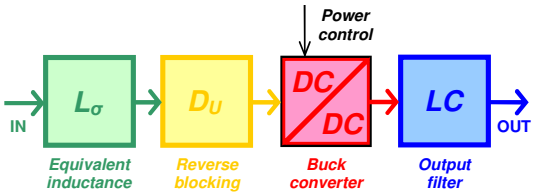

Fig. 5. Principled block diagram of derived simplified converter for development purposes.

In Fig. 6, the circuit diagram of derived simplified converter topology for development purposes is shown and in Fig. 7, the corresponding control algorithm of this simplified converter topology is shown.

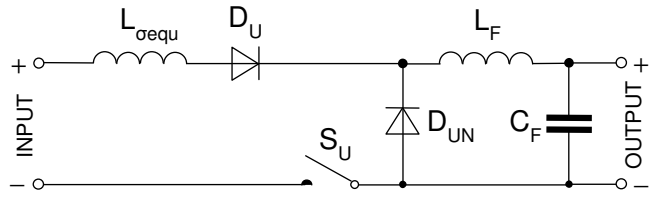

Fig. 6. Circuit diagram of derived simplified converter for development purposes.

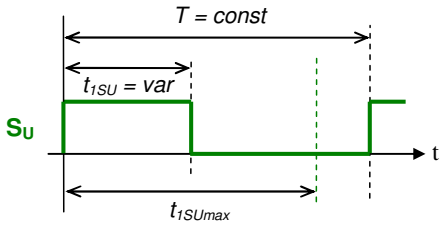

Fig. 7. Control algorithm of derived simplified converter for development purposes.

In Fig. 8, the block diagram of model of soft switching development converter topology is shown. It is obvious that a realization of model of this kind of topology is simple. There is no primary and secondary side, high frequency transformer is not needed and also inverter with drivers, optocouplers and corresponding control signals is not needed.

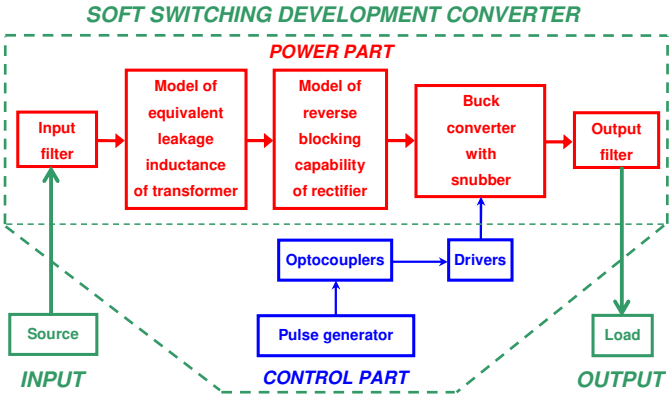

Fig. 8. Block diagram of model of soft switching development converter.

IV. Conclusion

By the proposed solution a lot of money, material, work and time can be saved. The realization of measurements is simple and in case of laboratory measurements also safer because of alternating current and transformer electromagnetic interference absence. Currently, many different topologies of secondary side snubber are developed by this way. Finally, the advantages and disadvantages of every developed snubber topology should be evaluated and in this way, the optimal soft switching DC/DC converter with active rectifier with one switch topology could be developed.

Acknowledgment

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Software Library for Microphone Array Signal Processing

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***Abstract*— This paper discuss the issue of processing acoustic signals recorded by spherical microphone array in order to improve the quality of input signals for automatic speech recognition systems. This work includes design and description of the proposed system for recording and processing of audio signals using spherical microphone array in the form of software library. The core of the proposed system is formed by selected algorithms for localization and tracking of sound sources and algorithms for spatial filtering. In order to demonstrate the functionality of proposed software library demonstration application has been created. This paper also includes the experimental results of testing of proposed software library.**

***Keywords*—Automatic Speech Recognition, Beamforming, Microphone Arrays, Source Localization, Spatial Filtering, spherical Microphone Array**

I. INTRODUCTION

The quality of input speech signals for automatic speech recognition (ASR) systems is crucial. Using microphone arrays and related algorithms for recording and processing of acoustic signals is one of the possible solutions to improve quality of the speech signal. Their application is especially useful in difficult acoustic conditions where signal recorded by a microphone and associated single-channel signal processing methods cannot suppress the negative effect of multipath propagation [1]. In general, the systems for processing acoustic signals recorded by microphone array are mainly formed by algorithms for localization and tracking of sound sources and algorithms of spatial filtering. Localization algorithms are mostly used to determine the position of one or more, static or moving sound sources. Information about the position is then used in spatial filtering in order to suppress unwanted signals from different direction. In other words, they allow multi-channel separation respectively a signal pre-processing step for automatic speech recognition systems [2][3].

II. PROPOSED SYSTEM

The proposed system was designed as the software library in C++ in order to control a spherical microphone array Eigenmike i.e. tool that handles multichannel signals recorded by spherical microphone array using the selected algorithms for sound source localization and spatial filtering. This implementation consists of two parts:

- Software library MAPL
- Demonstration application Array Studio

A. MAPL – Microphone Array Processing Library

The internal function of proposed processing library for microphone array data processing can be divided into several functional blocks. The main block is the microphone array manager that control all input data processing and represents interface between software library and demonstration application. The input data are processed in three processing blocks. The first is localization block that is intended to estimate the relative position of the sound sources with respect to the microphone array, number of active sources and their acoustic activity. These data are then used in beamformer that is adapting directional characteristic for each sound source. The output is represented by processing data either in one channel or in separated channels for each of the sound sources. Beamformer output can be optionally post-processed and sent as processed data frame to the demonstration application [4].

1) Sound Source Localization

Sound source localization method used in proposed system is statistical method based on time-frequency analysis and statistical test called the direct path dominance test. This test is based on local frequency smoothing formulated in the spherical harmonic domain. This method is computed in four main stages [4][5]:

- **Spatial transformation:** Transformation of recorded microphone data into SH-STFT (Spherical Harmonic – Short Time Fourier Transformation) domain using STFT and PWD (Plane Wave Decomposition). The results of this transformation are SFT (Spherical Fourier Transformation) vectors of the amplitude density of the plane waves composing the sound field:

$$a_{nm}(\tau,\upsilon) = \boldsymbol{Y}^H(\theta,\phi)\boldsymbol{s}(\tau,\upsilon) + \overline{\boldsymbol{n}}(\tau,\upsilon), \qquad (1)$$

where $\boldsymbol{Y}^H$ is the steering matrix, $\boldsymbol{s}(\tau,\upsilon)$ represents useful signal and vector $\overline{\boldsymbol{n}}(\tau,\upsilon)$ represents noise.

- **Spatial correlation:** Creating time-frequency correlation matrices in SH-STFT domain using time and frequency averaging:

$$\widehat{\boldsymbol{R}}_a(\tau,\upsilon)=\frac{1}{J_\tau J_\upsilon}\sum_{j_\tau=0}^{J_\tau-1}\sum_{j_\upsilon=0}^{J_\upsilon-1}\boldsymbol{a_{nm}}(\tau-j_\tau,\upsilon)\boldsymbol{a_{nm}}^H(\tau-j_\tau,\upsilon)\,. \quad (2)$$

- **Direct path dominance test:** Use of the direct-path dominance test for identification of time-frequency bins that contain contributions from significant source and no contribution from room reflections. The set of the desired TF-bins is selected as follows:

$$A_{DPDtest}=\left\{(\tau,\upsilon):erank\left(\widetilde{\boldsymbol{R}}_a(\tau,\upsilon)\right)=1\right\}. \quad (3)$$

One possible way to implement this selection is by analyzing the singular values of matrix $\widetilde{\boldsymbol{R}}_a(\tau,\upsilon)$:

$$\frac{\sigma_1(\tau,\upsilon)}{\sigma_2(\tau,\upsilon)}>\alpha\ \Rightarrow erank\left(\widetilde{\mathbf{R}}_{\mathbf{a}}(\tau,\upsilon)\right)=1\,, \quad (4)$$

Where $\sigma_1(\tau,\upsilon)$ and $\sigma_2(\tau,\upsilon)$ are the largest and second-largest singular values of matrix $\widetilde{\mathbf{R}}_{\mathbf{a}}(\tau,\upsilon)$.

- **Direction of arrival (DOA) estimation:** Association of directional data from significant sources in order to create overall spatial (MUSIC) spectrum for DOA estimation:

$$S_{MUSIC}^{incoh}(\Omega)=\sum_{(\tau,\upsilon)\in A_{DPDtest}}\frac{1}{\|U_n^H(\tau,\upsilon)y^*(\Omega)\|^2}, \quad (5)$$

Where $\Omega=(\theta,\phi)$ and U_n^H represents noise subspace [6][7].

2) Spatial filtering

Beamforming method used in proposed system represents compromise between maximum WNG (White Noise Gain) and maximum directivity beamformer. Balance between those two measures of performance represents the balance between reducing acoustic noise and reducing sensor noise. Weights of beamformer that reduces overall noise can be expressed as:

$$\boldsymbol{w_{nm}}^H=\frac{\boldsymbol{v_{nm}}^H\boldsymbol{R}^{-1}}{\boldsymbol{v_{nm}}^H\boldsymbol{R}^{-1}\boldsymbol{v_{nm}}}, \quad (6)$$

where

$$\boldsymbol{R}=\sigma_a^2\boldsymbol{B}+\sigma_s^2\boldsymbol{A}, \quad (7)$$

where σ_a^2 represents dispersion of spherically isotropic noise and σ_s^2 represents sensor noise [8][9].

III. Testing Scenarios and Experimental Results

Testing of crated software tools was carried out in two steps. In the first step the audio data have been recorded in a difficult acoustic environment in order to verify basic functionality, performance, and weaknesses of the proposed system. Audio data have been recorded simultaneously by spherical microphone array Eigenmike, circular microphone array Microcone and close talk microphones AKG. Proposed software tools have been used only to process recordings from spherical microphone array. Recordings obtained by circular microphone array have been processed by original software from manufacturer. Recordings from close talk microphones have been used as a reference signal without any processing.

The performance of the proposed software tools have been evaluated by ASR (Automatic Speech Recognition) system. The recordings have been divided into phrases according to the text of scenario and further compared with the recognition results. Table I shows the results of Word Error Rate (WER – percentage of incorrect words compared to the reference text) for recording from individual devices. High word error was caused by high level of reverberation in recording room.

TABLE I
RESULTS OF WORD ERROR RATE EVALUATED IN ASR SYSTEM

Recordings	WER			
	Speaker 1	Speaker 2	Speaker 3	Average
EM32 SFTB ($\sigma_{a=0,80}$ $\sigma_{s=0,20}$)	50,6	80,6	77,9	74,4
EM32 SFTB ($\sigma_{a=0,99}$ $\sigma_{s=0,01}$)	54,1	85,1	72,5	75,3
EM32 SFTB ($\sigma_{a=0,00}$ $\sigma_{s=1,00}$)	58,7	84,5	84,5	80
EM32 SAC	68,0	89,7	92,8	87,1
MICROCONE	64,7	66,6	51,2	60,8
CTM	16,6	27,3	16,9	21,7

Speaker 1 – male – 482 words
Speaker 2 – male – 978 words
Speaker 3 – female – 1306 words
„EM32 MAPL SFTB" – processed recording using proposed system
„EM32 SAC" – single acoustic channel from EM32

IV. Conclusions

Proposed software tool have implemented a beamformer with considerably higher directivity than a microphone array. This caused that the microphones capture relatively high level of interference coming from the same direction. That can be solved by using proper adaptive beamforming technique.

Acknowledgment

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Special Part of Cover Generating Methods

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***Abstract*—This paper deals with research summarizing of the past year of my postgradual study. The main task was working on the fulfillment of the thesis of my minimal thesis. Thus I was studying cover generating methods. My research culminated in publishing the article with name Cover selection steganography, where the novel method was proposed. Research is still in progress since the method is still very time consuming. Next work is focused on how to make it more effective from that point of view.**

***Keywords*—cover selection, past year, results, steganography, summarizing**

I. Introduction

Image steganography is principally utilized to a secure communication by embedding the messages in the background of static images. The security of such a system is based on undetectability of hidden information. This means it aims to conceal the very existence of a secret message.

The image steganography is still denoted as a very actual topic in the information hiding research. However, the steganography is mostly used by criminals. Now the question arises: Why a research in this field is performing when the results can be abused? Likewise, in the field of cryptography there is an opposite scientific discipline, cryptanalysis, steganography has steganalysis. Scientific research tries to be at least one step ahead of criminals. Yes, they develop novel sophisticated methods of steganography too, however they simultaneously work on building effective approaches to detect established secret communication by steganalysis. Steganalysis is connected with observation of steganographic methods impact to certain statistical parameters of an image. Parameters which were changed by an embedding process are suitable for the training of a model. Model represents output of steganalyzer and it is basis for the detection process. Important part of steganalysis is a type of classifier as well. In the article [1] was shown that the best way is the use of ensemble classifier with bootstrap aggregating (bagging). Their detecting efficiency is similar to SVM classifier (Support Vector Machines) but the training process is much shorter. The main part of this summarizing article deals with a cover selection steganography. This addition to the classic steganographic methods improves their undetectability.

II. Initial Status

In the field of image steganography there are several methods which differ in cover image preprocessing and embedding process. Substitution techniques belong among basic methods in the spatial domain. Bits of the cover image are replaced by secret message bits. The knowledge about position of inserted bits is only important to the receiver. The most popular substitution methods are LSB, pseudorandom permutation, parity bits and cover regions, quantization and dithering. Transformation methods transform cover image by some transformation, whereas the insertion is performed by modification of transformation coefficients. It ensures undectability improvement against steganalysis performed in the spatial domain. Among the most used transformations belongs DCT (Discrete Cosine Transformation) and DWT (Discrete Wavelet Transformation). Other methods use DSSS (Direct Sequence Spread Spectrum) to spread a secret message signal. Embedding process is like a modulation than. If steganography changes some statistical parameters of a cover image, it belongs to the distortion methods. To gain a secret message a receiver compares specific statistical parameters extracted from cover and stego image. Such methods need the cover image to be presented in the receiver part as well as stego image. Finally, cover generating methods originates special cover image during the embedding process according the secret message. Secret message do not interfere any natural features of an image, which is reflected in improvement of a system security. As a special case of cover generating techniques is considered the cover selection steganography. It deals with a selection of the most appropriate cover image to the secret message in order to decrease number of modification bits whereas embedding capacity remains.

III. Results of the Solved Tasks

In this section, there are introduced results of the most valuable works of my previous year.

A. Image Steganography with using QR Code and Cryptography

In this work, the image data were used as cover medium and the secret message is defined by QR code [2]. The QR code can code different types of input data (numeric, alphanumeric and binary). In the proposed method, QR code can be compressed due to different sizes of module. The higher size of the module is important so that QR code can be read from the higher distance. On the other hand, there are some redundant bits in each module which can be effectively reduced without loss of information before the embedding process. This compression is very useful knowing that embedding process could be successful even if the input QR code is bigger than modified area. Subsequently, QR code included the secret message is encrypted using AES and it is embedded into the DWT sub-images of the cover medium. The comparison of PSNR and embedding capacity with other tools is shown in the TABLE I.

In the table there is shown that embedding capacity 141.744 kbits is achieved by the modified method for QR code of version 40 with L error correction level, whereas PSNR between cover and stego image (Lena) was 50.24 dB. Better results of PSNR are achieved by the proposed method in comparison to the other verified tools for the same or even higher embedding capacity.

TABLE I
COMPARISON OF OUR PROPOSED METHOD WITH OTHER STEGANOGRAPHIC TOOLS

		Our method	Chan et al.	Luo et al.	Lin
Lena (512×512)	PSNR [dB]	50.24	37.23	38.8	37.7
	Capacity [kbits]	141.744	99.947	66.064	129.791

Summarily, in this paper, we proposed image steganography tool with using LDWT (Haar wavelet) and QR coding. Improvement of security was performed by AES ciphering of QR code. The advantage of the method is compression of the module size in the QR code before embedding process. The aim of our research was to compare our proposed method with other image steganographic tools with regards to imperceptibility of embedded secret message and embedding capacity. The results show that PSNR of proposed method achieves higher values as compared tools for the same or very similar capacity.

B. Cover Selection Steganography

The key idea of this proposed steganographic method was to minimize substitution changes by embedding process with any loss of a secret message length [3]. It consists in selecting such cover image, the embedding area the most matches with bits of a secret message. Optimal steganography method is going to be undetectable by perfect concordance. Probability of finding such appropriate cover image approaches to zero. Respectively, the cover image database would have to be infinity large. In the experiments was used database of 2,000 cover images.

Embedding process is based on the work [4], whereas the main features were:

- color space model of cover images – YC_bC_r,
- insertion – DWT domain of component C_b,
- substitution of HH, HL, and LH LSBs.

DWT transformation and decomposition of thousands of images is time-consuming thus the cover image database is being previous processed. Block diagram of the preprocessing is illustrated in the article [4].

TABLE II
TIME CONSUMPTION OF THE CS METHOD

Image size [pixel]	Size of secret message [bit]	Proposed method (CS) Time [min]	Method [4] Time [s]
512×512	21,760	30	3.5
	43,520	106	4
	65,280	350	4.5

It is clear that the proposed CS method is more time-consuming than the same embedding method without cover selection (TABLE II). Embedding process by the cover selection method took almost 6 hours, whereas the method without CS was performed within 5 seconds.

Dependence of a cover image database size from number of changes is illustrated in the Fig. 1. Whereas the database size was increasing, the number of changes was decreasing. Embedded secret message length was 16,128 bits.

Fig. 1. Dependence of embedding changes number from cover image databases size.

Results shows that steganographic method with cover selection achieved 10% less number of changes with the same secret message. It means that security of the method is theoretically 10% stronger against steganalysis as well. Among disadvantages of the method belong duration of an embedding process and limited choice of the particular cover image.

IV. Next Steps

The next steps in my research are related with improvement of cover selection steganography. More accurately:

- acceleration of selecting the appropriate cover image from cover image database
- to improve an efficiency, thus reducing the number of changes caused by embedding process
- analyze the improved cover selection method by common steganalysis techniques
- finding statistical parameters which would be appropriate for the training process of steganalyzer to achieve better detection of the method

My present research is connected with Radioelektronika 2017, 27th International Conference, where our article "Accelerated cover selection steganography" has been already accepted. The proposed technique deals with an acceleration of cover selection by shortening a secret message vector for the comparison process.

Acknowledgment

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Students Social Based Mobility Model for MANET-DTN Networks

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***Abstract*—In this paper, a new social based mobility model called Students Social Based Mobility Model (SSBMM) for Mobile Ad-Hoc NETwork (MANET) and Delay Tolerant Network (DTN) will be described. SSBMM mobility model is inspired by the daily routine of student's life. Since many current social based mobility models give nodes freedom in term of movement according to social feeling, attractivity to other nodes or places, this model focus more on the mandatory part of our life, such as going to work, school and so on. Finally, proposed SSBMM was tested and verified. Based on simulations we observe, whenever proposed mobility model shows signs of social behaviour.**

***Keywords*—MANET - DTN, Social behaviour, Mobility model, MANET routing protocols, Students , Evaluation method**

I. Introduction

Social based mobility modelling is actually the application of social network theory into mobility modelling [1]. A Mobile Ad Hoc NETwork (MANET) and Delay Tolerant Networks (DTN) are networks, where a group of wireless mobile devices communicate wirelessly without fixed infrastructure [2]. Nowadays, problems in MANET-DTN became popular topics for researchers. New routing protocols and improvements in routing process are one of the main problems. Mobility models as simulation tools are therefore important to verify correctness and functionality of protocols. Many researchers use random mobility models as simulation tools. In the real world, wireless mobile devices are carried by humans. For those reasons, it is useful if mobility models as simulation tools used to test proposed routing protocols in MANET-DTN, follow the behaviour of humans. Humans are social creatures and they move and organise themselves in social groups [3]. Tracking movement of human and implement such a social behaviour into mobility models may be a difficult task. Social mobility models become popular simulation tools in MANET-DTN networks and many types of research nowadays rely on social behaviour [4], [5]. We decide to observe and follow the life of students in the university campus of the city area. The most of the current social based mobility models give nodes a freedom in terms of movement because they move as they want according to social feeling, attractivity to other nodes or places [6], [7], [8], [9], [10]. The main idea is, that humans have their duties and responsibilities such as going to work or school. This part of humans life is mandatory and not a free choice. Therefore, we decide to create a Students Social Based Mobility Model (SSBMM) that follow the routine of student's daily life and also take into account mentioned mandatory part of the human's life.

II. Students Social Based Mobility Model

Students Social Based Mobility Model (SSBMM) follow the routine of student's daily life and also take into account mandatory part of the human's life. The main idea is capture usual day or week of the students. This mobility model is composed based on the university campus in the city area. Simulation area depicted in Fig. 1 displays collocation of different areas in which students move.

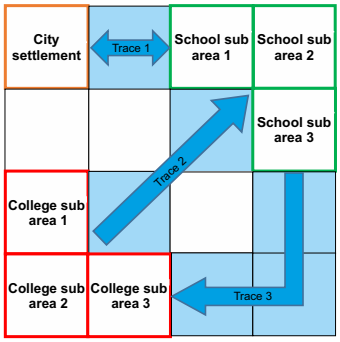

Fig. 1. Simulation area of SSBMM.

There are three main areas placed in simulation grid:

1) **School area** - an area where students supposed to be in mandatory part of the day. This mandatory part is defined for every student. The area is divided into three sub-areas, which can be interpreted as e.g Laboratory, Lecture Hall and so on.
2) **City settlement area** - an area where students could be in their free time. In this area moves students that live in this particular city. This area simulates students living in the flat houses.
3) **College dormitory area** - another area where students could be in their free time. But in this area lives students that are not from the particular city. This area is divided into three sub-areas, which can be interpreted as e.g Rooms, Gym and so on.

In Fig. 1 is also possible to see travel traces. Those traces are used to simulate travelling of students to or from school to or from their origin areas. Some traces are one-way and some are two-way.

Because there are different areas in the simulation area, students are therefore divided into two groups by origin. The first group represent students living in City settlement and second represents students living in College dormitory.

Students are divided in half into those groups in the initial phase of the model. Another division of students represents study groups. A number of study groups can be different, e.g from 2 to N. This division is performed in the initial phase of the model and divides students into groups evenly.

Every student follows its own daily routine based on the model timeline (Fig. 2). This timeline divides one week into five business days and two weekend days. Every day is also divided into free time and mandatory time for every student. Mandatory time of the day is defined by the schedule. The schedule is different for every business day and there is no schedule defined for the weekend. It is defined for every study group, not for every student separately because this could cause big matrices and data stored in memory. The schedule stores information about in which school sub-area students from particular study group should be in mandatory part of the particular day.

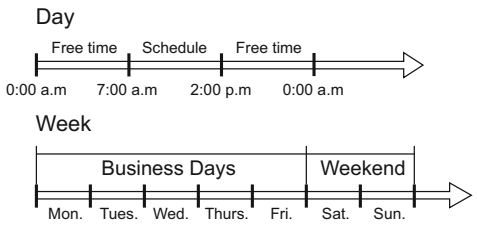

Fig. 2. Timeline of the model.

Students live in different areas and they behave differently in those areas. For every area of the simulation grid, is defined different behaviour. This behaviour is described in following subsections.

A. Node's behaviour in city settlement

From the observation, we assumed, that students from city spend most of their free time at home. They move along their apartment, which is basically the small range of movement. At the initial phase, the positions of students with city settlement origin are randomly generated inside settlement area. Then new goal (1) in the new time slot is randomly chosen from current position plus small range.

$$\begin{aligned} x_{t+1} &= x_t + rand[x_{min}, x_{max}] \\ y_{t+1} &= y_t + rand[y_{min}, y_{max}] \end{aligned} \tag{1}$$

In the equation 1 x_t, y_t represent coordinates in current time slot and x_{t+1}, y_{t+1} are coordinates of the node in the time slot $(t+1)$. These coordinates are computed from ranges $[x_{min}, x_{max}]$ and $[y_{min}, y_{max}]$ with which the small range of movement in the apartment is simulated. Coordinates x_{min} and y_{min} from ranges should be negative and opposite numbers of x_{max} and y_{max} from ranges, for example $[-5, 5]$.

B. Node's behaviour in school

The School is the area, where students are every business day according to their schedule. The mobility of nodes or students respectively is according to the schedule. Every student knows his schedule and he also knows in which study group he is. So, if student A has chemistry in laboratories at 7:00 a.m., node that represents this student just randomly generate his position inside laboratory sub simulation area, as it is depicted in Fig. 3.

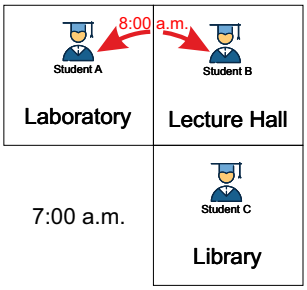

Fig. 3. Mobility of students in school area.

On the same figure is also possible to see that student B has physics in the lecture hall at the same time. If student A has physics in the lecture hall at 8:00 a.m. and student B has chemistry in laboratories at the same time according to the schedule, they just change their sub-areas by randomly generating positions inside sub-areas that correspond to the cells of the simulation grid.

C. Node's behaviour when they travel

Travelling in this model is realised by traces, along which students can travel. On the Fig. 1, blue arrows represent a traces. We can also see that trace from city settlement to school is two-way and other two traces are just one way. So, if nodes are travelling from college dormitory to school, they follow trace 2. On that way, in time slot t they randomly generate their position inside the first cell (light blue) that crosses a trace 2. On time slot $(t+1)$ their positions inside the first cell are just shifted to the second cell on that way. These positions are not generated again, they are shifted by the cell size in x-direction and y-direction by equation 2 :

$$\begin{aligned} x_{t+1} &= x_t + s \\ y_{t+1} &= y_t + s \end{aligned} \tag{2}$$

where s is the size of the cell in simulation grid. This implies that node requires one time slot to pass by one cell of simulation grid while travelling.

D. Node's behaviour in college dormitory

In this section, a social behaviour of nodes (student's resp.) in college dormitory will be described. One of the ways how to model relationships between nodes or students is weighted graph [3]. Each student represents a node in this graph. The edges and their weights are representing the strength of nodes relationships. An example of that weighted graph is shown in Fig. 4.

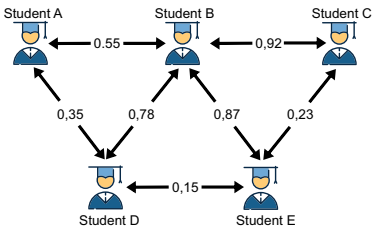

Fig. 4. Example of weighted graph created by students, which represent network.

Weighted graph representing a network of five students. These students are vertexes of this graph and weights of the

edges are the strength of their relationships between each other. This strength is represented by value in the range [0,1], where 0 indicate no relationship between the pair of students and 1 indicate the strong relationship. This weighted graph can be also interpreted by the 5x5 symmetric Social Relationships (SR) matrix, showed in Fig. 5.

$$SR = \begin{array}{c} \\ \text{Student A} \\ \text{Student B} \\ \text{Student C} \\ \text{Student D} \\ \text{Student E} \end{array} \begin{array}{c} \begin{array}{ccccc} \text{Student A} & \text{Student B} & \text{Student C} & \text{Student D} & \text{Student E} \end{array} \\ \begin{pmatrix} 1 & 0.55 & 0.23 & 0.45 & 0.15 \\ 0.55 & 1 & 0.92 & 0.78 & 0.87 \\ 0.23 & 0.92 & 1 & 0.30 & 0.63 \\ 0.45 & 0.78 & 0.30 & 1 & 0.95 \\ 0.15 & 0.87 & 0.63 & 0.95 & 1 \end{pmatrix} \end{array}$$

Fig. 5. Example of symmetric Social Relationships (SR) matrix.

College dormitory in simulation area will be divided into three sub-areas. The mobility of nodes in this sub-areas will be as follows:

- *First goal selection* - as there are three sub-areas, in initial phase nodes with origin in college dormitory will be randomly divided into three groups with approximately (in case an odd number of nodes) the same number of nodes. Then the first goal of every student from the first group in time slot t, will be randomly generated inside first sub-area cell of college dormitory simulation area and then the first goal of every student from the second group in second sub-area and so on.
- *Subsequent goal selection* - is when the first goal in time slot t is generated, new goal in the time slot $(t+1)$ is selected by the following mechanism presented by authors in [3]. A certain number of nodes is associated with sub-area cell C_k. Each cell exerts a certain social attractivity for a certain node. The social attractivity of a cell is a measure of its importance in terms of the social relationships for the node taken into consideration. For each node is calculated social attractivity of all three cells (3):

$$SA_{C_{k_i}} = \frac{\sum_{\substack{j=1 \\ j \in C_k}}^{n} sr_{i,j}}{w} \tag{3}$$

where w is the cardinality of cell Ck (number of nodes in Ck) and $sr_{i,j}$ is the element of SR matrix between node i and j. In other words, the social attractivity of a cell for node i is defined as the sum of the elements of SR matrix that represent the relationships between node i and the other nodes that belong to that particular cell, normalised by the total number of hosts associated with that cell [3]. If the cell is Ck empty then w =0 and is $SA_{C_{k_i}}$ also 0. The new goal for node i is then randomly generated inside the cell with the highest social attractivity for that node.

III. Simulations and Results

The set of simulations is oriented on testing proposed mobility model by our evaluation method proposed in Tools for Evaluation of Social Relations in Mobility Model [11]. Results are focused on number of communities, modularity quality and average weighted degree. Contacts among nodes was calculated and stored in Meeting matrix based on nodes' movement in Matlab software and processed by external Gephi software [12]. SSBMM was simulated a compared with two random mobility models, Matis model [13] and Random Walk mobility model [14]. Simulations was performed using different radio ranges and different number of nodes and other parameters presented in Table I. In this paper is presented just some main results from [11].

TABLE I
Set values of Variables for simulations

Variable	Value
Area [m]	1500x1500
Number of nodes	50, 100, 200
Radio range [m]	20, 50, 100, 300
Time slots per day	48
Simulation duration [days]	28

A. Number of communities

In radio range of 20 meters (Fig. 6) is possible to see, that SSBMM has way more communities with 200 and 100 nodes simulation. In the simulation with 50 nodes, the SSBMM has one more community than model Matis model and two more than Random Walk mobility model. While SSBMM has a significantly growing number of communities with growing numbers of nodes, in random models number of communities grows just slightly.

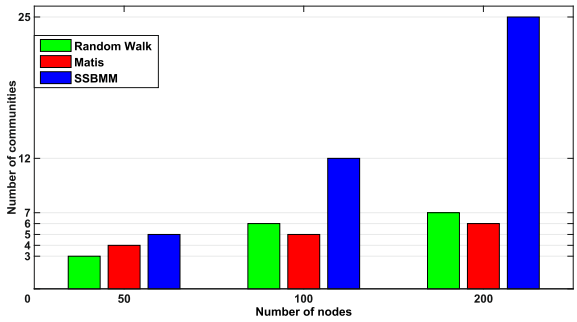

Fig. 6. Number of communities in 20 m radio range.

On Fig. 7 the same behaviour was observed for radio range of 50 meters. SSBMM has bigger numbers of communities, while random models have almost same numbers of communities that grow just slightly.

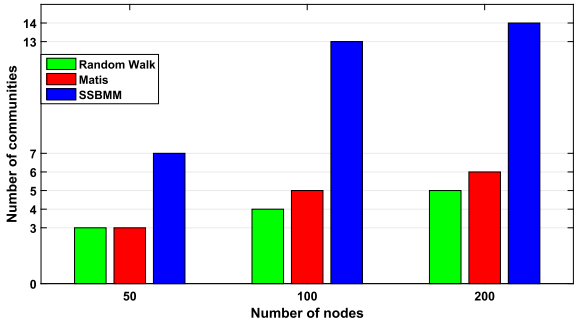

Fig. 7. Number of communities in 50 m radio range.

On Fig. 8 is possible to see the graphic division of nodes into communities on 50 meters radio range by Gephi software. The SSBMM has thicker edges inside than among communities. This means, that there are stronger relationships among nodes. In the random models, edge thickness inside and among communities is comparable, thus weaker relationships among nodes are created.

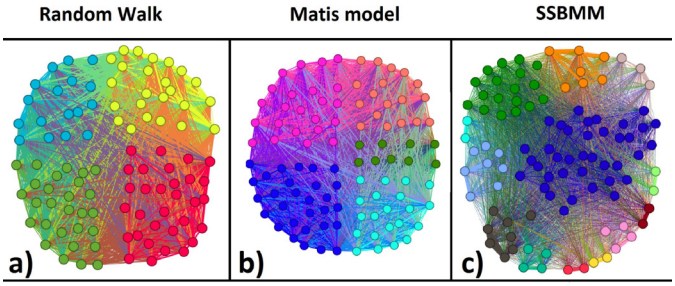

Fig. 8. Division of nodes into communities in radio range of 50 meters by Gephi (a) Random Walk b) Matis model c) SSBMM

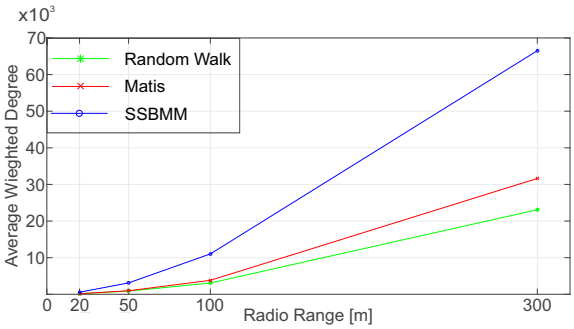

Fig. 10. Average Weighted Degree of 200 nodes.

B. Modularity quality

On Fig. 9 are depicted a modularity quality results. It is possible to see that modularity quality of SSBMM was always better than in random models. Even in radio range of 300 meters, where numbers of communities were lower in the case of SSBMM in very dense network scenario. Modularity quality measures how well a given partition of a network compartmentalises its communities. The modularity of a partition is a scalar value between -1 and 1 that measures the density of links inside communities as compared to links between communities. The modularity can be either positive or negative. Positive values indicating that there is some community structure. Authors in [15] declared, that nonzero values represent deviations from randomness, and in practice, it is found that a value above about 0.3 is a good indicator of significant community structure in a network. In our simulation scenario, modularity quality was still better and above 0.3, which proves SSBMM deviation from randomness.

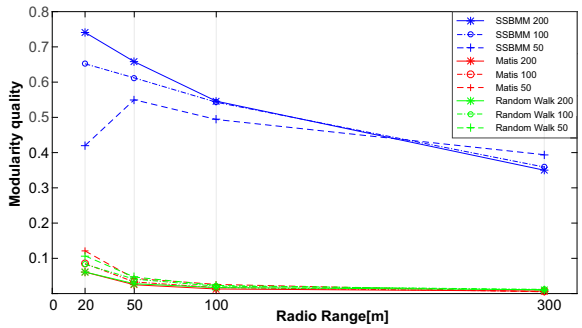

Fig. 9. Modularity quality results.

C. Average weighted degree

On Fig. 10 are depicted results of average weighted degree for 200 nodes. The SSBMM outperform random models in all radio ranges. The frequency of contacts among some nodes in SSBMM was higher than in random models, which also push average weighted degree values higher. Therefore, it is possible to say, that social ties among nodes cause more often contacts among nodes and this behaviour affects average weighted degree values. The same behaviour was observed using 50 and 100 nodes.

IV. Conclusion

Both Students Social Based Mobility Model and Tools for Evaluation of Social Relations in Mobility Models were written as papers for current content journals and they are in the submission process. Results and movement of mobility model will be used as simulation tools for my future work in Cognitive Radio-MANET, especially for composing CR routing protocol.

Acknowledgment

This work was performed in the framework of research project VEGA 1/0075/15, funded by the ministry of education of Slovak Republic and COST Action CA15127 (“Resilient communication services protecting enduser applications from disaster-based failures - RECODIS”) supported by COST (European Cooperation in Science and Technology).

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Studied the dielectric properties of magnetic fluids in various diagnostic methods

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***Abstract*— This paper offers information about research of the dielectric properties of magnetic fluids. It is very important to understand electrical and dielectric properties of this insulation. In seeking to replace mineral oils magnetic fluids it is necessary to know the electrical and dielectric properties this material. It is also important to know how to behave this composite material under the influence of electrical, magnetical and thermal stresses. Another aspect to be taken into consideration is the concentration of magnetic particles contained in the magnetic fluid. The article is focused on the measurement of the dielectric properties of magnetic fluids using two diagnostic methods. The article it contained dependence the impact of electromagnetic radiation on the degradation of magnetic fluids depending on the concentration of magnetic particles in the magnetic fluid.**

***Keywords*— magnetic fluids, concentration, thermal stress, electrical stress.**

I. INTRODUCTION

For more than one hundred years, the majority of liquid-immersed transformers have been filled with mineral oil. The significant use of this petroleum-based product has been justified until now by its wide availability, its good properties, its good combination with cellulose and its low cost. In a liquid-filled transformer, the insulating liquid plays an important function by providing both the electrical insulation (in combination with a solid such as cellulose) and the means of transferring the thermal losses to the cooling system. The insulating liquid can also provide important and easily obtainable information for use in diagnosing the health of a transformer. Whereas, in the electrical power engineering sector as well as in other sectors seeking to improve the reliability of electricity facilities, a search for any new insulation materials, which would replace the used insulation systems in order to improve the operational capability and reduction of electrical losses in electricity devices, has started. Magnetic fluids [1] appear to be such a materials, by which the main idea was to use this fluids in the insulation system of a transformer, which would provide a cooling function and improve the offtake of a waste heat, which would reduce the losses. The materials used in power engineering as well as the magnetic fluids succumb to effect of aging, resulting in degradation of their insulation qualities. Reduction in electric strength due to effects of aging may cause a breakdown insulation of electrical device [2]. In consideration of the fact, that a reliable supply of energy is one of the main aims in the power engineering, several diagnostic methods for detecting the state of insulation materials were developed to consequently predict the life expectancy of electrical devices by these tools. The magnetic fluids are composite materials consisting of several elements, which production is very expensive, therefore it is necessary to determine whether we are able to determine the state of these fluids by the conventional diagnostic methods, or the developing of new specific methods and apparatus for their diagnosis is needed [3].

II. RECENT RESEARCH

Research of electrical and dielectric properties of magnetic fluids is the aim of many scientific collective. Properties such as breakdown voltage, dissipation factor, relative permittivity belong between the basic of diagnostic variables [4].

Current research in this area compared dielectric properties of magnetic fluids with different concentrations of magnetic particles contained in the magnetic fluid. The results of is set, the magnetic fluid with a higher concentration of magnetic particles has a higher loss factor than the magnetic fluid with a lower concentration of particles. Temperature is one factor that has a strong bearing on the state and dielectric properties of magnetic fluid [5].

III. MY RESEARCH

Since last SCYR conference my research was focused only on magnetic fluids. Properties as relative permittivity, dissipation factor, and PDC analys were measured. Electrical and dielectric properties of different magnetic fluids are major parts of my research. My research I started with measurements of magnetic nanofluis [6]. Dissipation factor and capacity of different types of magnetic fluids was measured in dependent of frequency . Further measurements, the measurements of polarization and depolarization current (PDC). There were used tree types of magnetic fluids. Magnetic fluid has been drawn up in concentrations that are expressed using magnetization. The samples were labeled as a GAUSS 10, GAUSS 25 and GAUSS 50, the concentration of particles in the individual samples did not exceed 5%. Results of these measurements, I published on 17th International Scientific Conference on Electric Power Engineering (EPE) 2016 in Prague [7].

When measuring the polarization and depolarization current be seen of interference they were influenced measurement results, so the measurements were also carried out in an non-reflective EMC chamber and out of the chamber. When magnetic fluid have higher values of dissipation factor liquids with a higher concentration of magnetic particles. It was also, an increase in the value of charge and discharge streams of samples with a higher concentration of magnetic particles. The aim of my next research was, determine of changes of frequency dependence of dielectric loss factor of magnetic liquid depending on the temperature. Dissipation factor except frequency are strong dependent on temperature. During the test were temperature increased from 20°C to 100°C with step 20°C. The results shown that dissipation factor is increasing with increasing temperature. The next experiment was aimed to determine the effect of electromagnetic radiation on the degradation of magnetic fluids. In this experiment, only three samples of magnetic fluids in various concentrations of particles. To verify the status of the liquid was applied PDC analysis to determine the dielectric properties of magnetic fluid. Results of this measurement will be published in the journal Archives of Electrical Engineering number 66 (260) - 2/2017.

At the same time when measured externally applied magnetic field, when exposed to a magnetic field has been studying the effects of magnetodielektric anisotropy. When another experiment, the samples were irradiated with electromagnetic radiation measured at the action of external magnetic field. The aim was to verify the effects magnetodielektric anisotropy and its effects on irradiated magnetic fluids. These results will be published on 18th International Scientific Conference on Electric Power Engineering (EPE) 2017 in Kouty nad Desnou [8].

This area of research is not good researched, therefore is necessary doing lot of measurement and devote a lot of attention of this area. Lot of equipment has insulation system created with more than one part. Insulation system is usually created with liquid part and solid part. It is necessary to find out how these two isolation systems. It influences each other whereas magnetic fluids is composed of several components. It is also necessary to find out the electric strength of the combined insulating systems, such as insulating paper and magnetic fluids [9]. A further experiment was carried out with the intention to check the accuracy of diagnostic instruments with different frequency range. The measurements were carried out on high-voltage insulators plastic. In this experiment were measured variables such as dissipation factor, capacity and permittivity material. Subsequently, these variables compared, and deviations in the measured value evaluation. These results will be published at the 9th International Symposium on Electrical Power Engineering, Power Engineering in 2017 in Stará Lesná. These experiments and many more further measurements were carried out over the past year since the last conference SCYR.

IV. FUTURE RESEARCH

Nowadays, research of magnetic fluids as substitute traditional mineral oils is very important. My next steps will be focused on research of properties of different types of magnetic nanofluids. Research of influence of temperature on magnetic fluid, also influence of temperature on dissipation factor of magnetic nanofluids. Next aim will be measurement charging and discharging current of magnetic fluids in big temperature range. Very important property of magnetic fluids is magnetodielektric anisotropy. Therefore measurement of influence magnetodielectric anisotropy influence on a selected sample of magnetic fluids will be realized.

CONCLUSION

This article presented some electrical and dielectric properties of magnetic fluids. In seeking to replace mineral oils substitute for magnetic fluids it is necessary to know what these fluids have dielectric properties. It is therefore necessary that the research of magnetic fluids continue focusing on their behavior on exposure to electric, magnetic and thermal stresses. Other focus in this area of research should be devoted to the process of electro-magnetic fluids with different concentrations of magnetic particles.

ACKNOWLEDGMENT

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Superconductor-Insulator Transition in Ultrathin Films

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After several decades of active research many integral questions regarding Superconductor-Insulator Transition (SIT) as one of the central points of interest of contemporary condensed matter physics remain unanswered. SIT is one of several known realisations of a continuous quantum phase transition. Unlike regular thermodynamic phase transitions, quantum phase transitions occur as a consequence of quantum fluctuations rather than thermal fluctuations. This is only possible in the zero temperature limit. Such a transition is then manifested as a change of the ground state of the system and can be caused by a variation of an external parameter of the total system Hamiltonian. In the case of superconductor-insulator transition this parameter could be charge carrier concentration, external magnetic field, disorder, or 2D limit. Experimentally, it is possible to study quantum phase transitions at a finite temperature by observing the changes in the physical properties of the system associated with the ground state change which would occur at zero temperature. In this brief review the main results of the experimental investigation of SIT in ultrathin disordered films will be presented as well as theoretical approaches used to elaborate on different possible scenarios of superconductor-insulator transition in two-dimensional limit. Concluding the review, future outlooks of the research in this area will be discussed.

***Keywords* — Disordered superconductors, Quantum phase transitions, Superconductor-insulator transition, Ultrathin films**

I. Introduction

Superconductor-insulator transition is a type of a continuous quantum phase transition: a phase transition that occurs at zero temperature due to a change in the ground state of the system. A quantum phase transition is facilitated by quantum fluctuations as opposed to thermal fluctuations associated with regular phase transition. The ground state change occurs as a result of a variation of an external parameter in the Hamiltonian describing the total energy of the system. The most basic examples of such parameters (specifically for the superconductor-insulator transition) are disorder, charge-carrier concentration, external magnetic field and lower dimensionality of the system. Quantum phase transitions take place in a variety of complex systems such as high temperature superconductors, strongly correlated electron materials, geometrically confined electron gases and ultracold atom systems, all novel materials being at the forefront of the research activities in contemporary condensed matter physics. Despite several decades of intensive research efforts in this area, a substantial number of problems still pose a challenge to theoreticians and experimentators alike, an issue only exacerbated with the emergence of new novel materials and experimental techniques. The review focuses on the ongoing research of superconductor-insulator transition in amorphous or polycrystalline disordered films in 2D limit. Reducing the dimensionality of a material via preparing a film with thickness on the order or below the top band electron wavelength is a simple way of realising easily tunable SIT [1].

II. Current Status of the Research

When it comes to the electronic properties of solids, the nature of the ground state electron wave function at the Fermi level determines whether the material behaves as a metal (electron wave function is delocalised) or an insulator (electron wave function is localised). Before the advent of unconventional superconductors it was generally accepted that superconductivity can only emerge in metallic systems, where incoherent but delocalised electron wave functions assume long-range coherence as opposed to a transition from localised to delocalised states. However, when the system is forced to

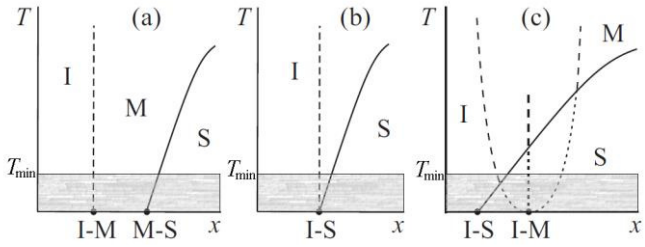

Fig. 1. Three possible (x,T) diagrams of the superconductor-insulator transition. S stands for superconducting phase, M for metallic phase and I for insulating phase. The dots on the x axis mark the quantum critical points, solid lines are thermodynamic phase transitions and dashed lines represent boundaries of the critical regions [1].

transition from superconducting state via a change in external conditions at zero temperature, the now incoherent wave functions can become localised. This change in the electron ground state is a quantum phase transition. Superconducting phase can, of course, be broken in the same manner at nonzero temperature in which case it occurs via a regular thermodynamic phase transition. Quantum phase transition

then can be understood as a suppression of the thermodynamic transition temperature to zero as a result of the external parameter variation. This is demonstrated in the form of (x,T) phase diagrams in Fig. 1, where x is the external control parameter. The dots on the x axis represent quantum phase transitions, solid lines represent the thermodynamic phase transitions and the dashed lines are imaginary boundaries of the critical regions (purely insulating phase is only possible at T = 0 due to thermal excitations at nonzero temperatures) [1].

If under a reduction of x the material exhibits a transition from a superconducting state to a metallic state first, the phase diagram may resemble Fig. 1a. Further change of the control parameter subsequently leads to a metal-insulator transition. This scenario is realised in amorphous Nb_xSi_{1-x} alloy [2]. The SIT quantum critical point (the value of x – Nb concentration – at which the transition temperature is suppressed to zero)

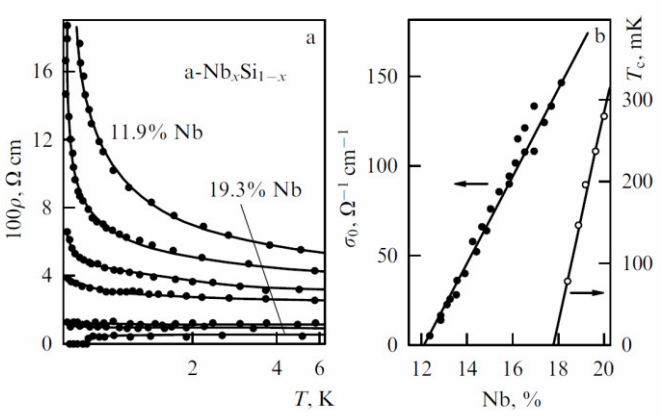

Fig. 2. a) Temperature dependences of electrical resistivity of the amorphous Nb_xSi_{1-x} alloy within a range of different Nb concentrations [2]. b) Superconducting transition temperature T_C dependence and the depence of the expected zero temperature conductivity on the Nb concentration [2].

appears at ~18% Nb in the alloy while the metal-insulator transition critical point is at ~12% Nb (Fig. 2b). In Fig. 2a we can observe how the electrical resistivity of the alloy with lower Nb concentration diverges close to T = 0, signifying an insulating state, then reaches a residual value for a broad range of higher Nb concentration as in a metal. The lowermost curve exhibits an apparent superconducting transition at T < 0.5 K.

Another possible case is a direct superconductor-insulator transition (Fig. 1b). An extrapolation of resistivity temperature dependence measurements to T = 0 reveals all curves above the critical point diverging and all curves below exhibiting sharp superconducting transition with the transition temperature scaling accordingly. This seems to be the case in ultrathin amorphous Bi films (Fig. 3) with the control parameter x being film thickness [3].

If the metal-insulator critical point lies inside the superconductivity region (Fig. 1c), metallic state only occurs at elevated temperatures and material may exhibit significant insulator-like increase in resistivity with decreasing temperature before transitioning into superconducting state. Such phase diagram was observed in ultrathin TiN films with varying levels of excess nitrogen concentration [4].

Several theoretical models of SIT in ultrathin films have been proposed, yet not one has succeeded to quantitatively describe a wider variety of different systems without significant caveats. Various physical systems exhibit different manifestations of the transition and experimental data often support multiple theories. A single universal mechanism is uncertain at this time. Many factors may influence the transition scenario such as the type of film (amorphous or polycrystalline, homogeneously disordered or granular), the control parameter (thickness, disorder, charge carrier concentration), even the substrate the film is prepared upon might impact the aspects of SIT in a nontrivial way.

The motivation behind the study of SIT comes from the experiments on disordered superconductors. It has been demonstrated by Anderson [5] and then by Abrikosov and Gorkov [6] that presence of nonmagnetic impurities has no effect on the superconducting transition temperature as the electron states taking part on the pairing process have the impurity scattering included in their wave function. However, once the impurity concentration raises above a certain threshold, Anderson (strong) localisation occurs in the electron subsystem and the superconducting pairing is suppressed despite the phonon spectrum allowing for the attractive electron-electron interaction. Situation changes in 2D limit as in such system the transition becomes topological in nature and is called a Berezinskii-Kosterlitz-Thouless transition [7]. It was assumed all two-dimensional electronic systems would be localised regardless of disorder. This idea has since been

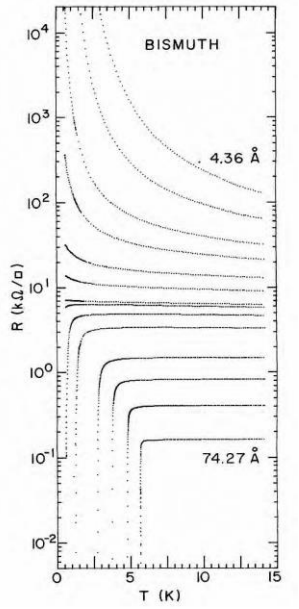

Fig. 3. Temperature dependences of electrical resistivity of the amorphous Bi films with varying thickness, increasing from top to bottom [3].

refuted when metal-insulator transition was observed in metal-oxide-semiconductor field effect transistors at certain conditions [8]. There have been several distinct approaches proposed to elucidate the destruction of superconductivity in ultrathin films with the tuning control parameter being thickness, magnetic field or charge carrier concentration. In this review we will only focus on the two most prevalent theories: fermionic localisation model and bosonic localisation model.

The fermionic model emerged as a potential theory explaining SIT in systems where homogeneous disorder on a microscopic level is expected. The driving mechanism is a competition between electron-phonon interaction and Coulomb repulsion. Anderson's localisation theory does not take Coulomb repulsive interaction into consideration. This was later corrected by McMillan [9] and Allen and Dynes [10].

Their work incorporated both electron-phonon and electron-electron interactions as distinct parameters and formulated a relation quantifying the influence of those on the superconducting critical temperature T_C:

$$T_C = \frac{\langle\omega\rangle}{1.2} e^{-\frac{1.04(1+\lambda)}{\lambda-\mu(1+0.62\lambda)}},$$

where $\langle\omega\rangle$ is the average phonon frequency, μ is the Coulomb coupling and λ is the electron-phonon coupling. The parameters depend on the material and can be obtained from spectroscopic measurements [11, 12]. The effect of nonmagnetic impurities on the critical temperature of ultrathin films was confirmed in various experiments. The effect may result from a change in either of the coupling constants. Schmid and Keck considered the variation of electron-phonon interaction [13]. Altshuler and Aronov have discovered intriguing behavior in the 2D limit systems in the presence of electron-electron Coulomb interaction [14]. Based on this work Finkelstein proposed an idea that the superconducting critical temperature is reduced with increasing disorder due to how Coulomb interaction is renormalised [15]. In Finkelstein's model (Fig. 4) the critical temperature T_C is derived as a function of sheet resistance R_S:

$$T_C = \frac{\hbar}{k_B T}\left(\frac{\sqrt{g}-\sqrt{g_c}+\sqrt{\frac{g_c}{8\pi g}}}{\sqrt{g}+\sqrt{g_c}+\sqrt{\frac{g_c}{8\pi g}}}\right)^{\sqrt{\frac{\pi g}{2}}},$$

where $g = 2\pi\hbar/e^2R_S$ is electrical conductance, $g_c = \frac{\ln^2(\hbar/k_B T_{C0})}{2\pi}$ is a critical conductance and T_{C0} is the critical temperature of the same system in the absence of disorder. Fermionic scenario thus describes the destruction of the superconducting order via gradual reduction of the pairing

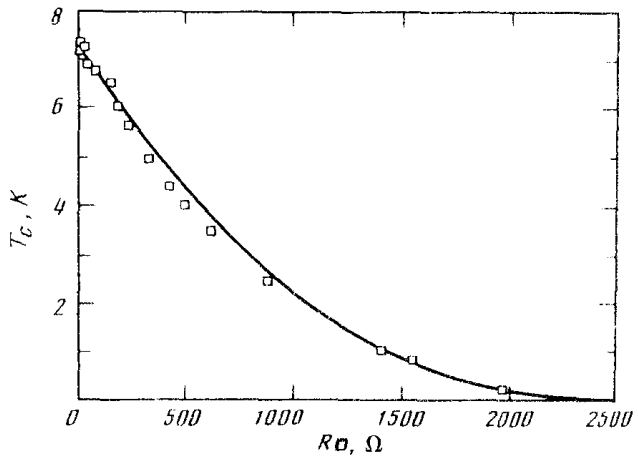

Fig. 4. Finkelstein's model for the superconducting transition temperature T_C dependence on disorder of the homogeneously disordered films in 2D limit. The disorder level is characterised by the sheet resistance R_S. The circles represent experimental data from amorphous MoGe film measurements [1].

interaction and the SIT in the systems the model was applied to possibly involves an intermediary bad metal phase. In recent years the experiments on homogeneously disordered MoGe [16] and MoC [17] films demonstrated some signs of this mechanism being realised:

1. The critical temperature T_C decreases with increasing sheet resistance R_S of the films as predicted by Finkelstein (Fig. 4).
2. With increasing disorder the superconducting critical temperature T_C decreases proportionally with the decrease of the energy gap Δ – the coupling strength parameter $\frac{2\Delta_0}{k_B T_C}$ remains constant and the gap apparently vanishes at the critical point [16, 17].
3. With increasing disorder the presence of single-quasiparticle in-gap states (fermionic excitations) was observed in specific experiments (Fig. 5).
4. The energy gap Δ appears to be spatially homogeneous up to T_C [17].

The bosonic model, on the other hand, revolves around the quantum fluctuations' capability of disturbing the global long-range coherence of the superconducting electron quasiparticle wave function [18]. In general, if any phase gradient of the superconducting order parameter appears in the system, the induced supercurrents eliminate it to restore the phase coherence, as evidenced by the Josephson effect. Quantum fluctuations are a dynamic process by nature; the induced supercurrents are not time-constant and cause voltage variations which lead to the appearance of bosonic excitations, as opposed to thermal fermionic quasiparticle excitations. These phase fluctuations possess the ability to destroy the global superconducting state by means of disturbing the global

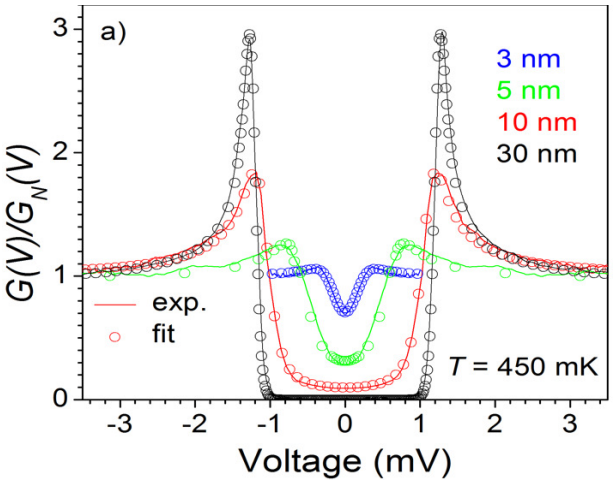

Fig. 5. Tunneling differential conductance spectra measured on ultrathin homogeneously disordered polycrystalline MoC films at 450 mK with four different thicknesses. The positions of the peaks mark the characteristic energy of the superconducting gap Δ [15].

macroscopic coherence of the order parameter – they prevent the incoherent Cooper pair clusters from establishing phase coherence via the supercurrent flow leading to a macroscopic insulating state. A disorder in the form of mesoscale granularity apparently leads to such state. The SIT in a granular system can be modeled by an array of Josephson junctions as demonstarted by Doniach [19]. Increasing a control parameter such as perpendicular magnetic field closes the junctions between the superconducting grains via the Coulomb blockade, isolating them into separate superconducting condensates with different phases of the order parameter.

The experiments performed on ultrathin films of TiN [20], NbN [21], InO [22] point towards the bosonic localisation model:

1. With increasing disorder the superconducting critical temperature T_C decreases faster than superconducting

energy gap Δ – the coupling strength parameter $\frac{2\Delta_0}{k_B T_C}$ increases and Cooper pair islands may locally persist even on the insulating side of the transition [20].

2. Even the strongly disordered films close to the SIT exhibit full superconducting energy gap (Fig. 6b).
3. Spatial energy gap fluctuations on the order of the superconducting coherence length ξ suggest the loss of long-range coherence (Fig. 6a).
4. Inability to observe the vortex lattice close to the critical point is another hint towards gradual loss of long-range coherence [21].
5. Tunneling spectra measured above T_C show the presence of pseudogap – possible result of incoherent clusters of Cooper pairs in normal state [20].

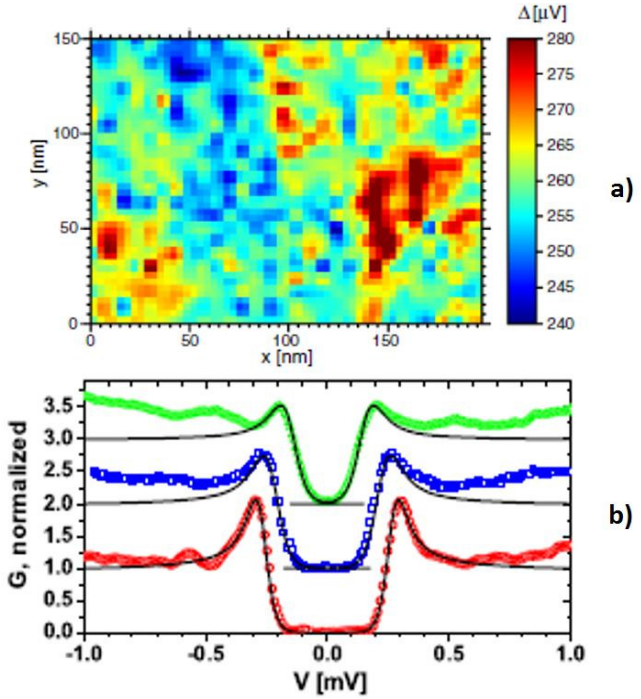

Fig. 6. a) Superconducting energy gap map on a 150x200 nm^2 surface area of ultrathin polycrystalline TiN film. The gap value increases from blue to red [20]. b) Normalised tunneling differential conductance spectra measured on ultrathin polycrystalline TiN films at 50 mK with thickness increasing from top to bottom and demonstrating the suppression of the energy gap Δ when approaching the SIT. Spectra are shifted for clarity [20].

III. Conclusion

Following the substantial amount of effort that has been directed towards explaining the intricacies of superconductor-insulator transitions in 2D limit systems, future endeavours have to provide answers to many open questions, such as: What are the different mechanisms that govern the SIT in these systems and how to identify them? Why are the processes on the insulating side of the transition so different between homogeneously disordered and granular systems? Solving these problems and other more material/system specific issues presents the future direction of the SIT research.

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The Obfuscation Based on Code Integration

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***Abstract*—Obfuscation is primarily used as tool for protecting the written code against reverse engineering, but there also exist other schemas for the obfuscation process, which primarily focus on hiding the true purpose of the written code by transforming its blocks, which causes the inability of comparison the obfuscated code sequence to code stored in database by static or hybrid analysis. When trying to overcome this type of analysis weakness, man should be well educated in obfuscation schemas.**

***Keywords*—Code obfuscation, analysis, code integration, software correctness.**

I. Introduction

There are many principles how to make hard to apply the reverse engineering of the selected program. Common techniques used are cryptography, different kinds of morphism (oligomorphism, polymorphism, metamorphism) and different kinds of obfuscation techniques and with some limits, using of steganography principles. Common approach of these techniques lies in disabling the readability of selected code. Cryptography and morphism techniques however, alter the code in so called rude way, which leads to applying special conditions for running it in infected environment (changing the way of compiling the program sequence or altering the method of the accessing and persisting system method). The least invasive technique for so called code hiding can be considered the obfuscation [1][2][3].

II. Code Obfuscation

Obfuscation technique is widely used to cover the harmful components. Uses obfuscation techniques or software that principle lies in transformation of the source code or an executable file in incomprehensible code, with one condition, the function of selected code should remain semantically untouched. It is important, that the code should be illegible to the reader [1]. It is used to cover the control flow of the software as well as the DATA structures that contain sensitive information and is used to mitigate threats of the reverse engineering, which was the largest cause of obfuscation. Collberg et al. define obfuscation as the transformation of the program P to the P 'such that P and P' have the same visible behavior [2]. In order to obfuscated transformation be legal, it must satisfy following conditions:

- *If P is completed or terminated with an error so P 'may or may not finish.*
- *If P is completed or terminated with an error so P 'may or may not finish.*

Every obfuscation process has a price which can be defined as follows:
The obfuscated program P′ is more complex than original program P.
For good obfuscation process is then essential to accomplish following conditions:

- To keep complexity of the obfuscated result to minimum,
- To keep semantics of the result untouched,
- To obfuscate the original program in most effective, thus most unreadable as possible. Unreadability in this case may be connected to destroy code formalization(minimalizing the javascript libraries for example), or in more complex ways to hide code original semantics by renaming variables, dividing or joining data structures or adding the instructions, which resets themselves in the final result.

Based on unreadability the obfuscation can be divided into basic families such as data flow obfuscation, control flow obfuscation, layout obfuscation and others [3][5][6][7][8].

III. Obfuscation Based On Code Integration

The idea of joining two code sequences by using the principles of obfuscation can be proven as efficient, when hiding the code signature. Most of the control flow or data flow obfuscation techniques principles lie in adding the new structures, functions, segments to the chosen code, which alternatively don't have impact on final result of the program, but effectively change the program signature. Idea presented in this paper aims to go one step further:
Joining two separate segments of the code from higher programming language in a way, when the signature of both of them is mixed and thus indistinguishable and the result perform actions from both input segments [6].
The main goal of this method should lie in joining two pieces of the code, when meeting some influential conditions:

- Result should be able to perform functionalities from both inputs,
- Both inputs should be joined as much effectively as possible by mixing up their data structures and the functional structures together,
- Result should not be over complex,
- Result should have changed the names of data structures from input based on the obfuscation principles (names of the variables should be random chosen).

Basic schema of the presented method is shown on Figure 1.

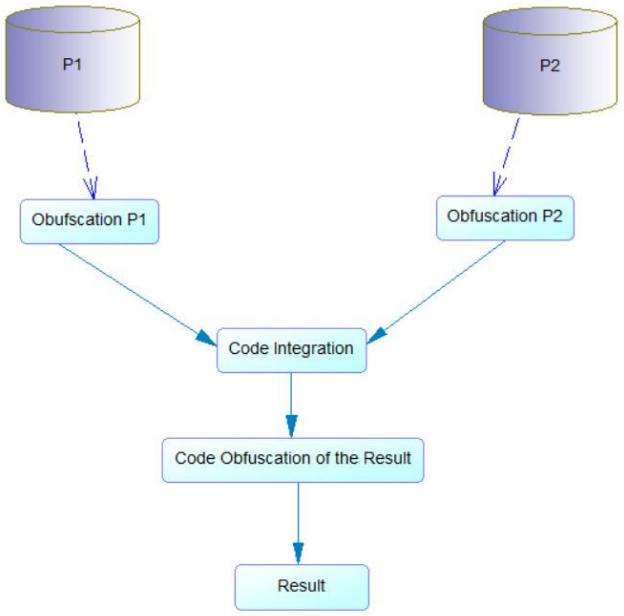

Figure 1 Basic Schema of Code Integration

Considered two given code sequences *P (B, ϕ, I, O)* and *P′ (B′, ϕ′, I′, O′)* where:

- B and B′ represent the union of code blocks in P (sequence, alternative, cycle),
- ϕ and ϕ′ represent the software specification aimed at software correctness,
- I and I′ represent input parameters,
- O and O′ represent output parameters.

Then P′′ (B′′, ϕ ′′, I′′, O′′) = In (P, P′) where ϕ ′′ = ϕ U ϕ′ ∧ I′′ = I′ U I′′ ∧ O′′ = O′ U O′′.

Given S_s (S, Cv, ϕ, Vi, Vo, Di, Dd, P) where:

- S represents shape of the code block (sequence, alternative, cycle),
- Cv represents union of control variables,
- ϕ represents software correctness,
- Vi represents input variables,
- Vo represents output variables,
- Di represents the degree of independence from other code blocks,
- Dd represents domain difference from the integrated part of the code sequence,
- P represents the order number of the code block.

Then the integration process can be defined as:
S′′ (S′′, Cv′′, ϕ′′, Vi′′, Vo′′, Di′′, Dd′′, P′′) = In (S, S′) where S′′ = S′ = S′′ ∧ Cv ′′ = Cv U Cv′ ∧ ϕ′′ = ϕ U ϕ′ ∧ Vi ′′ = Vi U Vi ′ ∧ Vo′′=" Vo U Vo′ ∧ Di′′ keeps Di ∧ Di ′ ∧ Dd′′ keeps Dd ∧ Dd′.
If P < P′ then P′′ = P else P′′ = P′.

IV. Basic Test Results Applied Against Antivirus Software

Testing the proposed obfuscation technique was performed as set of these steps:

- Choosing the appropriate malware samples written in higher programming language,
- Testing them against the virustotal.com, the analytic portal, which gives the opportunity to test chosen file against 60 different antivirus software solutions,
- Applying the proposed obfuscation technique by integrating the two malware samples,
- Testing the newly created hybrid against the virustotal.com.

Testing results are presented in Table 1.

File Name	Virus Total Score	Code Integration	Virustotal Score of New Hybrid
c_bootini.c	17/56	c_bootini.c-BullMoose.c	0/56
c_folder.c	12/56	c_folder.c - BullMoose.c	0/56
c2.c	8/55	c2.c - BullMoose.c	3/56
ps.c	10/57	ps.c - BullMoose.c	0/56

Table 1 Results of Testing the Obfuscated Malware Samples

V. Conclusion

As can be seen in presented results, the proposed method of obfuscation has been proven as efficient in terms of hiding the code signatures even by combining the two widely known malware samples and creating the hybrid with combined functionality and therefore can be successfully used as the tool for hiding even the widely known malware sample.

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The Overview of the Smart Grids Research

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***Abstract* – Main theme of this paper is to describe overview of smart grid in the world. Today's grids were designed to work in vertical structure from generation, transmission and distribution functions. On the other side, smart grids are going to operate in other way as horizontal system. Seller and buyer of electric energy will be more equal to each other. The first paragraph is introduction into this article, what the smart grids are. The second paragraph describes implementing and building of the smart grid. Next part is about situation of the smart grid around the world and situation in the Slovak republic. In the last part of this paper is the summary of smart grid projects and the view for further approach.**

***Keywords*—Smart grid, renewable energy source, smart grid projects, smart grid building.**

I. INTRODUCTION

Theme smart grid introduces new system of the communication between operator of the distribution grid and consumer of the distribution grid. Involving new technologies of the communications, metering, quality -check, remote plug or unplug or automatically reconfiguring grid for the prevention without blackout.

The topic of smart grids is currently receiving the forefront also in the energy sector. Not so long ago, customer did not have direct access to his own data of his electricity consumption and thus in this way could endeavour to reduce their consumption. The introduction of smart meters has also changed the strategy of distribution companies and greater orientation on the customer.

One of the advantages of the introduction smart metering is the fact that new grid includes two- way communication which is beneficial both for the customer as well as the service provider. This enables the customer to be not only consumers but also suppliers of electricity. Connected the two entities is a possibility of rebuilding the system to a state of self-sufficiency. All this, however, is still music of the future.

However, the topic of smart grid is the theme of this decade, it is still very clearly defined model and there are many different projects in this area in all around the world. This article describes the current state of the construction and operation of smart grids throughout the world. A research in intelligent networks is heading to make these new networks and these have become really smart in terms of prediction dangerous cases with a view to achieving maximum uptime.

II. IMPLEMENTATION OF THE SMART GRID

Smart electric grids are the key element in the strategy of the European Union in the field of energy. In recent years, smart grid projects are growing in numbers, size and spreading across the Europe as well. According to recent surveys is obvious that there are currently more than 200 smart grid projects scattered throughout Europe.

The total budget of projects that has began up to now and also already finished is over 5 billion €. It shows that the significant efforts have already been undertaken, but that we are just at the beginning of the Smart grid transition. The conservative estimates quantify Smart Grid investments by 2020 at 56 billion €.

Deployment projects cover the lion's share of investments commitments about 56% of the total budget while R&D and demonstration projects are small to medium size (about 4,4 million € for R&D projects and about 12 million € for demonstration projects), suggesting the need to invest in larger scale demonstration projects to gain a better knowledge of functioning and impacts of some innovative solutions and to validate results to a broader extent.

Smart grid projects are not uniformly distributed across Europe. Most of the projects and investments are located in countries with higher economic growth. The uneven distribution of projects and the different pace, at which the Smart Grid projects are being deployed across Europe, could make trade and cooperation across national borders more difficult and endanger the timely achievement of the EU energy policy goals. Increasing the number of projects highlights the trend towards a fruitful cooperation between different organizations, which brings together network operators, academia, research centres, manufacturers and IT companies. The implementation of Smart Grid is also a significant opportunity for European industry to research, market and export new technologies, to create new jobs and to maintain global technological leadership. Most Smart Grid benefits are systematic in nature as they arise from the combination of technological, regulatory economic and behavioural changes. In almost all countries a significant amount of investments has been devoted to projects, which address the integration of different Smart Grid technologies and applications. Most technologies are well-known, but the new challenge, that these projects are now confronting, is their integration.

Distribution system operator has the leading role in coordinating smart grid deployment across Europe. DSO leds about 27% of all projects and about 67% of investment. The current regulation in EU generally provides network operators with the incentive to improve cost efficiency by reducing operation costs rather than by upgrading grids towards a smarter system. The regulatory incentive model should be revised in order to accelerate the investments potential of

network operators and to encourage them to move to more service – based business model. Regulation should also ensure a fair sharing of costs and benefits in the set – up of service – based market platforms. Network operators are expected to sustain the majority of upfront investments whereas several players might get benefits when market platforms become operational.

Consumer awareness and participation is crucial for the success of smart grid projects. Most projects highlight the need to involve consumers at the early stages of project development, to give them the freedom to choose their level of involvement and to ensure data privacy and protection. It is imperative to ensure that they are trusting and understanding the whole smart grid process and receive clear tangible benefits. To different extents, consumers will be able to reap numerous potential benefits: energy savings, the reduction of outages, more transparent and frequent billing information, participation in the electricity market via aggregators, and a better business case for the purchase of electric vehicles, heat pumps and smart appliances.

An open and secure information and communication infrastructure is at the core of the successful implementation of the smart grid. Addressing interoperability, data privacy and security is a priority requirement for making the information and communication infrastructure truly open and secure reducing transaction costs among smart grid users. In actual running projects, we can highlight the convergence towards proven standards and best industry practices used for IT systems. However further coordinated effort in this fields needed to fully tap EU potential in this field and move to the deployment phase. Standardization developments are a movement into the right direction. New projects focused on data handling would be useful to assess how data handling principles from other industries could be applied to smart grids.

III. THE OVERVIEW OF THE SMART GRID PROJECTS

The smart grid landscape is highly dynamic and rapidly changing with emerging economies as major players in smart grid investments across the whole world.

European Union

A recent report by Pike Research forecasts that during the period from 2010 to 2020, cumulative European investments in Smart Grid technologies will reach 56,5 billion of euros, with transmission counting for 37 % of the total amount. The report also suggests that by 2020 almost 240 million smart meters will have been deployed in Europe [2].

According to the International Energy Agency (IEA), Europe requires investments of 1,5 trillion € over 2007-2030 to renew the electrical system from generation to transmission and distribution. This figure includes investments for smart grid implementation and for maintaining and expanding the current electricity system [3], [4].

United States

The full implementation of smart grids in United States will require investments between 338 and 476 billion dollars over the next 20 years. Costs allocated for transmission and substations are between 19 and 24 % of total costs, while costs allocated for distribution are between 69 and 71 % and costs for consumer systems are between 7 and 10 %. These costs are in addition to investments needed to maintain the existing system and meet electric load growth [5].

According to some reports there are about 1,5 trillion of dollars necessary to update the grid by 2030 of which 560 billion of dollars is needed for renew and replacement generating plants and 900 billion of dollars for transmission and distribution together [5].

At the end of 2010, the number of smart grid projects in the US will exceeded up to 130, spreaded across 44 states and two territories. According to few recent estimates, more than eight million smart meters have been deployed by United States electric utilities with 60 million expected to be in use by 2020 [6], [7].

China

The distribution grid in China is less mature than in other developed countries and the penetration of small-scale renewables is limited at the moment too. However, according to a report by innovation observatory, China is set to roll-out 360 million smart meters by 2030 and is investing heavily in more efficient distribution transformers [8].

In 2010, China granted smart grid stimulus investments of more than 7,3 billion dollars [10].

Presently, Chinese smart grid effort are focusing on the creation of a large capacity interconnected transmission backbone to transfer bulk power and accommodate fast growing electricity demand [10].

South Korea

South Korea plans to spend 24 billion dollars over the next two decades on smart grids to make electricity distribution more efficient, cut greenhouse gas emissions and save billions in energy imports [10].

State-run electricity monopoly Korea Electric Power Corp plans to install 500 000 smart meters in 2010 and about 750 000 in 2011 and complete roll-out by 2020 with a total of 24 million smart meters installed. The company is expected to cover all metering costs and retrieve them through power bills [12].

Australia

Australia invested 360 million dollars in stimulus funding for smart grids [9].

Australian utilities have a mandate for the installation of smart meters. Under the smart grid, smart city initiative the Australian government has committed 74,6 million of Australian dollars to develop in partnership with the energy sector, a smart grid demonstration project which will provide cost-benefit analysis of smart grid technology [13].

India

According to the ministry of power, India´s transmission and distribution losts are among the highest in the world. When nontechnical losses such as energy theft are included in the total, average losses are as high as 50%. The need to decrease losses and energy theft, together with the new trend towards increasing energy efficiency and the share of renewables in electricity and the share of renewables in electricity generation, are all important drivers for the development of a smarter grid [14].

Brazil

In 2010 Brazil invested 240 million dollars in stimulus funding for smart grids [9].

Brazil has announced massive smart meter roll-out projects and is planning to replace 63 million electricity meters with smart meters by 2021. As one of the first countries plans the nationwide smart metering and could also be an important testing ground for deployments in the rest of the world [9].

Japan

In 2010 Japan invested 849 million dollars in stimulus funding for smart grid. According to recent news, Japan is planning to increase renewable energy sources in its new energy plan and is considering the use of smart grids technologies in establishing a new energy system following the nuclear crisis of Fukushima [9], [15].

IV. SMART GRID AND THE POSITION OF THE SLOVAK REPUBLIC

The development of smart grids in Slovakia should be based on the real needs of the power system. Such highly expensive smart grid need investments for its building to be fairly divided among all electricity market participants. From the perspective of the distribution companies is the key element integration of green energy into the grid. Such a green energy displaces market flexible resources from the power system such as, steam power plants that are important for the provision of support services. In view of the preference production from renewable energy sources becomes the further usage of conventional sources uneconomical. This problem requires the comprehensive view which would provide a consistent and sustainable way to promote renewable energy.

Distribution system operators must flexibly adapt to smart technologies. Power grid need to prepare the capacities for connecting renewable energy sources and also the absorption of distributed generation at the consumer level. To the future, consideration should be given with full deployment of electric vehicles. To integrate electric vehicles into the power system analyses show that in recent years the greatest emphasis is placed on the charging and communications infrastructure. It is required to ensure the proper functioning of the infrastructure before running a complex application of smart grids. The power grid is becoming more decentralized and the power flows must operate in both ways, from the side of high voltage to the side of low voltage and a vice versa. Smart grids, in combination with smart metering, brings many benefits for consumers, suppliers and for network operators.

Slovakia had project *ENERGOZ*. This project is classified as a research and development project, which started in 2011. *ENERGOZ* is dedicated to applied research in the field of efficient production, storage and use of energy from renewable energy sources. Mostly it comes to maximizing the socio – economic impacts to research in renewable energy sources.

Slovak republic adopts a decree about intelligent metering systems. There are terms and dates when smart meters must be installed for consumers. The minimum level of consumption for installing intelligent meter is declared for 4 MWh per year. It means that more than 500 000 consumers in Slovakia will get new intelligent meter with both way communication and other functionalities.

V. CONCLUSION

The short overview of smart grid projects gives us opportunity to be knowledgeable in the field of future generation, distribution and consumption of electricity. There are many projects in the world with deployment and development of smart grids. The goal of my doctoral thesis is to gather information about actual situation and projects that are currently in progress. The finalization of gathered projects and their analysis for the future purpose is also one of the targets of my thesis. I would like to utilize all experience about smart grid, gained while studying projects, for modelling micro grids by means of simulating tools in matlab. I choose small village and implement the power grid to matlab, where I will simulate more states. It means power grid with renewable energy source and without them, energy storage and its impact on the power system, integration of electric vehicle to that small region. I would like describe the connection on smart metering projects, that are the best in discussions in local distribution system of operators in Slovak Republic. I will complete the results from matlab analysis and evaluate the pros and cons of smart grids implementation to the real network. I would like to eliminate all negative impacts while using new, modern and many times not tested technologies that must be deployed to the distribution grid.

I also agree with modernization of distribution grid, but in a smart way, it means to analyse and test all the devices that will be implemented to functioning process. Many companies offer devices that are just taken off from the production line and are not tuned up from different kinds of failures that can lower the efficiency and reliability of building smart grid.

The development of smart grids must be based on the real needs of the network. It is necessary to take into account a number of levels:

- physical network parameters – load and network capacity,
- user level – focusing on electricity consumption,
- the issue of distributed generation from renewables and other sources.

Smart grids optimizes the generation of electricity from fossil fuels due to the availability of energy produced and stored from the renewable energy sources. In terms of transmission and distribution of electricity the role of researchers is optimizing the supply of energy from producer to consumer with the highest reliability and lower losses. On the side of consumers, smart grid optimization ensures its behaviour with respect to the price of energy we consume, which is conditioned by the current demand and load of the network.

It is necessary to think about conditions where will be deployed various sources of renewable energy, production and storage of energy which will be connected with available power grid according to the needs of consumers who are represented by different areas of consumption, like: lighting, heating and technological equipment. In the future the smart grid will intelligently control heating and cooling of building with its technological equipment.

In my doctoral thesis I would like to check the operation of micro grid in extremely situation as the breakup of the grid is. Steady switching to the island operation and maintaining the power balance must be also integrated to that intelligent grid. Renewable energy sources and storage energy must be able to cover the small outages during the continuous operation. The internal logic of smart grid should analyse many states and maintain the power balance in the area, also maintain the frequency in required limits, and voltage regulation. All these requirements characterize the modern electric grid that is going to be in recent years. A conclusion section is not required. Although a conclusion may review the main points of the paper, do not replicate the abstract as the conclusion. A

conclusion might elaborate on the importance of the work or suggest applications and extensions.

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The combined approach for sentiment analysis

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***Abstract*—People create a lot of information on the internet every day. This information are very useful for other people, who can make a decision depending on this knowledge. If there is a huge amount of data it is difficult to process them manually, so good application for sentiment analysis is necessary. We proposed two approach, which can help with this problem. The first method is used in the pre-processing stage and it can make faster sentiment analysis based on dictionaries. The second approach combines a dictionary approach and a probability method. It creates training set for the probability method by using the dictionary approach. The final results show that combined approach can significantly outperform the standard dictionary approach.**

***Keywords*—dictionary approach, machine learning, Naive Bayes classifier, opinion classification**

I. Introduction

The sentiment analysis is part of the Natural Language Processing (NLP), which includes collecting and emotion analysis about a product, opinion analysis about political situation or classification of the reviews. These reviews can be collected form social networks, forums or blogs. The number of reviews significantly increased, in last few years. It is not problem to analyze them manually, if there is not a lot of data. When we have a lot of data, the sentiment automatic analysis is very useful. A sentiment expresses human feelings, emotions or opinions towards any object. The sentiment can be positive, neutral and negative.

We can use two main types of methods for sentiment analysis. The first type contains methods based on dictionaries. The second type uses methods based on machine learning. There are also hybrid methods, which combine both of previously mentioned approaches. The dictionary approaches use words called *opinion words*. These words contain information about desired states (positive words) or unwanted states (negative words). The dictionaries are often focused on words, which are able express sentiment the best way. The methods based on machine learning use machine learning algorithms for sentiment analysis. The most widely used methods are Naïve Bayes classifier (NBC), Maximum Entropy, Support Vector Machines (SVM) or k-Nearest Neighbors. The hybrid methods were introduced to solve disadvantages of previous approaches. In case, that we use the dictionary approaches, the big disadvantage is creation of the dictionary. If we want to create a new dictionary manually, it is time-consuming. Automatically generated dictionaries are often less accurate, than manually created ones. The disadvantage of machine learning approaches is a labeled dataset. It can be difficult to create the dataset in some domains.

We decided to create combined approach, which can use dictionary method and Naïve Bayes classifier. Dictionary method was used to label unlabeled comment in the dataset. Then we used NBC to classify comments, which were not labeled by the dictionary method.

II. Related works

Combined approaches are based on combination of two or more methods. Sindhwani and Melville [1] created combination of the unsupervised and semi-supervised learning. The Unsupervised method uses a dictionary of 2986 human labeled words. In the next step, their method merge sentiment analysis of documents with words based on a bipartite graph representation of the data. The method of the regularized least squares was used for classification. Their semi-supervised lexical models significantly outperform purely supervised and competing semi-supervised techniques. In work [2], the authors presented combined method for sentiment analysis in Facebook. They detected and classified the change of sentiment in social network Facebook.com. They created a new lexicon based on the Spanish framework Linguistic Inquiry and Word Count (LIWC)[1] and slang words using. The decision tree C4.5, NBC and SVM were used for classification. The classifiers achieved 83.17% accuracy for C4.5, 83.13% accuracy for NB classifier and 83.27% from SVM.

III. Our combined approach

The first and very important role in sentiment analysis is pre-processing. In this stage, the text is prepared for analysis. The text is split into the smaller groups. This process is called segmentation and tokenization. Then stop words can be removed. The Slovak language is language with rich morphology with many forms of each word. We decided to create our own stemmer to stem words with polarity[3]. This stemmer allowed to reduce size of dictionary and increased efficiency of classification using this dictionary. Our stemmer is based on removing prefixes and suffixes. All prefixes and suffixes were collected. After collection of all prefixes and suffixes, we removed the duplicated ones. Finally we collected 13 prefixes and 130 suffixes. All of them were used in our stemmer. The stemmer is based on rules and it is able to find a stem of the most frequent words. The prefixes are removed at the beginning. There are some cases, when the removing of prefix creates a new word with one or two letters. To avoid this case, the length of word is checked, in each rule.

[1]http://liwc.wpengine.com/

If word is too short, the prefix is not removed. In the next step, the algorithm removes sufixes. They are sorted from the longest to the shortest. The reason why we remove sufixes from the longest to the shortest is because shorter sufixes can be part of longer sufix. After sufix removing, the length of word is checked. In the last few steps, the algorithm removes superlative form of adjectives. Our stemmer was tested on dictionary, which contained 17872 words. There are 2473 nouns, 11293 adjectives and 4016 verbs.

TABLE I
THE ACCURACY OF STEMMING FOR EACH TYPE OF WORD.

Type of word	stemmed	not stemmed	all	accuracy (%)
nouns	2390	83	2473	96.64
adjectives	11137	156	11293	98.61
verbs	4011	95	4106	97.68

We achieved good results. They were caused by using mostly regular words. The sentiment words are often regular and we did not work with irregular words with no sentiment.

After pre-processing we can classify each comment. We proposed a combined approach for sentiment analysis [4]. This approach consists of two main steps. The first step uses a dictionary approach. The dictionary approach classified unlabeled comments in a dataset. Then a machine learning method was trained on comments labeled by dictionary approach and it was tested on the rest of the dataset.

A. Dictionary approach

At the first step, we used the dictionary approach. A new dictionary was created for this approach. The dictionary was translated to Slovak form its English version [5]. Each word in the dictionary had been assigned polarity and strength of polarity. We decided to use a range of polarity from -3 (the most negative) to +3 (the most positive). Our dictionary approach implements two additional functions: intensification and negation. Each intensifier has assigned a strength of polarity form 1.0 to 2.0. This type of intensification allowed us to assign higher intensity for words with high strength of polarity and lower intensity for words with the small strength of polarity. The second function is a negation. The algorithm uses two types of negation:

- switch negation - reverses of the polarity of the lexical item
- shift negation - shifts the polarity degree toward the opposite polarity by a fixed value

The approach described above achieved accuracy about 72%. The main disadvantage of this method is, that this version was not able to classify around 18% comments in the dataset.

B. Probability method

In order to classify comments which were not classified by the dictionary approach, we decided to machine learning approach. For this task the Naive Bayes classifier was used. It divided comments from dictionary into two groups. The first group, the training set, contained comments labeled by dictionary approach. The second group, the testing set, was created from comments, which could not be labeled by dictionary approach. After that, NBC was trained on the training set. Then it was tested on the testing dataset. The original dataset consisted of 5242 comments. 4191 comments were classified by dictionary approach and used to create the training set for NBC. The testing set contained 1051 comments. The achieved results for NBC are in the table II.

TABLE II
THE PRECISION AND RECALL OF THE NAIVE BAYES CLASSIFIER USED AS A PART OF THE COMBINED APPROACH.

	Precision (%)	Recall (%)
positive comments	29.31	61.69
negative comments	85.94	61,17

The combined approach achieved average precision 57.63% and average recall 61,43%. The results were influenced by a few reasons. The first reason could be inaccurate classification by the dictionary approach. The second cause could be the unbalanced training and testing dataset. The training dataset contained more positive comments and less negative comments. On the other hand, the testing dataset contained more negative comments and less positive comments.

In our next paper [6], we focused to solve some problems from previous combined approach. The same dictionary approach was used. We focused more on the creation of a training and testing dataset. In this method, the comments classified by the dictionary approach were divided into the positive and negative group. These two groups were sorted from the most positive/negative to the less positive/negative. Then they were compared to find which group contains fewer comments. A new joined dataset was created using all comments from the smaller group and the same number of samples from the bigger group. This method created the balanced training dataset. It contained 50% of positive and 50% of negative comments. This distribution was very important because, if we had more comments with one polarity, it could influence the results. After that, we trained NBC on this dataset. For testing, the whole dataset was used. This combined approach was tested on the same dataset than previous one. The results of comparison with the standard dictionary approach can be seen in table III.

TABLE III
THE PRECISION AND RECALL OF THE NAIVE BAYES CLASSIFIER USED AS A PART OF THE COMBINED APPROACH.

	F1(+)	F1(-)	Macro F1
dictionary approach	0.742	0.645	0.694
combined approach	0.872	0.863	0.868

The results show that the combined approach achieved better results than the standard dictionary approach. The combined approach was able to correct some comments, which were incorrectly classified by dictionary approach.

IV. FUTURE WORK

In our future work we want to try other machine learning approaches, which could be combined with the dictionary approach. There are another machine learning algorithms, which are widely used for sentiment analysis such as SVM or k-nearest neighbors. We want to focus our work on creation a universal, domain independent dictionary. This new lexicon can be used to domain adaptation in combination with combined approach. Manual creation of dictionary is

time-consuming. We will work on semi-automatic method. This method will use combination of human knowledge and machine learning algorithm to assign strength of polarity to each in the dictionary.

V. Conclusion

This paper describes two new approaches that are useful for sentiment analysis. The first approach is part of the pre-processing of the text. It makes the classification faster, in comparison with dictionary approach and more accurate. The second approach uses a combined method for sentiment analysis. It is useful in cases that the standard dictionary approach is not able to classify all comments, because they contain no sentiment words.

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Towards Cloud-based Facial Emotion Assessment for Affective Loop

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***Abstract*—The paper describes current goals of the field of affective computing concerning facial emotion recognition. Furthermore, in this paper two approaches of facial emotion assessment representations are described and presented as cloud-based solutions using the Microsoft Azure Emotion Assessment Software as a Service embedded in an application for lecturing. The conclusion of this paper informs about further development which is emphasized on precision and personalization during the assessment process.**

***Keywords*— emotions, emotion assessment, affective computing, affective loop, cloud computing, personalization, e-learning**

I. Introduction

In the last few years the facial emotion recognition phenomena appears in almost every field of research or business involving human communication or interaction. The usefulness of facial emotional information in evaluation processes is undoubtedly high due to the provision of additional information involved in the communication process or determination of human mental states. The field which studies processing of information exchange during the interaction between humans and machines and tries to simulate the natural perception of interaction for the machine is known as human-machine interaction (HMI). With the machine side of interaction is dealing the field of affective computing.

In [1] Rosalind Picard states the goals of affective computing. She also explains the importance of embedding emotion recognition systems into machines, presents possible analyzes drawn upon data from wide spectrum of disciplines, from neurobiology to folk psychology. Picard emphasizes the design and construction of computers which should have human-like capabilities of observation, interpretation and generation of affect features.

Although, affective computing is becoming a major field when it comes to interactive design development, there are only a few frameworks dealing with the problematic of affective interaction.

II. Summarization of Research Status

To have an approximate idea about emotions, we choose to go with the definition from the English language dictionary which states that emotions may refer to the affective aspect of consciousness, a state or feeling, or a conscious mental reaction towards an object accompanied by behavioral and or physical changes [2].

However, there are several constructs, originating in the field of affective neuroscience, from which emotions can be differentiated [3]. From these constructs the construct of affect appeared to be the most suitable for machine processing [4] due to its general meaning and best application potential in human-centered systems [5][6] while it is an encompassing term, used to describe the topics of emotion, feelings, and moods together, even though it is commonly used interchangeably with emotion.

During the last year, we have successfully incorporated the affect sensing in an interaction loop in educational environment where we investigated several approaches to the perception of emotions considering discrete emotional categories, dimensional representation of emotions and aggregation of multiple emotional values from multiple subjects.

III. Performed Experiments

A. Discrete emotion assessment during a lecture

The first experiment was about evaluation of the emotion assessment performance of the Microsoft Emotion API [7] and using it in an education scenario to evaluate the recognition speed in the cloud. The setup consisted of a web camera, situated in a small room where the lecture took place, which was connected to a laptop in a different room to not interfere the emotion expression of the students during the lecture. The video stream was acquired in real time and sent to the cloud at a fixed frequency (1 frame per 3 seconds).

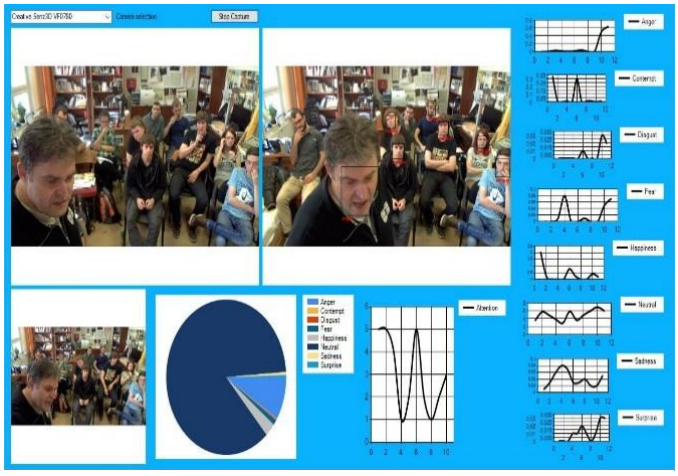

Fig. 1 Example of software interface for discrete emotion assessment during a lecture in a small class.

The resultant emotions where aggregated for each emotional label separately and also together. The results were visualized in line and pie charts in a graphical user interface as shown in Fig. 1, however it was not presented to the lecturer.

B. Cloud-based lecture emotion-based improvement service

The second experiment was also conducted in a lecturing environment [8]. This time the goal was to extract emotion polarities based on emotion aggregations and to approximately state arousal and valence values which were to resemble the circumplex model of affect [9]. For this experiment, we have defined three simple aggregation equations for emotional atmosphere polarity assessment [10]. We indicated polarity as follows:

$$\rho_t = \sum_{i=1}^{N}\left(\frac{\sum_{k=1}^{K} p_{ik}}{K}\right) - \sum_{j=1}^{M}\left(\frac{\sum_{j=1}^{K} n_{jk}}{K}\right),$$

where ρ_t is the immediate polarity coefficient, N represents the number of positive emotions, M represents the number of negative emotions, K is the number of recognized faces, p and n are the positive or negative emotion values where $n, p \in \langle -1,1 \rangle$.

However, if we have a number consecutive images i.e. a video stream, we are able to add a relation between two consecutive emotion polarity measurements. The existence of this relation is based on our assumption that the emotions slowly degrade back to a "neutral" state and that consecutive emotion measurements affect each other. Therefore, we proposed another two equations, which apply a linear scaling factor and adaptive engagement normalization for both arousal and valence coefficients:

$$\alpha_t = \gamma \alpha_{t-1} + \frac{2K - K_m}{K_m},$$

where α_t is the arousal coefficient where $\alpha_t \in \langle -1,1 \rangle$, γ is the engagement scaling factor which we set low ($\gamma = 0{,}05$) hence the engagement value decreases much quicker than the emotion polarity value, K is the same as in first equation the number of recognized faces, and K_m is the maximum number of faces measured.

For valence:

$$\beta_t = \omega \beta_{t-1} + \frac{2\rho_t - 3K_m(N+M)}{NK_m + MK_m},$$

where β_t is the arousal coefficient where $\beta_t \in \langle -1,1 \rangle$, ω is the polarity scaling factor ($\omega = 0{,}6$), ρ_t is the measured immediate polarity, N and M are the numbers of positive and negative emotions, K represents again the number of recognized faces, and K_m is the maximum number of faces measured.

For a real world experiment we decided to test the solution on a lecture with 45 students which took place at our university. We have created a setup consisting of a Kinect 2.0 sensor for image acquisition in FullHD resolution which was connected to a laptop that was streaming the visual data directly to our cloud service [12].

The experiment was successful and we gathered feed-back data to various actions during the lecture. In the Fig. 2 results from the lecture are shown and we can easily distinguish various sections of the lecture. We can identify four sections. Introduction – during this part the students were informed about the experiment and were requested to prepare for the upcoming short test. From 0 to 50 around 2.5 minutes. Test – students writing a test. From 50 to 530 around 25 minutes. Pause – students were allowed to leave the lecture room. From 530 to 740 around 10 minutes. Lecture – classic lecture. From 740 to 1750 around 50 minutes.

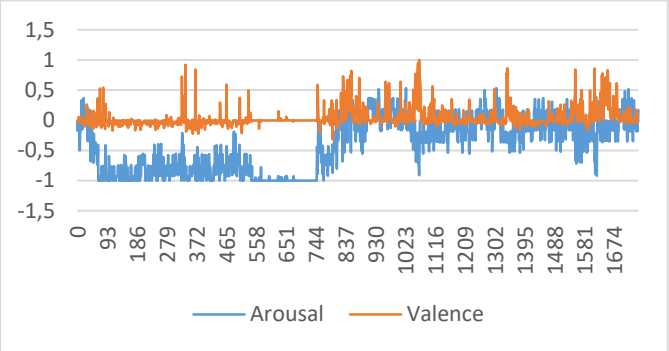

Fig. 2 Graph of emotional arousal and valence assessment during a lecture, where the horizontal axis holds the time factor measured in frames acquired every 3000 milliseconds.

IV. Conclusion and Future Work

In this paper we stated the issues of facial emotion assessment in affective computing we are trying to tackle, along with the need for a unified framework in this area. We described already performed experiments with an initial real-time cloud-based emotion assessment solution in the field of education where we tested the core of the two facial emotion assessment representations.

In our future work we want to investigate transitioning between existing emotional models in order to diminish information loss and to provide more precise emotional output during the facial emotion assessment, enhance the affective loop facial emotion assessment performance in various environments by personalization of emotional models.

Acknowledgment

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Using data mining methods with a focus on Parkinson's disease

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***Abstract*—This article in the introduction explains the area of medical data analysis for the purpose of early diagnosis as well as the basic characteristics of Parkinson´s disease. Then it describes the current state and method of collecting the data from people suffering from this disease in order to create classification models. The mPower mobile application is also mentioned in terms of authors sourcing the additional data from the individuals, capturing their memory activities, walking and tapping on the screen. The last section of the paper describes our previous results achieved in the speech data analysis of patients utilizing the programming language R. In conclusion, we describe the future direction of our work.**

***Keywords*—Parkinson´s disease, data mining, speech, handwriting, mPower**

I. Introduction

Modern hospitals are now equipped with various monitoring devices for collection of various types of data. This is relatively inexpensive way of collecting and storing the primary data, which is then used in the hospital information systems. The main goal of predictive data mining is to create models which can work with specific information about the patient and based on these information provide descriptive and/or predictive models that assist doctors in decision making [1]. Predictive methods are used in creation of decision models, such as prognosis, diagnosis and treatment plan. A typical medical procedure for diagnosis a patient's disease is tedious and time-consuming. First, the doctor needs to gather the necessary information and results of examination of the patient and, consequently provide decision (diagnosis or proper treatment procedure). Over time, the volume of these data is significant and the data mining methods can accelerate the process and also help the doctors decide in difficult situations.

Parkinson´s disease (PD) [2] is one of the most common chronic neurodegenerative diseases, which affects about 3.8 million patients worldwide. Comparing men and women, the disease currently occurs 3 times more often in men, which may be also related to the protective effects of estrogen in women [3]. Typical primary symptoms may be, for example, shaking hands, arms, legs, also the slowness of movement, muscle rigidity and problems with speech [4]. Currently, there is no appropriate method of treatment, which is capable to assist patients suffering from the disease completely. Drugs replacing the missing dopamine are partially helpful in relation to keeping the patients in good condition.

II. Current State

Since there is still no proper cure for PD, a number of researchers are currently focusing on the creation of decision-support systems, which may serve for early diagnosis of this disease. PD affects the proportion of the brain known as the substantia nigra, which controls the movement of the body. Unlike healthy people, patients with this disease are demonstrated by the disruption in the implementation of practical skills such as handwriting and speech. Therefore, many researchers attended to the collection of these data types from the patients.

In several publications [5] [6], P. Drotar et al. engaged in the handwriting of PD patients which were recorded on the tablet. They monitored the movement on the tablet surface, the movement over the surface in the air, and also, the pressure applied when writing. These types of data were exported to a range of indicators, which were then compared utilizing the data mining methods (e.g. SVM, AdaBoost, and KNN).

M. Little and A. Tsanas et al. [7] [8] worked with the data from Parkinson´s patients and recorded their speech signals using different indicators. These indicators were used subsequently to classify patients. Similar data were also collected by the authors O. Kursun and B. E. Sakar et al. [9], were they focused on different types of words in Turkish.

Mobile application mPower: Mobile PD Study [10] measures and tracks symptoms associated with PD, thanks to which authors managed to map a large number of healthy people as well as patients suffering from this disease. The application itself consists of demographic, UPDRS and psychological (PDQ-8) survey, along with the recording of memory, voice, movement and tapping activities of people.

III. Achieved Results

In the current research, we worked only with the data that are freely available on the UCI Machine Learning Repository and refer to patients' speech. We focused on two datasets, which were obtained by different authors and subjects [11]. Patients' speech was transformed in both datasets to parameters (attributes), which in most cases were the same and additionally derived [12] [13]. In the phase of the data understanding, we focused on tracking all the attributes individually checking their dependence to the target attribute, which has been expressed in binary form. It informed about whether the patient is suffering from PD (1) or not (0). For

this task, we used Welch´s two-sample t-test comparing the average values of individual attribute's distribution by grade of the target attribute. In this statistical test p-value is monitored principally. The lower the value, the more likely the target attribute according to the selected numeric attribute is. For comparison, at the first set of data, we achieved the lowest p-value (0.028) among the target attribute Status and attribute expressing the maximum vocal frequency. In the second dataset the highest dependence (p-value = 0.0000000609) was achieved to the target attribute in Jitter (local, absolute).

A. Creating models

For the first dataset which we have worked with, only the common speech patients' records were available. The models were created using Naïve Bayesian classifier and the method of decision trees (algorithms C4.5, C5.0, and CART), which are easy to interpret and understand by the doctors. The data split into the training and testing sets was carried out on a 70/30 and 80/20 basis, whereby the ratio of the target attribute values in both sets was retained from the original set of data (stratified data division). For each method and algorithm, we have developed 10 models and the resulting accuracy was calculated as the average of all accuracies achieved. The highest average accuracy of 87.46% was reached utilizing algorithm C4.5 (70/30), while the lowest average accuracy was achieved by Naïve Bayesian classifier. For the best method of decision tree algorithm C4.5, the results in the form of contingency table are presented in Table 1 below, which shows the comparison of the real values in the testing set with the predicted values using classification models [12].

TABLE I
CONTINGENCY TABLE

C4.5		**The real value**	
		0	**1**
Predicted value by the model	0	11	3
	1	4	41

In the second dataset, we already had available records of the subjects who pronounced the vowels A, U, O, numbers (1-10), 4 short sentences and 9 words. Our main goal was to determine which type of speech can be used to create classification models with the highest accuracy. In order to maintain the accuracy of the data split into the training and testing sets, 4 and 5-fold cross validation was used and the ratio of target attribute values was retained also. The modeling was implemented only using the method of the decision trees and algorithms C4.5, C5.0, CART, and RandomForest. From the accuracies obtained, we found that the model with the highest accuracy (71%) was achieved with the algorithm RandomForest and records, where subjects pronounced the numbers from 1 to 10. On the other hand, the worst results (50.63%) were received by models from the records with pronunciation of vowel U [13].

IV. CONCLUSION

Based on the results obtained from the data capturing patients' speech we can conclude that the classification is possible with the highest average accuracy at the level of 87.46%. In the publication [14] the highest accuracy of 76% was achieved using the same data utilizing the method of Support Vector Machine. In addition, the accuracies broken down by the type of speech may help to determine which words subjects should be pronouncing, when recording their speech in the future. Moreover, obtaining transformed attributes of patients' speech is quite simple. There are several tools available for this purpose, e.g. Praat Acoustic Analysis.

V. FUTURE WORK

In future work, we would like to focus on creating and comparing models employing different types of data which we received from the mPower Company. Then, based on the accuracies and other indicators, we want to focus on a particular type of the data and highlight the typical values of selected parameters or their cut-off points. Also, our aim is not only to determine whether the patient is suffering or not suffering from PD, but also what stage of the disease they are in (for example prediction UPDRS). The main objective is to develop and verify the decision-support system for the doctors in case of the primary diagnosis of people with PD.

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Virtual Reality Application in the Development of User Interfaces for a Smart Environment

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***Abstract*— The rapid advancements in the development of smart devices and communication technologies provide new possibilities in monitoring and controls of the environment where we live. These devices are continuously connected and embedded into the complex system of a smart environment. This paper deals with techniques of development, validation and verification of particular parts and whole entity of the smart environment using virtual reality from the user perspective.**

***Keywords*— virtual reality, smart environment, user interface, CAVE**

I. INTRODUCTION

Smart environment (SmE) and IoT phenomena are overlapping fields of interest nowadays [1]. Sensors, controllers and actuators are capable of significantly enhance and support human activities in physical space [2]. The user interface (UI) of SmE is inspired by natural ways of communication between people (speech, written text, gestures, pose) and an interaction with wearable devices. The UI of computational system of SmE is hidden from direct users view and provides more ways to perform particular task according to user's preferences. This approach of UI design is suitable to fulfil the needs of physically and mentally impaired people [3].

II. LIVING LABORATORIES

Emerging technologies require new approaches of development and testing to become usable in wide scope. *The Aware Home Research Initiative* at Georgia Tech is dedicated to exploration of services based in the home with a multidisciplinary approach. One of its research contributions is aimed at building a SmE, which is aware of user's activities and capable to support elderly people. In this way they are supposed to be able to live alone and be more independent on other family members [4].

MavHome project [5] launched at the University of Texas at Arlington is defined by four layers of hierarchical architecture (*decision, information, communication and physical*). It is aimed at perception and activity prediction. Information gathering is accomplished also through 3D simulator which is not aimed at UI development and simulation of near real-life experience from user's perspective.

Another initiative is called *House_n* and it is a Department of Architecture research group at MIT. It is aimed at new technologies in connection with dynamic and evolving places (in the scope of a home, a workplace and a city) that respond to the complexities of life. Home research area includes *The PlaceLab* - the real home environment equipped with hundreds of sensing components. These components provide innovative user interface applications to help people easily control this environment. Inhabitants live in the lab for varying lengths of time and have no contact with researchers. Collected data are analyzed off the site [6].

III. VIRTUAL ENVIRONMENT

Approach of living laboratories provides testing similar to real life situations occurring at home and it is suitable for collection of significant data for improvements. These improvements may require changes at several layers of SmE and rebuilding of interior, which could be expensive and time consuming. Several insufficiencies could be overcome by SmE virtualization without the loss of credibility in particular UI tests. There are two widely used techniques to deliver immersive and semi-immersive experience of virtual reality with satisfying predictions of desired results for SmE virtualization.

Head-mounted displays (HMD) are suitable devices to bring virtual environment to one user at a time. They are becoming highly portable and available for a price with a decreasing tendency. Most popular and available HMDs include *Oculus Rift*, *HTC Vive*, and *PlayStation VR*. Sensing of user's movement could be provided by cameras and motion capture systems. Recorded outputs have to be mapped to virtual objects representing human body parts.

CAVE automatic virtual environment is a room-sized space consisting of several projection walls. Despite the stereoscopic projection is adjusted according to one user's view, others could share the same virtual environment without additional cost on view change synchronization. The user can freely move in the space of a CAVE and experience his/her body in close interaction with virtual scene, mostly through contactless motion capture system.

IV. CAVE LIRKIS

For providing the experience similar to the living laboratory physical space, it is appropriate to virtualize SmE using the CAVE system. Requirements include the possibility of rapid prototyping and sharing a virtual scene with multiple people.

The CAVE of LIRKIS laboratory was used to fulfil the goal of this work.

Fig. 1- LIRKIS CAVE solution

The system includes 20 stereoscopic screens in a non-cubic layout, spatial sound and user's movement is captured using a markerless *Optitrack* system. The whole solution is shown in Fig. 1. The computational system is based on customized engine consisting of three parts:

- Control Center
- Java Console
- Video Renderer

Control Center is the core of the system and it is required to mediate the communication between other parts. *Java Console* is used for the remote control of the whole system and also provides opportunity to interact with currently loaded virtual environment. *Video Renderer* is responsible for 3D scene rendering and it is based on *OpenSG* toolkit.

Scene package includes textures, 3D models. Additional logic and interaction with enhanced peripheral devices is implemented using Ruby script, which is included in the package. Thus the system requires only changes on the level of the scene.

V. SmE User Interface Development

From the user's perspective we identified two most common ways of interaction with a SmE:

1. Natural user interface (NUI) in the meaning of hands-free interaction based on human body movements, speech and other activities captured using sensory network.
2. Monitoring and control through personal smart and wearable devices.

Therefore a modular framework (*Unified user interaction resolver*) had to be developed to the capable to provide opportunity to experiment with both types of interaction in cooperation. This component is designed to mediate interaction with the LIRKIS CAVE engine and also to the potential non-virtualized SmE and other clients through API. Conceptual model is shown in Fig. 2.

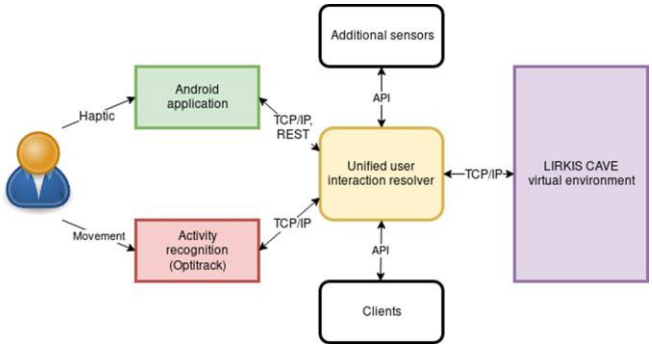

Fig. 2- User interface of SmE

Particular attention is aimed at activity recognition. In this stage we are also focused on the development of an Android application which will be used to assign, modify and remove recognized users moves to control particular devices, placed in the virtual scene of SmE.

Results will be shown to the user in the form of a rendered virtual environment with achievable credibility. Initial prototype is shown in Fig. 3.

Fig. 3- Virtualized SmE in CAVE LIRKIS

VI. Conclusion

This article introduces development stages of the system for SmE UI validation. Further effort will be dedicated to implementation of API for additional sensors e.g. electroencephalogram, sensors for galvanic skin response recording and others in cooperation with Institute of Neurobiology SAS in Košice and the Department of Biomedical Engineering and Measurement at Technical university of Košice.

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Virtual-reality system in distributed computer environment

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***Abstract*—This paper describe actual state of VR using in different area of life. Analysis shows medicine addition from application field, which is most widespread field. Deciding factor is not only low cost but also a beneficial aspect. Using of distributed computing system appears as the most effective solution due to rapid deployment of possibilities of the system. Given the availability of solutions and possibilities in LIRKIS laboratory its reasonable to use these resources for rehabilitation and possibly improve interaction in this environment.**

***Keywords*—CAVE, Handicapped people, Mixed reality, Rehabilitation, Virtual reality**

I. Introduction

Virtual reality (VR) systems still have more influence on our lives. There are many solutions and technological possibilities which includes VR in daily activities, entertainment, trainings, industrial improvements or rehabilitations.

Distributed systems have in this regard a significant advantage, which gives not only users but also scientists and developers to adapt the conditions for actual needed. That system allows a better perception of the environment thanks to better interaction and involvement of multiple senses. However the significant advantage is partially computing. This system creates conditions for better communication interface that allows you to view graphical information in our real world. This interface can also finds application in the field of education (the learning process), medicine (in operations), construction in the planning and design, in the military sphere (showing the position of the enemy soldier in perspective) as well as for advertising and presentation purposes.

Based on a study that predicts an increase in the availability and use of VR until 2018. Therefore is possible to considered this technology as suitable in finding new solutions [1].

II. Distributed computer environment and VR technologies

Currently, there are many tools supporting immersed VR approach and the one of the most fully immersive systems for virtual reality environments is the Cave Automatic Virtual Environment (CAVE) system. The most widely spread is in the shape of a cube. The walls of the cube serves as a display surface using rear projection. Usually, they used 5 or 4 walls of the cube [2], [3], [4]. For better viewing angles exist also cylindrical form (Fig. 1 - a). The advantage of curved surfaces is fewer passes and the problem with wrapping image [5]. Disadvantage is rear projection, which creates the impression of stretched picture and possible problems with binding of images from projectors. An example of a cave with a cylindrical shape is CAVE2[6] (Fig. 1 - b) or CAVE in our LIRKIS laboratory[7] (Fig. 1 - c).

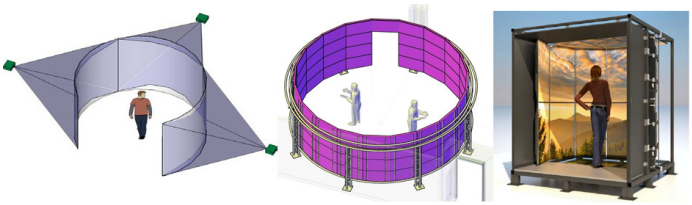

Fig. 1. Prototype of CAVE with curved surfaces (left)[5], prototype of CAVE2 (middle)[6] and prototype of CAVE in LIRKIS laboratory (right)[7]

One of the greatest challenges in the CAVE systems is the way of interaction. Currently it can be used two types of wands [5] or markers only[4] using optical sensors. To recognize the trajectories of hand gesture can be adopted e.g. Hidden markov model (HMM) [3].

Typically, tracking system can be optical (e.g. OptiTrack) or infra-red (e.g. Kinect)[8]. Optical sensors needs to have a set of markers for proper detection of movements and gestures, but infra-red not. Exist also combination of infra-red sensor using a markers giving better motion detection (e.g. finger tracking) [9].

The distributed computer system includes a data helmets to see the mixed reality. They are also called Head Mounted Displays (HMD) and allows to see virtual objects in real world. Examples include **nVisor ST-60** [10], which is a part of our laboratory equipment. The latest device of this type is **Microsoft HoloLens** [11] that (compared to nVisor-ST60) works by wireless, it is controlled by hand gestures and the entire computing system is in a helmet.

III. Application area of VR for rehabilitation

Due to various health problems, this area is relatively popular research topic. Virtual environment particularly affects the way of human body movement. Some research show, the standard movement for lifting the object from the ground is subtly different from the same movements in a virtual environment [12]. There are many approaches to the patient as to simplify and streamline the process of rehabilitation. According to [13] can be visual control their own movements to activate "mirror nervous system" **learn by imitating**. A similar research was also given to another study, which aimed

to apply the skills learned in the virtual environment to the real environment [14]. Brain computer interface (BCI) with neural headset can captured brain activity and cognitive information [15].

It should be noted that playing games (e.g. Grab The Life) can motivate patients to continue their rehabilitation activities [16]. Incurable **Parkinson's disease** shows improvement in the rehabilitation process by playing video games (directly for patients) through the Wii Balance Board (WBB) or Kinect [17].

For older people with total paralysis of half the body (hemiplegia) was created different kinds of robots to rehabilitation training of the lower limbs [18].

Early and intensive physical therapy can improve arm movement and hand in humans after a stroke. Method **Fitts Law** based on predictive modeling movement of the hand and the inclusion of 3D virtual environment can improve the standard of rehabilitation, which is normally only with the help of physiotherapists (Fig. 2). In this context has been created **NeuroR** AR-based system, where patients see themselves projected on the canvas as in a mirror. For sensing Kinect with markers detection in first version and without markers in new (actual) version [19].

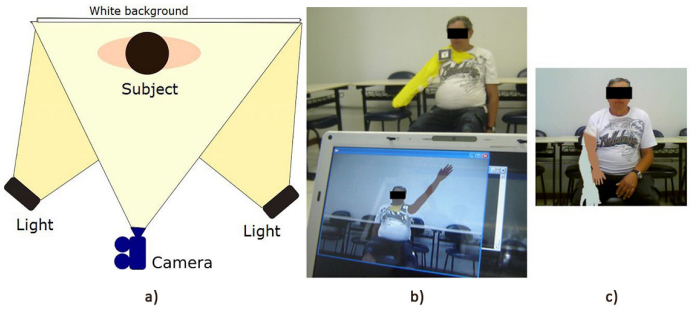

Fig. 2. a) Scheme of physical environment, b) patient uses the marker tracking system, c) patient without markers [19]

IV. Conclusion

This paper describes the current status of distributed VR systems and their use in everyday life, in particular the possibility of applying for medical purposes. The work shows the importance of the use of a distributed computing system for deploying the correct solution to the problem. Thanks to comprehensive technological possibilities of such system (e.g. CAVE) it can be customized to the current problem (e.g. after consultation with the a neurologist).

The VR system is essentially based on subsystems that are affected by or affect human senses, the natural use of the rights of the VR and its technology. Given the current software options, it is appropriate to include solutions and possibilities for interaction and editing scenes and subsequently implement mixed reality technologies. This direction is the subject of further research.

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Voice Analysis and Voice Recognition System

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***Abstract* – This article is dedicated to a brief introduction the human voice and its verification. The first part of this article is devoted to origin of speech, which is also explained how sound arises. We are also engaged by identifying the speaker and then also the problem of verification. And we will explain what you need to know for proper recognition of speech signals. In the second part of this article we will discuss either alone systems for comparing the voice and also we will specify the method currently used for voice analysis. In the end of this article it will be designed a possible improvement in the speaker verification based on voice, for example the possibility that faster speaker authentication or the speaker identity verification in view of his age or gender.**

***Keywords* – analysis model, identification, speaker, speech recognition, verification.**

I. INTRODUCTION

The voice is audible speech produced by the voice authorities. It is the acoustic basis of human speech and singing. Speech can be defined as a fundamental means of communication for people. We know that every human voice is different, yet it has got a similar common base in some of the speech-sounds (the speech-sounds represent vowels and consonants), which a particular person produces.

Except that human language has for us a certain value content, it hides in itself also the important acoustic information about a voice, because of which we can identify the speaker. There are many methods used for that purpose which we call biometrics [1].

Identification of the person, voice authentification or problem of identity verifying on the basis of some voice samples are among the problems, which people deal with in the past.

If we want to recognize a person by voice, we will analyze his speech signal and based on the specific features of a voice, decides his identity. It is this process deals with voice analysis.

II. ORIGIN OF SPEECH

Sound is any mechanical wave in the environment that is capable of eliciting in a human ears auditory sensation The frequency of the audible sound of man is in the range of about 20 Hz to 20 000 Hz and outside these limits man cannot perceive sound. In a broader sense it can be considered as sound also waves outside this range.

Sound with a frequency below this range are called infrasound. These frequencies have, for example, seismic waves during an earthquakes, storms or eruptions of volcanoes. Infrasound is very important for many animals.

On the other hand, the sound with a higher frequency than 20 000 Hz are called ultrasound. It is perceived, for example, by dolphins and that use it for orientation in space and for hunting.

The sounds, that we perceive not represent random phenomenon, but usually the speech, music or singing. Each of the forms of representation of the sound has specific attributes. In terms of voice analysis is interesting particularly speech, which acoustic foundation is exactly voice [2]. The range of human speech is between 500 Hz to 1600 Hz, while the range of the human voice is from 64 Hz to 2048 Hz. The basic tone of the human voice has yet only around 400 Hz, which may be changed according to the position of the tongue, teeth and lips.

III. SPEAKER IDENTIFICATION

Biometrics is used for identification or verification of persons, which is based on their unique physical or customary features. Biometric systems are used to uniquely identify the person. It is therefore a form of electronic key and the key is the human himself [3][4]. Biometrics therefore allows:

- identify the person whose identity is unknown,
- verify whether the person is actually identical with the person claims to be.

At present, a voice authentication use for example company Tatrabanka, what is the first private bank in Slovak Republic. Voice biometrics use also company Slovak Telekom, what is the largest provider of fixed telephony services, Internet and IPTV (digital TV on IP [internet protocol] platform) in Slovak Republic. It is a voice authentification without the need for data validation, only need a voice.

The advantage of biometric identification of persons is:

- versatility – biometric element, which have every person on earth,
- uniqueness – biometrics is such an element, which with absolute certainty distinguish one person from all others,
- stability – every person to such an element retains virtually all his life,
- safety – the biometric features of one person cannot be transferred to another person, as for example in the case of ID cards or passwords,
- practicality – there is not necessary to remember any IDs or passwords.

IV. Issue of Verification

It is the results of complex transformations taking place at different levels, on the semantic, linguistic, articulation and acoustic levels. Changes at these levels have a direct impact on the acoustic characteristics of the speech signal [5]. There are two kinds of variability in vocal speech.

The first type of variability represents the attributes that increases recognition ability among speakers. A key attribute to distinguish persons can be considered a different anatomical structure of the vocal tract, because its size and shape is fixed. Support attribute is a style of speaking individuals, their vocal speech, intonation, which the person eventually acquire. This attribute consider variable because time may change the style of narration, given by the environment or the culture in which the person is located.

The second form of variability are changes in the voice of a person, for example due to momentary emotional or health status of the speaker, but also changes in the speed of narration.

Proper verification of the speaker helps maximize the first form of variability and minimizing second form of variability.

V. Recognition of Speech Signal

Speech recognition systems can be divided into two groups, namely those which divide isolated spoken words, with a dictionary containing several tens to hundreds of words and those which classified collocations or whole phrases or sentences, working with hundreds or thousands of words [6].

Human speech is characteristic by acoustic structure, linguistic structure and subjective expression of personality speaker. The above-mentioned basic tone of the speaker is about 400 Hz, but excluding the basic tone also appears a reinforced upper range of tones, which are called formants. The basic tone is a zero formant f_0 and its changes we perceive as the melody of the speech signal. While spreading the speech signal there is a resonance in cavities of vocal tract and amplifications of some parts of the sound spectrum. For the Slovak language are the most important formant – a range of frequencies (of a complex sound) in which there is an absolute or relative maximum in the sound spectrum. The most important formants are formant f_1 and f_2, sometimes also occurs formant f_3, which shows the color of the voice [7]. For the smallest sound element of speech can be considered a speech-sound. Speech-sounds are divided into vowels and consonants. The frequency of these basic formants f_1 and f_2 is important for distinguish the individuals vowels and is shown in Figure 1.

u:	f_1 = 300 - 500 Hz	f_2 = 600 - 1000 Hz
o:	f_1 = 500 - 700 Hz	f_2 = 900 - 1200 Hz
a:	f_1 = 750 - 1100 Hz	f_2 = 1100 - 1500 Hz
e:	f_1 = 500 - 700 Hz	f_2 = 1500 - 2000 Hz
i:	f_1 = 300 - 500 Hz	f_2 = 2000 - 3000 Hz

Figure 1 – Frequency of fundamental formants f_1 and f_2

Unlike the vowels, consonants consist of noise, so in exhaled air this air flow strikes in the creation of consonants on an obstacle. Most consonants can be divided into couple of pairs, but some don't have a pair. Division of consonants is shown in Table 1.

Consonant		Hard	Soft	Duplicitous	
Pair	resonant	d, g, h	ď, dz, dž, ž	b, z, r	
	sharp	t, k, ch	ť, c, č, š	p, s, f	
Impair	resonant	n, l	ň, ľ, j	m, r	Ĺ, ŕ

Table 1 – Division of Slovak consonants

For the smallest unit of speech we can be considered a phoneme. Phoneme represents the smallest unit of a complex sound system of language. About the phoneme we can talk as a abstraction of second level, a lower level of abstraction is a speech-sound. Phonemes are combined into a sequence, where another building unit is syllable. Slovak linguist, prof. PhDr. Eugen Pauliny, DrSc. was expressed in 1979 about the syllable as a unit whose primary function is to create a contrast associated phoneme. In the Slovak language we can be understood one phoneme as one grapheme, and the grapheme represents the smallest graphic unit – a letter.

VI. System Based on Voice Comparison

Each system for voice recognition consists of two parts, the first part is coaching system and the second part is actual verification of the sound sample [8]. Most modern systems for voice recognition has a similar architecture as shown in Figure 2.

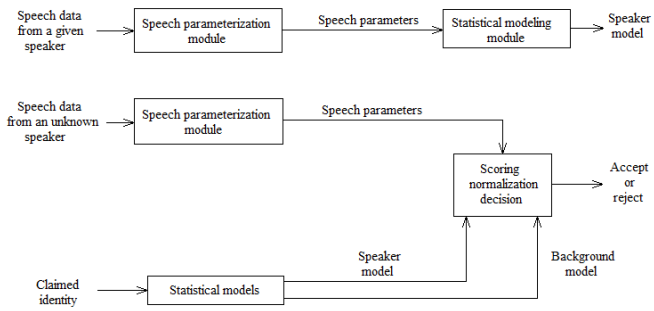

Figure 2 – Architecture of systems for speech recognition

In principle, voice recognition consists of three phases:

- obtaining acoustic observation of voice recording
- comparison of the characteristics with the database, in case of identification or with the model, in case of verification
- decision on the basis of the results of the previous phase

VII. Voice Analysis Methods

Currently used approaches to the analysis of acoustic signals are:

A. Spectral analysis

The role of this analysis is to analyze the frequency spectrum of the input sound signal. By using spectral analysis is obtained a set of frequency components from which the given signal is composed [9][10]. The spectral analysis include:

- *Discrete Fourier Transform (DFT)*
- *Fast Fourier Transform (FFT)*
- *Shifted Discrete Fourier Transform (SDFT)*
- *Discrete cosine transform*
- *Modified discrete cosine transform*

B. Cepstral analysis

Cepstral analysis is based on frequency analysis. Currently, the most widely used and highly computationally efficient method of frequency analysis is Fast Fourier Transform, which has computational complexity O(N log N).

Because the speech signal is variable in time, if we want to record a change in the spectral range, we have to analyse their segment of a length at which we can assume stationarity of the signal [11]. For choosing a segment we can choose one of the following approaches:

- *Pitch-synchronous segmentation* – segment length corresponds to over one period of voiced speech
- *Pitch-asynchronous segmentation* – segment length is fixed and independent of the base period of glottal tone, also equal to two to three periods

The first approach – pitch-synchronous segmentation is used only exceptionally, it is implementational and computationally demanding. And also in this kind of approach we lose information about basic tone [12]. For the second approach – pitch-asynchronous segmentation, the segment unresponsive signal period and therefore it is necessary to use a larger segment length. Figure 3 shows the real cepstrum segment of vibrant "a" obtained by pitch-asynchronous segmentation.

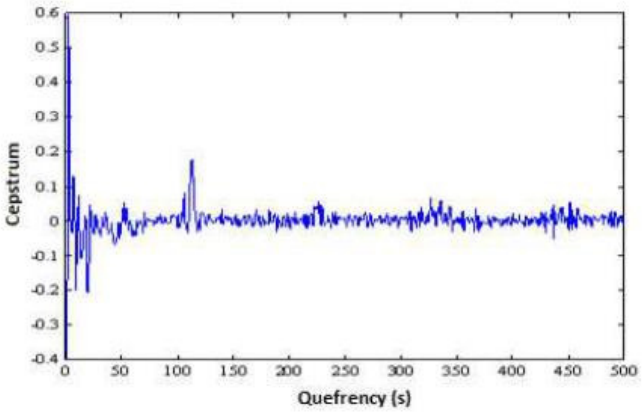

Figure 3 – The real cepstrum segment of vibrant "a"

C. Linear predictive analysis (LPA)

Calculating linear predictive coding method is currently probably one of the most used methods for speech signal processing. Although this method was known in the 70´s of the last century, it is still very popular and is used mainly in the field of speech processing. The advantage of this method is its relatively low computational complexity and also the possibility of a retrospective reconstruction while processing a signal.

The principle of linear prediction is based on the assumption, that the speech signal is composed of sections of fixed lengths and all of the following sections can be predicted by a linear combination of previous stacionary sections. While determining an estimation, there occurs a discrepancy from the true value, thus, it is obvious that in the estimate is only an approximation [13, 14]. Thus described assumption can be expressed in the following equation (1).

$$s(k) = \sum_{i=1}^{M} a_i \, s(k-i) \tag{1}$$

D. Fitler bank

Perception spectrum of human ear is not linear, because the human ear is more sensitive to higher frequencies, while the most sensitive is precisely the frequency with range 3 kHz to 4 kHz. Figure 5 shows the characteristic area of human perception of sound along with the threshold of hearing and the threshold of pain.

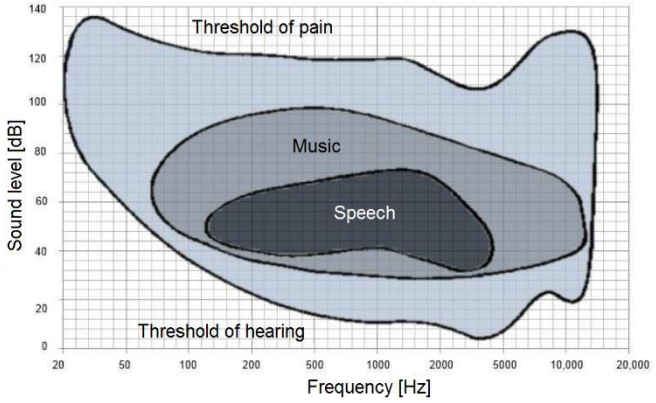

Figure 4 – Characterized range of perception acoustic sounds of the human ear

Signal processing method called filter bank have been compiled just for the sake of knowledge about perception of sounds by the human ear. Simplicity can be said that filter bank is a set of pass filters tuned to a certain frequency [15].

The sensitivity of the similar spectrum, such as the human ear has is solved by introducing a Mel-frequency scale, which causes non-linearity of the original linear scale. Figure 6 shown a filter bank sample with triangular pass filter uniformly distributed on the Mel-frequency scale. The shrtcut mel is derived from the English word melody and was first introduced in 1937 by Stevens, Volkman and Newman.

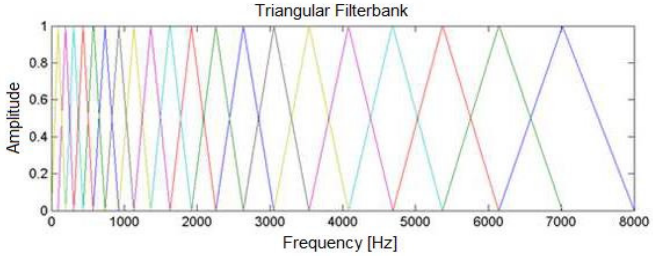

Figure 5 – Triangular filterbank on the Mel-frequency scale

E. Mel-frequency cepstral coefficients (MFCC)

This method is currently one of the most common used representations of speech signal. The issue of speech recognition is in addition to the above-mentioned method of linear predictive analysis used the method called Mel-frequency cepstral coefficitents.

The main feature of this method is to adjust the acoustic signal as it similarlyis perceived by the human ear. It highlights the lower frequencies of the signal. This method is in practice implemented by Mel-frequency scale, which original frequency disslinearized and highlights the characteristic frequency for the human ear [16].

F. Vector quantization

Quantization is the process of approximation analog value as one of a finite number of numeric values. In case that we carry out a quantization of associated block (vector) variables or parameters as a whole, we call such a vector quantization process [17]. This procedure include:

- *K-means algorithm* – one of the most popular classic and easy access cluster analysis [18]
- *Gaussian mixture models* – the model is described as a probabilistic model which assumes that the data belongs to the mixed probability distribution; the most common type of mixed probability distribution is Gaussian function of density, which all the components have Gaussian probability distribution [19][20]

VIII. POSSIBLE IMPROVEMENTS

As mentioned above, the primary purpose of my research is to analyze and then choose the most appropriate option for verifying the audio sample and its subsequent comparison in the database of audio samples, which we would like to achieve verification of the identity of the human. First, I will create an application that will contain voice samples of the speakers and their main characteristics such as age, gender, affiliation of ethnicity, highest level of education and so on. Also, the application should be able to compare and verify the speaker´s voice with already available samples and evaluate the results, thus, which speaker it is.

This solution may be a bit more difficult, because the systems for a speaker recognition decides his identity in two ways. The first way is that works with an open set of speakers. Then system can determine that the voice belongs to one of the speakers stored in the database, or does not belong to one of them, that is a foreign person. The second possibility is that the system will operate with a closed set of speakers, although the voice does not belong to either one of the speakers stored in the database, the system identifies the voice as a person with the most voice similarities.

The first variant of verification is acceptable for us, because it reduces the risk that the voice from the database will be assigned to a foreign person. This would prevent unauthorized access to the system.

Another possible improvement such an application can be a faster time to verify the speaker, when the system need only a few seconds to evaluate whether they are authorized persons or not.

I also would like to do a research on the possibility of verifying the person according to age. Detect the precise age of man only from his voice is quite difficult, but the ability to detect at least the approximate age of the person from voice could possibly give estimate. Then compared with information about the person to which is assigned the voice, whether such information is consistent.

Perhaps a more simple way to verify person based on age is verification based on speaker gender, because male and female voices are significantly different. While a woman´s voice is thinner and finer, a man´s voice is coarser, resulting in the thickening of a teenage age. Female voices are thus moving at higher frequencies that the male voices, so it should be fairly easy to determine whether the voice on the record is female or male voice.

The last possible improvements is the detection from the speaker record, whether it is a person with an education or an extension of what level of education goes. And this based on the words that the speaker elected and how to formulate phrases into sentences. In general, that expression of a person is proportional to its level of education. Thus, the higher education the person gets, the more his expression would be at a higher level compared with the expression of a person who has completed only primary education. However, also there are exceptions for example in which environment person grows or currently existing.

IX. CONCLUSION

In the future, based on the analysis can be improved voice authentification, for example speaker recognition based on his age, gender, affiliation of ethnicity and so on. Also can be improved verification speed of the speaker.

This analysis was a necessary step for my preparation for the dissertation work.

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