Електроника
Телекомуникације
Рачунарство
Аутоматика
Нуклеарна техника

# ЗБОРНИК АПСТРАКТА И ПРОГРАМ

## 63. КОНФЕРЕНЦИЈЕ ЕТРАН

Сребрно језеро
3 - 6. јун 2019. године

Београд, јун 2019.

## Поштовани учесници 63. конференције ЕТРАН-а и 6. конференције ИцЕТРАН

Друштво за ЕТРАН Србије као најважнији део своје активности организује годишње конференције које окупљају истраживаче из низа дисциплина које су срж процеса обухваћених именом *Industry 4.0*. Председништво и организациони одбор су изабрали као најповољнију понуду са Сребрног језера да буде домаћин који може да просторно подржи активност на којој учествује око 400 истраживача. Ове године је предвиђено да конференције трају три дана, што је краће од уобичајеног трајања од четири дана. Разлози за скраћење су тривијални: 1) учесници немају времена да проводе време на састанку па су практично све секције којима је понуђено да буду четвртог дана то енергично одбиле наводећи различите разлоге; 2) иако на основу информација које добијамо из медија и других извора економски процеси дају изванредне резултате, они се још нису осетили на прави начин у финансирању истраживача, па то директно смањује интерес за учествовањем на локалним конференцијама; и 3) млади истраживачи суочени са ситуацијом да само резултати који доносе поене према правилима које је донело Министарство губе интерес да саопштавају своје резултате на националним конференцијама.

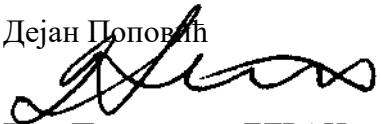
Овогодишњи ЕТРАН 2019 и ИцЕТРАН 2019 су привукли мањи број учесника у односу на претходне године. Смањио се и број иностраних учесника. Но, и даље су ове конференције вероватно највећи скупови у области електротехнике и рачунарства у нас.

За организацију састанака су ангажовани млађи кадрови и они су уложили велики напор да се методологија пријављивања, рецензија и свега осталог прилагоди данашњим технологијама. Увођење нових метода свакако није једноставан посао, посебно што се ни једна активност не плаћа у време у коме је новац једина мера. Глобално, уз безначајна трења је процес рецензија ове године укључио два рецензента на сваком раду, позивање истакнутих истраживача из света са којима учесници желе да развију сарадњу, искоришћене су многе од могућности платформе *Easychair*, и очекивање је да ће Зборник радова угледати светло на сајту Друштва у току јуна 2019. године. Зборник радова ће бити јавно доступан на сајту, па ће свако од аутора моћи једноставно да цитира свој рад позивајући са на интернет сајт друштва.

Пре неколико месеци Председништво је покренуло акцију формирања списка чланова Друштва. Ова акција треба да резултује базом података колико инжењера гравитира циљевима које негује Друштво. Резултат ће бити база података која ће да омогући једноставнију и потпуну комуникацију и видљивост. Надамо се да ће ова акција дати позитиван резултат.

На крају желим учесницима конференција на Сребрном језеру у периоду од 3. до 5. јуна 2019. добро дружење, упознавање са колегиницама и колегама, успешна излагања и нове идеје које ће водити размишљању „Сваког дана, у сваком погледу, све више напредујем“.

Дејан Поповић



Београд, 2019.

Ваш Председник ЕТРАН-а

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**ПОКРОВИТЕЉ**

Министарство просвете, науке и технолошког развоја републике Србије

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**ПОДРШКА**

IEEE – Institute of Electrical and Electronics Engineers, USA

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## Деск за регистрацију

**Деск за регистрацију се отвара у понедељак 3. јуна у 10 сати:**

**Радно време Деска:**

| | |
|---|---|
| **Понедељак, 3. јун 2019.** | **10:00 – 13:30 и 14:30 – 16:00** |
| **Уторак, 4. јун 2019.** | **10:00 – 13:30 и 14:30 – 16:00** |
| **Среда, 5. јун 2019.** | **10:00 – 13:30 и 14:30 – 16:00** |

## Колективни чланови ЕТРАН-а

1. Висока школа електротехнике и рачунарства струковних студија, Београд
2. Висока школа струковних студија за информационе и комуникационе технологије, Београд
3. Влатаком, Београд
4. Електронски факултет Универзитета у Нишу, Ниш
5. Електротехнички факултет Универзитета у Београду, Београд
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7. Електротехнички факултет, Универзитет у Источном Сарајеву
8. Електротехнички факултет, Универзитет Црне Горе, Подгорица
9. Факултет техничких наука у Чачку Универзитета Крагујевац. Чачак
10. Факултет техничких наука Универзитета у Новом Саду, Нови Сад
11. ИМТЕЛ Комуникације а.д, Београд
12. Иновациони центар Електротехничког факултета, Београд
13. Иновациони центар напредних технологија, Ниш
14. Институт Ирител а.д, Београд
15. Институт Михајло Пупин, Београд
16. Институт Никола Тесла, Београд
17. Институт техничких наука САНУ, Београд
18. РАТЕЛ, Београд
19. РТ-РК, Нови Сад
20. Саобраћајни факултет Универзитета у Београду, Београд
21. Технолошко металуршки факултет Универзитета у Београду, Београд
22. Универзитет Метрополитан, Београд
23. Универзитет Сингидунум, Београд
24. Факултет организационих наука Универзитета у Београду, Београд

Скраћенице:

| | IcETRAN | ETRAN |
|---|---|---|
| Електроника | ELI | EL |
| Телекомуникације | TEI | TE |
| Рачунарство | RTI | RT |
| Аутоматика | AUI | AU |
| Нуклеарна техника | NTI | NT |
| Акустика | AKI | AK |
| Антене и простирање | API | AP |
| Вештачка интелигенција | VII | VI |
| Електрична кола, електрични системи и обрада сигнала | EEI | EE |
| Електроенергетика | EKI | EK |
| Биомедицинска техника | BTI | BT |
| Метрологија | MLI | ML |
| Нови материјали | MOI | MO |
| Микроелектроника и оптоелектроника | MTI | MT |
| Микроталасна техника, технологије и системи | NMI | NM |
| Роботика и флексибилна аутоматизација | ROI | RO |

# Распоред дешавања на 63. Конференцији ЕТРАН

**Понедељак, 3. јун 2019 у 17:30 (сала 1)**
**СВЕЧАНО ОТВАРАЊЕ**
Проф. др Дејан Поповић: **Уводне напомене**

**Понедељак, 3. јун 2019 у 19:00 (сала 1)**

**Пленарна седница посвећена академику Рајку Томовићу**

Модератори:

Академик др Дејан Поповић, Универзитет у Београду, Србија,
Професор емеритус Срђан Станковић Универзитет у Београду, Србија
Професор Србијанка Турајлић Универзитет у Београду, Србија

**Понедељак, 3. јун 2019 у 20:00**
**Коктел добродошлице**

**Уторак, 4. јун 2019 у 11:15 (сала 1)**

**Пленарна седница: Нови материјали**

Модератори:

Дописни члан САНУ, Велимир Радмиловић, Београд, Србија
**Decoupling of Electrical and Thermal Properties in Nanostructured Materials**

Проф др Петар Ускоковић, Универзитет у Београду, (Србија)
**Synthesis and Supercapacitive performances of Electrospun Carbon Nanofibers Decorated with Spinel $Co_{1.5}Mn_{1.5}O_4$ Nanocrystals**

Проф. Владимир Срдић, Универзитет у Новом Саду, (Србија)
**Ultrafast Spin Dynamics in Multiferroic Oxides**

**Уторак, 4. јун 2019 у 19:00 (сала 1)**
**СКУПШТИНА ДРУШТВА ЗА ЕТРАН**

**Уторак, 4. јун 2019 у 20:00 „Ресторан Сидро“**
**СВЕЧАНА ВЕЧЕРА**

**Среда, 5. јун 2019 у 9:00**

**Пленарна седница: Центри изврсности**

Модератори:

Дописни члан САНУ, Бранислав Јеленковић, Београд, Србија
**Центар изузетних вредности: Центар за фотонику**

Професор Ђорђе Јанаћковић, Универзитет у Београду, (Србија)
**Центар изузетних вредности: Центар за нанотехнологије и функционалне материјале**

Научни саветник Бранко Матовић, Универзитет у Београду, (Србија)
**Центар изузетних вредности: Центар за вишефункционалне материјале**

**Среда, 5. јун 2019 у 16:30**

**НЕФОРМАЛНО ЗАТВАРАЊЕ КОНФЕРЕНЦИЈА ЕТРАН 2019 И ИЦЕТРАН 2019**

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**Изложба књига предузећа Академска мисао**

**(у току конференција)**

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Electronics
Telecommunication
Computers
Automations
Nuclear Technique

# Program and Abstracts

6th International Conference on Electrical, Electronic and Computing Engineering

**IcETRAN 2019**

In conjunction with the 63rd annual meeting of ETRAN Society

Silver Lake, Serbia
June 3 - 6, 2019

Belgrade, June 2019

## Dear participants of the 63rd ETRAN and 6th IcETRAN conferences

The Society for ETRAN of Serbia, as the most crucial part of its activity, organizes annual conferences that bring together researchers from a range of disciplines that are at the heart of the *Industry 4.0*. The Presidency and the Organizing board selected as the best offer to host the meeting the one from the Silver Lake. This year the conferences will last for three days, which is shorter than the usual duration of four days. The reasons for the shortening are trivial: 1) participants do not have time to spend time at the meeting, so practically all the sections offered to be on the fourth day were rejected; 2) although on the basis of the information obtained from the media and other sources, the economic processes in Serbia yield excellent results, they have not yet felt the right way to fund researchers, which directly reduces interest in participating in local conferences; and 3) young researchers are confronted with the situation that only results that defined by the Ministry of Science are of importance for their future jobs and funding lose interest in communicating their findings at national conferences.

This year's ETRAN 2019 and IcETRAN 2019 attracted fewer participants than in previous years. The number of foreign participants has also decreased. However, these conferences are still the largest gatherings in the field of electrical engineering and computing in Serbia.

Younger people, compared to previous years have been hired to organize meetings. They have made great efforts to adapt the methodology of reporting, reviews, and everything else to the current technologies. The introduction of new methods is certainly not a simple business, especially since none of the organizational activities is paid. Globally, with insignificant friction, the review process this year included two reviewers for each submitted paper, inviting prominent researchers from around the world with whom participants want to develop co-operation, many of the features of the Easychair platform have been exploited, and the expectation is that Proceedings of papers will see the sun on the site of the ETRAN Society in June 2019. The Proceedings will be publicly available on the site, so each author will be able to cite her/his work by pointing to the Society's website.

A few months ago, the Presidency initiated the formation of a list of members of the Society. This action should result in a database of how many engineers gravitate to the goals that the Society nourishes. The result will be a database that will allow for more straightforward and more complete communication and visibility. We hope that this action will have positive impact on the future of the ETRAN.

At the end, I would like wish to the participants of the ETRAN 2019 and IcETRAN 2019 on Silver Lake in the period from June 3 to 5, 2019, pleasant socializing, meeting with colleagues and successful presentations and new ideas that will lead to thinking "Every day, in every way, I'm progressing more and more."

Dejan Popović

Belgrade, 2019

**IcETRAN – International Conference on Electrical, Electronic and Computing Engineering**
Kneza Miloša 9/IV, 11000 Belgrade, Serbia

Phone: +381 11 3233 957, E-mail: office@etran.rs, https://www.etran.rs

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**Organizers**

ETRAN Society, Belgrade

Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, Serbia

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**Under the auspices of**

Ministry of Education, Science and Technological Development of the Republic of Serbia

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**With the support of**

IEEE – Institute of Electrical and Electronics Engineers, USA

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## Support to promotion of the awarded papers

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*Faculty of Technical Sciences, Čačak (Serbia)*

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## Program and Technical support

Mirjana Jovanić, *ETRAN*
Zlatko Jarnević, *ETRAN*

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## Program and Technical support

Marko Vujadinović, *Academic Mind, Belgrade*
Aleksandar Rašković, *Academic mind, Belgrade*
Boban Milijić, *Academic mind, Belgrade*

## Conference Desk

| **The registration desk of the IcETRAN conference will operate:** | |
|---|---|
| **Monday, June 3, 2019,** | **10:00 – 13:30 & 14:30 – 16:00** |
| **Tuesday, June 4, 2019,** | **10:00 – 13:30 & 14:30 – 16:00** |
| **Wednesday, June 5, 2019,** | **10:00 – 13:30 & 14:30 – 16:00** |

## Corporate members of ETRAN Society

1. College of vocational studies of Electrical Engineering and Computers, Belgrade
2. Faculty of Technical Sciences Čačak, University of Kragujevac (FTS Čačak)
3. ICT College of vocational studies, Belgrade
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21. University of Niš, Faculty of Electronic Engineering (FEE Niš)
22. University of Novi Sad, Faculty of Technical Sciences (FTS Novi Sad)
23. University of Podgorica, Faculty of Electrical Engineering (FEE Podgorica), Montenegro
24. Vlatakom Innovation Centre, Belgrade

| Acronyms | International | National |
|---|---|---|
| Electronics | ELI | EL |
| Telecommunications | TEI | TE |
| Computing and information engineering | RTI | RT |
| Automation | AUI | AU |
| Nuclear engineering and technology | NTI | NT |
| Acoustics | AKI | AK |
| Antennas and propagation | API | AP |
| Artificial intelligence | VII | VI |
| Power engineering | EEI | EE |
| Electric circuits and systems and signal processing | EKI | EK |
| Biomedical engineering | BTI | BT |
| Metrology | MLI | ML |
| Microelectronics and optoelectronics | MOI | MO |
| Microwave technique, technologies and systems | MTI | MT |
| New materials in electrical and electronic engineering | NMI | NM |
| Robotics and flexible automation | ROI | RO |

# IcETRAN Events Program

**Monday, June 3, 17:30 (room 1)**

**CONFERENCE OPENING**

Prof. Dr Dejan B. Popović: **Opening remarks**

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**Monday, June 3, 19:00 (room 1)**

**Special Session dedicated to academician Rajko Tomović**

**Moderators: academician SASA Dejan Popović,**
**professor emeritus Srđan Stanković and prof. Srbijanka Turajlić**

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**Monday, June 3, 20:00**
**Welcome coctail**

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**Tuesday, June 4, 11:15 (room 1)**

**Special Session: New Materials**

Moderators: corresponding member SASA Velimir Radmilović,
**Decoupling of Electrical and Thermal Properties in Nanostructured Materials**

Prof. Vladimir Srdić
**Ultrafast Spin Dynamics in Multiferroic Oxides**

Prof. Petar Uskoković
**Synthesis and Supercapacitive performances of Electrospun Carbon Nanofibers Decorated with Spinel $Co_{1.5}Mn_{1.5}O_4$ Nanocrystals**

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**Tuesday, June 4, 19:00**
**GENERAL ASSEMBLY OF THE ETRAN SOCIETY**

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**Tuesday, June 4, 20:00, Restaurant "Sidro"**
**GALA DINER**

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**Wednesday, June 5, 9:00**

**Special Session: Centers of Excellence**
**Moderators:**

Corresponding Member SASA Branislav Jelenković,
**Center of Excellence: Photonics Center at the Institute of Physics**

Prof. Đorđe Janaćković
**Centre of Research Excellence: Nanotechnology and Functional Materials Centre**

Dr Branko Matović
**Center of Excellence: Multifunctional Materials Centre at the "Vinča" Institute for Nuclear Sciences**

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**Wednesday, June 5, 16:30**
**CONFERENCE CLOSING**

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MONDAY, JUNE, 3RD, 11:15 – 13:30, HALL 1 89

### SESSION TEI2: TELECOMMUNICATIONS 91

MONDAY, JUNE, 3RD, 14:30 – 16:30, HALL 1 91

## ARTIFICIAL INTELLIGENCE/ VEŠTAČKA INTELIGENCIJA (VI) 93

### SESSION: VII1 + VI1: ARTIFICIAL INTELLIGENCE SYSTEMS AND DESIGNS 93

SREDA/WEDNESDAY, JUNE, 5TH: 14.30-16.30, SALA3/HALL3 93

# Acoustics/
# Akustika (AK)

## SESSION/SESIJA AKI1: SOUND DETECTION, SOUND PROPAGATION, NOISE CONTROL

Wednesday/Sreda, June, 05th, 11:15 – 13:30, Sala 5/Hall 5

**Chair: Romain Serizel, Université de Lorraine, CNRS, Inria, LORIA, Nancy, France**
**Dragana Šumarac Pavlović, School of Electrical Engineering, University of Belgrade, Serbia**

AKI1.1

SOUND EVENT DETECTION FROM PARTIALLY ANNOTATED DATA: TRENDS AND CHALLENGES (INVITED PAPER)

*Romain Serizel, Université de Lorraine, CNRS, Inria, LORIA, Nancy, France*
*Nicolas Turpault, Université de Lorraine, CNRS, Inria, LORIA, Nancy, France*

This paper proposes an overview of the latest advances and challenges in sound event detection and classification with systems trained on partially annotated data. The paper focuses on the scientific aspects highlighted by the task 4 of DCASE 2018 challenge: large-scale weakly labeled semi-supervised sound event detection in domestic environments. Given a small training set composed of weakly labeled audio clips (without timestamps) and a larger training set composed of unlabeled audio clips, the target of the task is to provide not only the event class but also the event time boundaries given that multiple events can be present in an audio clip. This paper proposes a detailed analysis of the impact of the time segmentation, the event classification and the methods used to exploit unlabeled data on the final performance of sound event detection systems.

AKI1.2

VISUALIZATION AND OPTIMIZATION OF FEATURES IN CLASSIFICATION OF MOTOR SOUND

*Ana Đorđević, Faculty of Electronic Engineering in Niš, University of Niš, Serbia*
*Dejan Ćirić, Faculty of Electronic Engineering in Niš, University of Niš, Serbia*
*Marko Ličanin, Faculty of Occupational Safety, University of Niš, Serbia*

Sound waves conduct a lot of important information about sound sources and environment, from individual physical events to sound scenes as a whole. Hitherto, in sound analysis and processing, two or three dimensional plots have been sufficient to correctly represent needed information, e.g. frequency response plot or spectrogram plot. With emerging machine and deep learning technologies, choosing the right technique for visualization of multidimensional matrices is of great significance for abstracting out the right information, understanding and interpreting the results clearly and easily. In this paper, various options for representation of acoustic features are analyzed in order to improve machine learning model for classification. This analysis is based on audio signals (sounds) of DC motors. Various types of visualizations have been used in order to optimize feature vector for classification.

AKI1.3

## ANALYSIS OF DC MOTOR SOUNDS USING WAVELET-BASED FEATURES

*Đorđe Damnjanović, Faculty of Technical Sciences Čačak, University of Kragujevac, Serbia*
*Dejan Ćirić, Faculty of Electronic Engineering in Niš, University of Niš, Serbia*
*Zoran Perić, Faculty of Electronic Engineering in Niš, University of Niš, Serbia*

Widespread usage of wavelets in signal processing nowadays confirms effectiveness of this method for different applications such as de-noising of audio signals. The wavelet method can be considered to be either the Fourier transform replacement or its complement and it is able to overcome some important disadvantages of Fourier transform. The wavelet transform typically provides the detail and approximation coefficients as results. They can be used for further processing, as it is the case in de-noising, but these coefficients can be used for some other applications, too. This paper presents the application of wavelet decomposition into detail and approximation coefficients as features of audio signals for their classification. Sounds of direct current (DC) motors with and without fault in both directions of rotation are recorded and used as test audio signals. The effects of wavelet parameters such as wavelet function and decomposition level on the features distinction is investigated. Time and frequency analysis is also done for the tested DC motors.

AKI1.4

## THE NUMERICAL STUDY OF ATMOSPHERIC ATTENUATION OF OUTDOOR SOUND PROPAGATION

*Milan Mišković, Military Technical Institute, Belgrade, Serbia and School of Electrical Engineering, University of Belgrade, Serbia*
*Miomir Mijić, School of Electrical Engineering, University of Belgrade, Serbia*
*Miljko Erić, School of Electrical Engineering, University of Belgrade, Serbia*

It is well known that atmospheric attenuation of outdoor sound propagation dominantly depends on meteorological conditions - ambient atmospheric parameters such as temperature, pressure, humidity, etc. The atmospheric attenuation is a function of frequency and propagation distance. In engineering practice as well as in theoretical and applied researches, numerical modeling of atmospheric attenuation of outdoor sound propagation is needed. So, such numerical study is a subject of this paper. Some results of numerical modeling of atmospheric attenuation are presented which quantitatively illustrate the influence of different meteorological parameters on atmospheric attenuation. In order to share their effort with readers, the authors attached MATLAB code for numerical modeling of atmospheric attenuation of sound during propagation outdoors in appendix.

AKI1.5

## USAGE OF AVERAGING IN GENERATION OF ROOM ENERGY DECAY CURVE

*Miljan Miletić, College of Applied Technical and Technological Sciences, Kruševac, Serbia*
*Dejan Ćirić, Faculty of Electronic Engineering in Niš, University of Niš, Serbia*
*Marko Janković, Faculty of Electronic Engineering in Niš, University of Niš, Serbia*

Acoustical quality of rooms is typically estimated by measuring a set of room impulse responses (RIRs) and extracting acoustical parameters from them including reverberation time and early decay time. These parameters are commonly determined by the backward integration of a squared RIR also known as Schroeder integration. In this way, a curve called backward integrated impulse response or energy decay curve (EDC) is obtained. After introduction of the Schroeder integration several decades ago, it has become a predominant method for EDC generation. One of the main reasons lies in the fact that the Schroeder integration considerably reduces the curve fluctuations providing smooth EDC. However, a weak point of this integration is cumulative summing of background noise. As a consequence, the late part of noisy EDC is bent upward. In this paper, an alternative method for generating smooth room EDC based on averaging of an RIR

is analysed. The averaging is also able to reduce the curve fluctuations. Besides, the cumulative summing is not a problem in this case. The target is to generate the EDC that deviates from the reference one (noiseless EDC) as little as possible. The effects of changing the number of points used for averaging are investigated.

AKI1.6

NOISE CONTROL SOLUTION OF THE HVAC SYSTEM

*Marko Ličanin, Faculty of Occupational Safety, University of Niš, Serbia*
*Darko Mihajlov, Faculty of Occupational Safety, University of Niš, Serbia*
*Miomir Praščević, Faculty of Occupational Safety, University of Niš, Serbia*
*Ana Đorđević, Faculty of Electronic Engineering in Niš, University of Niš, Serbia*

Building construction trends in designing the modern buildings very often exploits the use of the centralized HVAC units to maintain optimal water and air condition. These systems needs fair amount of space and requires significant airflow to operate properly. Being often placed at the open areas, where airflow is sufficient, they create the high noise levels that influence the living environment. This becomes a challenge for the noise control engineers to find the proper solutions for attenuating the generated noise, without enclosing the space around HVAC units. To account for the necessary airflow while still perform noise reduction, here, a simulation of the particular type of segmented barrier is done. Results of the simulation are, together with a noise measurements, then applied on the real case scenario of the HVAC units noise control. Results showed that the simulated barrier can be used as solution for this type of problems.

## SESSION/SESIJA AK1: GRAĐEVINSKA AKUSTIKA, AKVIZICIJA ZVUKA, PREPOZNAVANJE ZVUKA, AKUSTIČKI PRENOS PODATAKA, AKUSTIKA PROSTORIJA

Wednesday/Sreda, June, 05th, 14:30 – 16:30, Sala 5/Hall 5

**Chair: Miomir Mijić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija**
**Iva Salom, Institut Mihajlo Pupin, Univerzitet u Beogradu, Srbija**

AK1.1

ODREĐIVANJE ZAVISNOSTI OSTVARENE VREDNOSTI IZOLACIONE MOĆI FASADNIH PREGRADA OD TIPA IZVORA U URBANIM SREDINAMA

*Miodrag Stanojević, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Miloš Bjelić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Dragana Šumarac Pavlović, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Miomir Mijić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Tatjana Miljković, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

Oblik ugaone raspodele incidentne energije utiče na ostvarenu vrednost izolacione moći fasadne pregrade. U opštem slučaju oblik ove raspodele nije poznat. Primenom mikrofonskog niza i algoritama za prostorno-vremensku obradu signala moguće je eksperimentalno utvrditi funkciju gustine verovatnoće ugaone raspodele incidentne energije na fasadi zgrada. U urbanim uslovima postoji veliki broj izvora različitog tipa, spektralnog sadržaja buke koju emituje, snage itd. Zbog toga je uvedena pretpostavka da oblik ugaone raspodele, a samim tim i ostvarena izolaciona moć pregrade, zavisi od tipa izvora buke. U ovom radu prikazana je upotreba metodologije za eksperimentalno određivanje ugaone raspodele sa ciljem da se posmatraju razlike u ostvarenim vrednostima izolacione moći iste pregrade prilikom delovanja različitih tipova zvučnih izvora u urbanim uslovima. Ostvarena izolaciona moć izračunata je korišćenjem dobijenih funkcija gustine raspodele i pokazano je da se ona menja u vremenu i zavisi od trenutne strukture zvučnog polja. Takođe, izvršeno je poređenje ostvarenih vrednosti izolacione moći izračunatih za

pojedinačne događaje i izolacione moći izračunate za duži vremenski period. Na taj način moguće je sagledati uticaje pojedinih tipova izvora na generalno stanje zvučne izolacije fasada.

AK1.2

## UTICAJ „TIŠINE“ NA ZVUČNI KOMFOR

*Miomir Mijić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Dragana Šumarac Pavlović, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Miloš Bjelić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Tatjana Miljković, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

U novije građenim zgradama, stambenim i poslovnim, sve su češće pritužbe na nedostatak privatnosti govora kao bitnog elementa zvučnog komfora. Jedini numerički pokazatelj koji se danas koristi kao indikator stanja je građevinska izolaciona moć pregrada između prostorija na osnovu koje se izvodi zaključak o postignutom akustičkom komforu. Međutim, iskustva iz prakse pokazuju da se pri istim vrednostima izolacione moći u zgradama mogu zateći različita stanja privatnosti. Zbog toga se u radu razmatra mogućnost primene kompleksnijih numeričkih pokazatelja privatnosti koji integrišu stanje izolacije i ambijentalne buke u prostorijama, i koji su zbog toga bolje korelisani sa mogućnošću, odnosn nemogućnošću registrovanja govora iz okruženja. Na osnovu toga se predlaže dopuna forme standardnih izveštaja o merenju zvučne izolacije u zgradama podatkom kojim bi se na jednostavan način, uz standardne pokazatelje izolacije, pružile dodatne informacije o očekivanom stanju privatnosti govora.

AK1.3

## PLATFORMA ZA REALIZACIJU NAPREDNE AKUSTIČKE KAMERE

*Iva Salom, Institut Mihajlo Pupin, Univerzitet u Beogradu, Srbija*
*Vladimir Čelebić, Institut Mihajlo Pupin, Univerzitet u Beogradu, Srbija*
*Vladimir Ćatić, Institut Mihajlo Pupin, Univerzitet u Beogradu, Srbija*
*Jovana Novaković, Institut Mihajlo Pupin, Univerzitet u Beogradu, Srbija*
*Bratislav Planić, Institut Mihajlo Pupin, Univerzitet u Beogradu, Srbija*
*Veljko Janić, Institut Mihajlo Pupin, Univerzitet u Beogradu, Srbija*
*Marko Ralić, Institut Mihajlo Pupin, Univerzitet u Beogradu, Srbija*
*Dejan Todorović, Dirigent Acoustics, Beograd, Srbija*

U ovom radu prikazana je jedna realizacija napredne akustičke kamere, koja obuhvata specijalno projektovane module sa digitalnim MEMS mikrofonima, platformu za akviziciju do 32 signala i skladištenje podataka, dodatne module, koji se mogu priključiti u zavisnosti od primene akustičke kamere (GPS, meteorološki moduli) i video kameru. *Beamforming* algoritam realizovan je u programskom paketu MATLAB i kao rezultat postprocesiranja dobija se akustička mapa snimanog područja sa zadatom rezolucijom. Realizovan sistem pokazao se kao pouzdana platforma za realizaciju različitih mikrofonskih nizova sa dodatnim opcijama u zavisnosti od konkretne primene.

AK1.4

## POZICIONIRANJE MIKROFONA PRILIKOM SNIMANJA AUDIO KARAKTERISTIKA MOTORA PUTNIČKIH VOZILA

*Marko Milivojčević, Visoka škola elektrotehnike i računarstva strukovnih studija, Beograd, Srbija*
*Filip Pantelić, Visoka škola elektrotehnike i računarstva strukovnih studija, Beograd, Srbija*
*Dejan Ćirić, Elektronski fakultet u Nišu, Univerzitet u Nišu, Srbija*

U ovom radu je izvršena analiza audio zapisa dobijenih snimanjem zvuka u oblasti ispod motornog prostora putničkih vozila pokretanih motorima sa unutrašnjim sagorevanjem. Snimanje je ralizovano za tipove vozila sa longitudinalno i transverzalno postavljenim motorom u devet tačaka na površini sa izraženom refleksijom. Prilikom snimanja korišćena su dva tipa mikrofona, merni mikrofon sa omnidirekcionom karakteristikom i pzm (boundary) mikrofon sa kardioidnom karakteristikom. Izvršena analiza ima za cilj da ukaže na mogućnost upotrebe pzm

mikrofona za snimanje zvučnih karakteristika motora sa unutrašnjim sagorevanjem prelaskom vozila iznad mikrofona koji su svojom kontrukcijom daleko pogodniji za postavljanje na tlo, kao i da prikaže uticaj relativnog položaja mikrofona u odnosu na izvor zvuka na analizirane karakteristike audio zapisa.

AK1.5

## UPOTREBA RAZLIČITIH OBELEŽJA ZA PREPOZNAVANJE DRVENIH DUVAČKIH INSTRUMENATA KORIŠĆENJEM NEURALNIH MREŽA

*Tatjana Miljković, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Miloš Bjelić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Dragana Šumarac Pavlović, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Goran Kvaščev, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

U procesima automatskog prepoznavanja instrumenata koriste se različita obeležja zasnovana na analizi spektralnog sadržaja audio zapisa. U ovom radu prikazan je hroma profil tonova kao novo obeležje, izdvojeno iz audio zapisa muzičkog sadržaja, na osnovu kojeg se vrši prepoznavanje duvačkih instrumenata pomoću neuralne mreže. Kako bi hroma profil predstavljao validno obeležje izvršena je komparativna analiza sa MFCC koeficijentima. Duvački instrumenti koji su bili od interesa u ovom istraživanju su: klarinet, flauta i oboa. Metodologija karakterizacije duvačkih instrumenata bazirana na hroma profilu tonova pokazala je očuvanje osnovnih razlika u karakteristikama instrumenata. Hroma profil predstavlja prikaz relativnih odnosa energije na pojedinim tonovima unutar oktave. Posmatrani su hroma profili tonova računati nad celim signalom i po prozorima signala. Isti principi računanja obeležja primenjena su i na MFCC koeficijente. Korišćenjem hroma profila tonova i MFCC koeficijenata kao ulaznih parametara neuralne mreže ostvareni su visoki procenti prepoznavanja instrumenata.

AK1.6

## AKUSTIČKI PRENOS PODATAKA BAZIRAN NA OFDM TEHNICI

*Tatjana Miljković, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Miloš Bjelić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Miljko Erić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

Prenos podataka korišćenjem audio signala (*data over sound*) u poslednjih nekoliko godina se koristi sve više. Iako koncept nije nov, njegov rast podstaknut je velikim brojem pametnih i IoT uređaja i naprednih tehnika za obradu signala. Ova tehnologija može biti alternativa drugim tehnologijama za prenos podataka na malom rastojanju. Prednosti akustičkog (zvučnog) prenosa podataka u odnosu na radio tehnologije je mogućnost upotrebe na mestima na kojima je prenos radio talasa onemogućen. Prednost je i to što većina uređaja poseduje zvučnik i mikrofon i ne zahteva se upotreba dodatnih hardverskih komponenti. Ograničenje akustičkog prenosa podataka može biti manji protok u odnosu na druge tehnologije. U ovom radu prikazana je upotreba akustičkog signala za prenos podataka u vazduhu u čujnom delu audio opsega. Akustički prenos podataka realizovan je korišćenjem OFDM tehnike prenosa akustičkog signala. Mogućnost prenosa je ilustrovana rezultatima simulacije i realne eksperimente, bez tehnika zaštitnog kodovanja. Uvedena je tehnika za kompenzaciju vremenskog kašnjenja za necelobrojne vrednosti u broju odbiraka. Za uvedene parametre predajnika ostvaren je bitski protok od 3.2 Kbit/s. Dobijeni rezultati pokazali su mogućnost upotrebe ovakvog sistema za prenos informacija na malim rastojanjima u realnim uslovima.

AK1.7

## KRIVE OPADANJA DOBIJENE U REVERBERACIONOJ KOMORI PRI MERENJU KOEFICIJENTA APSOPRCIJE

*Dejan Ćirić, Elektronski fakultet u Nišu, Univerzitet u Nišu, Srbija*
*Kristian Jambrošić, Fakultet elektrotehnike i računarstva, Sveučilište u Zagrebu, Hrvatska*
*Nikola Stojković, Elektronski fakultet u Nišu, Univerzitet u Nišu, Srbija*

Jedan od klasičnih pristupa za merenje koeficijenta apsorpcije test uzorka je baziran na merenju vremena reverberacije prazne reverberacione komore i vremena reverberacije kada se test uzorak nalazi u komori. Dimenzije i osnovne karakteristike reverberacione komore su definisane u relevantnim standardima. Kada se ispune određeni uslovi, naročito kada je zapremina komore manja od preporučenih vrednosti, mogu se javiti neželjeni efekti sopstvenih modova prostorije na niskim frekvencijama. Uticaj ovih efekata pri merenju koeficijenta apsoprcije test uzoraka na krive opadanja zvuka je analiziran u radu. Merenja impulsnih odziva su izvršena u reverberacionoj komori zapremine oko 65 $m^3$. U opsezima terci ispod 160 Hz se mogu javiti specifična višestruka (najčešće dvostruka) opadanja zvuka koja daju konkavni oblik krivim opadanja. U ovakvim slučajevima se postavlja pitanje na koji način izračunati vreme reverberacije.

# Antennas and propagation/
# Antene i prostiranje (AP)

## SESSION/SESIJA API1 + AP1:

Ponedeljak/Monday, June 3rd, 11:15 – 13:30, Sala 2/Hall 2

**Chair/predsedavajući: Branko Kolundžija, School of Electrical Engineering, University of Belgrade, Serbia**

API1.1

SURFACE PLASMON POLARITON-LIKE PROPAGATION INDUCED BY STRUCTURAL DISPERSION OF SUBSTRATE INTEGRATED WAVEGUIDE AND ITS APPLICATION IN MICROWAVE CIRCUITS AND SENSING (INVITED PAPER)

*Vesna Crnojevic-Bengin, BioSense Institute, Serbia*
*Norbert Cselyuszka, BioSense Institute, Serbia*
*Žarko Šakotic, BioSense Institute, Serbia*
*Mihailo Drljaca, BioSense Institute, Serbia*
*Goran Kitic, BioSense Institute, Serbia*
*Vasa Radonic, BioSense Institute, Serbia*
*Nikolina Janokovic, BioSense Institute, Serbia*

Surface plasmon polaritons (SPP) present electromagnetic waves that occur at the interface of a dielectric and conductor due to the coupling of light to collective electron oscillations. Owing to the specific nature, SPPs allow for breaking the diffraction limit and as such, SPPs have been applied in various fields including optical communications, photonics, and sensing. Since SPPs naturally occur at optical frequencies, there have been proposed different concepts to engineer SPP phenomenon in other frequency ranges including microwaves and terahertz. Recently, a novel "natural" SPP-like concept in microwave regime has been proposed, which is based on exploitation of the well-known structural dispersion of the electromagnetic modes in parallel-plate waveguide structure filled only with materials with positive permittivity. In this talk, we will present how "natural" SPP-like concept can be realized in substrate integrated waveguides (SIW) in microwave range, and afterwards how it can be applied in sensing and design of microwave circuits. More concrete, we will demonstrate two dual-band filters that provide a great freedom to arbitrarily position the passbands in the spectrum, as well as excellent in-band characteristics and selectivity. A design of diplexer based on the proposed phenomenon will be also presented. Finally, we will present a microwave sensor aimed for very sensitive dielectric constant detection in liquid analytes.

API1.2

COMPARISON OF VARIOUS GEOMETRIES OF NONUNIFORM HELICAL ANTENNAS

*Jelena Dinkic, School of Electrical Engineering, University of Belgrade, Serbia*
*Dragan Olćan, School of Electrical Engineering, University of Belgrade, Serbia*
*Antonije Đorđević, School of Electrical Engineering, University of Belgrade, Serbia*

We present comparison of nonuniform helical antennas with linear, exponential, and piecewise-linear variations of the turn radius and the pitch angle. Parameters that define the geometry of these antennas are optimized at a single frequency and in a frequency range in order to maximize the gain. The obtained optimal designs are compared and some practical aspect are commented.

API1.3

## TWO-DIMENSIONAL GREEN'S FUNCTION FOR THE TRUNCATED WEDGE IN TERMS OF AN IMPROPER INTEGRAL

*Dragan Filipović, University of Montenego, Montenegro*
*Tatijana Dlabač, University of Montenego, Montenegro*

In this paper two-dimensional Green's function for the truncated wedge is derived by separation of variables in Laplace's equation in cylindrical coordinates. The sign of the separation constant is chosen so as to exclude periodical particular solutions (harmonics). Hence, Green's function is sought in the form of an improper integral (which is essentially a summation of continual harmonics). An unknown function in the integral is found from the boundary conditions, and the integral itself, although rather complex, is found in a closed form. This method is in contrast with the conventional one, where Green's function involves an infinite summation of discrete harmonics.

API1.4

## ON EFFICIENT EVALUATION OF POLE-FREE SOMMERFELD INTEGRALS

*Nikola Basta, School of Electrical Engineering, University of Belgrade, Serbia*
*Branko Kolundžija, School of Electrical Engineering, University of Belgrade, Serbia*

An approach to computation of pole-free Sommerfeld integrals is proposed using the example of free-space Green function in lossless media. Besides the cancellation of the branch-point singularity based on a change of variables, the proposed approach includes optimal choice of the lower endpoint of the tail subdomain and definition of thresholds that improve accuracy and efficiency of tail-integral evaluation. Additionally, formulas for estimation of the required number of integration points for given accuracy are given. The presented techniques are verified through numerical examples.

API1.5

## THE INFLUENCE OF CORONA ON THE LIGHTNING SURGE PROPAGATION ALONG TRANSMISSION LINES

*Milan Ignjatovic, School of Electrical Engineering, University of Belgrade, Serbia*
*Jovan Cvetic, School of Electrical Engineering, University of Belgrade, Serbia*
*Dragan Pavlovic, School of Electrical Engineering, University of Belgrade, Serbia*

Corona is the partial discharge that occurs around the wires and edges in inhomogeneous electric field. Minimum intensity of the electric field for the impact ionization of the gas is around 2.6 MV/m in dry air. In power systems, the corona is the unwanted effect caused by overvoltages. In this study the propagation of the overvoltage wave due to negative lightning along the transmission line is numerically simulated. The effect of the corona is modeled by the drift-diffusion-reaction equations for the electrons, the positive and the negative ions.

API1.6

## UWB PRINTED MONOPOLE ANTENNA WITH AND WITHOUT THE REFLECTOR

*Dragan Nikolić, School of Electrical Engineering, University of Belgrade, Serbia*
*Miodrag Tasić, School of Electrical Engineering, University of Belgrade, Serbia*

Measured reflection coefficient of a typical UWB monopole antenna is heavily dependent on the measurement setup. The antenna is connected to the network analyzer (NA) using coaxial cables. During the measurement, currents along the inner and the outer conductor of the coaxial cables are unbalanced, causing parasitic radiation. The NA chassis also radiates, so the entire measurement setup behaves like a single antenna under test. As a consequence, a simulated results can be very different from the measured ones, and the single antenna can behave very differently when mounted in different environments. Also, minor errors in the antenna fabrication

can cause significant differences in the measured reflection coefficients of similar prototypes. In this paper we examine if a reflector connected to the ground of the UWB monopole antenna can provide stabilization in the antenna characteristics, simulated and measured, and the satisfactory matching between reflection coefficients of different prototypes.

AP1.1

## АНАЛИТИЧКО РЕШЕЊЕ ВОЛТЕРИНЕ ИНТЕГРАЛНЕ ЈЕДНАЧИНЕ ПРВЕ ВРСТЕ ЗА ГЕНЕРАЛИСАНИ МОДЕЛ ПОВРАТНОГ УДАРА СА ПУТУЈУЋИМ СТРУЈНИМ ИЗВОРОМ

*Dragan Pavlović, faculty of electrical engineering Belgrade, Serbia*
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Разматрали смо аналитичку методу за решавање специјалне Волтерине интегралне једначине конволуционог типа која се примењује у прорачуну функције пражњења канала код генералисаног модела повратног удара са путујућим струјним извором (GTCS модел). У оквиру аналитичкоg метода, примењена је Лапласова трансформација уз употребу Meijer-G функције. Разматрани су и методи за инверзну нумеричку Лапласову трансформацију.

AP1.2

## LOKALIZACIJA TAČKASTIH IZVORA ELEKTROMAGNETSKOG ZRAČENJA TEHNIKOM RETKIH SIGNALA

*Marija Stevanović, School of Electrical Engineering, University of Belgrade, Serbia*
*Jelena Dinkić, School of Electrical Engineering, University of Belgrade, Serbia*
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Tehnika retkih signala primenjena je za lokalizaciju tačkastih izvora elektromagnetskog polja. Iako posmatrani problem lokalizacije spada u klasu "loše-definisanih" problema, korišćenjem l1 regularizacije, tj. predznanja da je broj izvora mali, moguće je odrediti nepoznate lokacije i momente električnih i magnetskih dipola. Predloženi algoritam za lokalizaciju testiran je na podacima dobijenim numeričkim simulacijama bez šuma, kao i sa dodatim šumom.

# Control Systems/
# Automatika (AU)

## SESSION/SESIJA AUI1:

Utorak/Tuesday, June 4th, 09:00 – 11:00, Sala 3/Hall 3

**Chair: Milan Rapaić, Faculty of Technical Sciences, University of Novi Sad, Serbia**

AUI1.1

RECENT RESULTS ON MODELING AND CONTROL METHODS APPLYING THE "FRACTIONAL" APPROACH (INVITED PAPER)

*Guido Maione, Politechnico di Bari, Italy*

This paper illustrates some recent results the author obtained in fractional modeling and control of complex engineering systems. Obviously the description is not exhaustive and does not consider many other appreciable results given by the literature. However, by the considered applications, the author aims at proving how the paradigm of fractional-order modeling and control as opposed to the usual integer-order modeling and control can offer benefits that are sometimes unpredicted or underestimated by researchers and practitioners.

AUI1.2

DISTRIBUTED CONSENSUS-BASED MULTI-TARGET TRACKING WITHOUT MEASUREMENT ASSIGNMENT

*Srdjan Stankovic, Faculty of Electrical Engineering, University of Belgrade, Serbia*
*Nemanja Ilic, College of Applied Technical Sciences, Krusevac, Serbia*
*Milos Stankovic, Innovation Center, Faculty of Electrical Engineering, University of Belgrade, Serbia*

In this paper the problem of distributed multi-target tracking in sensor networks is discussed. A new algorithm, based on a combination of probabilistic data association methodology requiring no explicit measurement assignment and consensus communication scheme, is proposed. Unlike standard joint data association methodologies, which enumerate all possible measurement-to-track assignments resulting in a numerical complexity that is combinatorial in the number of measurements and tracks, we propose an approach which is linear in this respect. This is accomplished by constructing a data association scheme which appropriately modifies the clutter spatial density at the location of the measurements and subsequently uses single target tracking filters. The proposed data association algorithm is combined with a multi-step consensus scheme, which provides an adaptive distributed tracking solution when sensors have limited sensing and communication ranges. Numerical experiments illustrate the underlying principles and performance of the proposed algorithm.

AUI1.3

QQ-PLOT BASED CLUSTERING

*Željko Nedeljković, School of Electrical Engineering, University of Belgrade, Serbia*
*Željko Đurović, School of Electrical Engineering, University of Belgrade, Serbia*

Clustering is widely applied, from everyday life to the most diverse fields of scientific activities. Different techniques of clustering are present, with their advantages and disadvantages. This paper examines the possibility of multidimensional QQ-plot based clustering. First, the multidimensional samples are transformed into a scalar form, using the Fibonacci sequence, after that the QQ-plot is formed for the such shaped samples, and then the piecewise linear approximation is constructed. On the basis of the linear segments of the piecewise linear approximation, clusters are segregated. The proposed procedure can be applied multiple times in

order to obtain a better result. The initial tests indicate that the proposed method achieves results comparable with conventional clustering methods.

AUI1.4

## ROBUST OBJECT TRACKING BASED ON SURF IN THERMAL IMAGES

*Nataša Vlahović, Vlatacom Institute, Serbia*
*Željko Đurović, The School of Electrical Engineering, University of Belgrade, Serbia*

This paper describes the problem of single object tracking in thermal image by using SURF (Speeded Up Robust Features) feature descriptor and Kalman filter. Kalman filter is as good as its model, so the measurement and process noise matrices calculation for the specific problem are inevitable and important step in obtaining good tracking results. On the other hand, outliers - deviations from the assumed noise distributions (Gaussian in the case of Standard Kalman filter) can affect and compromise the tracking result of Standard Kalman filter. That is why robust statistics methods are used. In this paper, Robust Kalman filter is modelled using the Huber influence function. The designed Robust Kalman filter is than used along with SURF feature descriptor in the task of pedestrian tracking.

AUI1.5

## THE CFAR CONTRIBUTION ON THE RADAR TARGET TRACKING

*Zvonko Radosavljevic, VTI, Serbia*
*Branko Kovacevic, ETF, Serbia*
*Dejan Ivkovic, VTI, Serbia*

The different kinds of the constant false alarm rate (CFAR) detectors are used in radar receivers to detect targets in the surveillance zone where all of parameters of the statistical distribution of clutter are not known, or where they are nonstationary. In this time, the standard Integrated Track Splitting (ITS) filter is efficient target tracking algorithm, which is capable to integrates multiscan track with probability of target existence, which becomes the measure of track quality in ITS. We investigate the contribution of two used CFAR algorithms (CA-cell averaging and CATM-cell averaging-trimmed mean) to the quality of target tracking. After the theoretical analysis, this contribution was experimentally tested on the example of single target tracking. Preliminary results of numerical simulations are given in this paper.

AUI1.6

## PROBABILITY OF DETECTION AND FALSE ALARM DENSITY ESTIMATION IN TARGET TRACKING SYSTEMS WITH UNKNOWN MEASUREMENT NOISE STATISTICS

*Asem Elhasaeri, School of Electrical Engineering, University of Belgrade, Serbia*
*Aleksandra Marjanović, School of Electrical Engineering, University of Belgrade, Serbia*
*Sanja Vujnović, School of Electrical Engineering, University of Belgrade, Serbia*
*Goran Kvaščev, School of Electrical Engineering, University of Belgrade, Serbia*
*Željko Đurović, School of Electrical Engineering, University of Belgrade, Serbia*

Successful implementation of any moving target detection system depends on precise knowledge of several statistical quantities such as the probability of target detection and false alarms density. These parameters are usually unknown as well as variable and, even though algorithms exist which are able to estimate them, they are further dependent on the knowledge of model parameters. This paper analyses the effect the unknown measurement noise covariance has on probability of detection and clutter rate estimation in target tracking systems and proposes improvement in a form of noise covariance estimation.

AUI1.7

ON THE PERFORMANCE OF THE PHD FILTER

*Predrag Vasilić, School of Electrical Engineering, University of Belgrade, Serbia*
*Sanja Vujnović, School of Electrical Engineering, University of Belgrade, Serbia*
*Aleksandra Marjanovic, School of Electrical Engineering, Serbia*
*Nikola Popović, School of Electrical Engineering, University of Belgrade, Serbia*
*Željko Đurović, School of Electrical Engineering, University of Belgrade, Serbia*

The Gaussian Mixture Probability Hypothesis Density (GMPHD) filter represents a closed form solution to the Probability Hypothesis Density (PHD) filter which solves the problem of multi-target tracking (MTT), namely the tracking of multiple targets using the collection of measurements at each time sample. Each target has a certain probability of detection. Besides the target-caused observations, there are others which represent clutters. The paper examines the performance of the GMPHD filter in a scenario with many false alarms and deviations in the initial assumptions of the filter model parameters. The performance is measured using the Optimal Subpattern Assignment Metric (OSPA), which is broadly used as a standard metric in the estimation of the distance between two sets of vectors.

## SESSION/SESIJA AUI2

Utorak/Tuesday, June 4th, 14:30 – 16:30, Sala 3/Hall 3

**Chair: Boban Veselić, Univerity of Niš, Faculty of Electronic Engineering, Serbia**

AUI2.1

ROBUST CONTROL DESIGN FOR A 3D CRANE SYSTEM

*Anja Buljević, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Miloš Miletić, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Aleksandra Mitrović, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Mirna Kapetina, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Milan Rapaić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

This paper presents an example of controlling complex electromehanical system of 3D crane. Parameters of simplified 3D crane model are estimated using RLS algorithm. After that two different control algorithms are applied. The first is fractional-order PI controller which parameters are tuned by Symmetrical Optimum Method, and second one is optimal PI controller which parameters are obtained to satisfy certain measures of the system performance and robustness. Performance of both algorithm are illustrated on the model and real system.

AUI2.2

INCIDENT SIMULATOR FOR ADMS PERFORMANCE TESTING

*Nedeljko Stojaković, Faculty of Technical Science, Serbia*
*Marina Stanojević, Faculty of Technical Science, Serbia*
*Darko Čapko, Faculty of Technical Science, Serbia*
*Tatjana Grbić, Faculty of Technical Science, Serbia*

The Advanced Distribution Management System (ADMS) is an Industrial Control System specifically designed and developed for the Smart Grid industry. One of the important components of this system is Outage Management Service (OMS) which is responsible for handling unexpected outages or planned maintenance. The most critical time for ADMS when its response and durability are of exceptional importance is when a storm occurs. In this paper, we analyze actual storm data, build storm model and propose a simulation of a storm. It is

imagined that the utilities could use such simulator in order to test and verify their ADMS according to the real storm conditions.

AUI2.3

## COMPARATIVE ANALYSIS OF THE USAGE OF DIFFERENT IMAGE DESCRIPTORS IN OBJECT'S VIDEO TRACKING

*Abdalgalil Abdulla, Faculty of Electrical Engineering -Blgrade, Serbia*
*Stevica Graovac, Faculty of Electrical Engineering, University of Belgrade, Serbia*

In this paper we tested a feature-based tracking algorithm for object tracking in video sequences, using different image descriptors (based on color, edge and texture) and particle filtering as a concept. A histogram-based framework is used to describe the object's features, where the object is a window consisting from a tracked vehicle and local background around it. Particle filtering has been proven as very robust one for nonlinear and non-Gaussian estimation problems and performs well when clutter and occlusions are present. However, tracker based on single feature may lose the track easily or may start to track the wrong object. One popular remedy for this problem is usage of multiple features. In our approach, we develop the feature based particle filter tracker that relies on the search for the window, whose feature histogram matches a reference feature histogram model as much as possible. This work includes a comparison of tracking performances obtained by usage of different image descriptors separately; showing that some kind of fusion of partial results should be a reasonable solution in the context of analyzed traffic scenarios.

AUI2.4

## GAUSSIAN PROCESS DOMAIN EXPERTS FOR PREDICTION OF ALZHEIMER'S DISEASE-RELATED COGNITIVE SCORES

*Nikola Popović, School of Electrical Engineering, University of Belgrade, Serbia*
*Ognjen Rudović, Massachusetts Institute of Technology, Media Lab, United States*
*Predrag Vasilić, School of Electrical Engineering, University of Belgrade, Serbia*
*Predrag Tadić, School of Electrical Engineering, University of Belgrade, Serbia*

We address the problem of automated estimation of the cognitive score - ADAS-Cog13 - a significant biomarker of Alzheimer's Disease (AD) progression, from past visits data of a sub-cohort of subjects who participated in ADNI~\cite{weiner2017} initiative. This is important for timely monitoring of the subjects' cognitive performance, and, consequently, for improving the selection of subjects for new clinical trials. To this end, we introduce a novel prediction model based on the notion of domain adaptive Gaussian Processes (GP). Specifically, in contrast to previous works that employed GPs for this task, here we formulate a mixture of domain-specific GPs, where each GP is trained on a subpopulation with different clinical status (cognitively normal (CN), mild-cognitive impairment (MCI) and AD). Furthermore, by using the probabilistic formulation of GPs, we personalized our model to the target subject (not used to train the model) using his/her previous visits' data, in order to reduce the estimation bias, which is typically pronounced when applying the population-level GP models to the target task. We show in the experiments presented here that while the proposed domain-specific mixture of adaptive GPs does not lead to large improvements in terms of the point estimate of the ADAS-Cog13 scores, compared to existing GP models trained on the whole training population, it provides much better uncertainty estimates for its predictions. This is an important advantage of our model as it allows to encode the model's prediction confidence more accurately than the single expert model (i.e. when a GP is trained on all three sub-groups together). We also show that the proposed approach has much lower computational complexity, as the necessary matrix inversions can efficiently be performed on the data-subsets corresponding to the target sub-populations.

AUI2.5

## TRAJECTORY AND KINEMATIC PARAMETER ESTIMATION USING PASSIVE MONOSENSOR CAMERA

*Marko Antonijevic, Vojna akademija, Univerzitet u Beogradu, Serbia*
*Filip Ilic, Vojna akademija, Univerzitet u Beogradu, Serbia*

In this paper distance and kinematic parameter estimation based on the area of the target which has been extracted using basic image processing methods has been analyzed. The results from the experiment designed to simulate target movement were used. The model for target tracking was made of the controlled camera, VC-C50i and a personal computer. The results show the calculated trajectory and basic kinematic parameters such as speed and angular speed.

AUI2.6

## ANALYSIS OF THE QUALITY OF THE ESTIMATION IN THE MULTI TARGET TRACKING SYSTEM USING ONE VIDEO SENSOR DEPENDING ON THE MEASURMENT NOISE

*Filip Ilic, Vojna Akademija, Serbia*
*Marko Antonijevic, Vojna Akademija, Serbia*

In this paper, the quality estimation in multiple target tracking system was analysed. Multiple target tracking system has a video sensor which is used for recording. Gauss noise of different variances was added to the generated trajectories of four imminent targets. The position estimation results were compared based on the algorithm that was used: Global nearest neighbor, N best solution and Munkres algorithm. The second analysis was made trough the influence of the calculation of the total estimation, that was calculated based on weight coefficients in interactive multiple model.

AUI2.7

## SOLUTION OF SINGULARLY IMPULSIVE DYNAMICAL SYSTEMS

*Natasa Kablar, Lola Institute, Serbia*

In this paper we present class of singular impulsive dynamical systems. These are the systems described with singular continual and singular discrete dynamics, ie. combination of differential, discrete and algebraic equations. Resetting set, which can be function of time, state, and/or control inputs determines when the states of the system are to be reset from singular continual to discrete dynamics, and vice versa. For the case of linear singular impulsive dynamical systems we firstly define notion of tractability and consistent initial conditions, and then we propose solution of the system by using Drazin inverse approach. Further work will discuss approach by using core-nil potent decomposition in obtaining the solutions.

AUI2.8

## TRANSFER FUNCTION MATRIX FOR SINGULARLY IMPULSIVE DYNAMICAL SYSTEMS

*Natasa Kablar, Lola Institute, Serbia*

In this paper is derived transfer function of singularly impulsive dynamical system for the first time. Singularly impulsive dynamical system is described with singular continual dynamics and singular discrete dynamics, with the set of resetting times or resetting states that defines times when resetting or impulses will occur, in order to switch from continual dynamics to discrete, and vica versa. Furthermore, it is given description of transfer function of singularly impulsive dynamical system and way of its deriving, description of characteristical polinomial, its input-output function, and way of calculation of transfer matrix for higher order systems by using Leverrier's algorithm. In absence of singular dynamics, result holds for the class of impulsive dynamical systems.

## SESSION/SESIJA AU1+ AUI3:

Sreda/Wednesday, June 5th, 11:15 – 13:30, Sala 3/Hall 3

**Chair: Željko Đurović, University of Belgrade - School of Electrical Engineering, Serbia**

AU1.1

PRIMENA NELINEARNOG ADRC ALGORITMA ZA UPRAVLJANJE PLANARNIM MANIPULATOROM

*Milan Svetozarević, Vojna akademija, Univerzitet odbrane u Beogradu, Serbia*
*Momir Stanković, Vojna akademija, Univerzitet odbrane u Beogradu, Serbia*

U radu je predložena primena nelinearnog regulatora sa aktivnim potiskivanjem poremećaja (Nonlinear Active Disturbance Rejection Control-NADRC) za upravljanje planarnim robotskim manipulatorom, koji predstavlja složeni nelinearni sistem sa dva ulaza i dva izlaza. Pri realizaciji upravljanja unakrsna dinamika sistema je uključena u totalne poremećaje po kanalima upravljanja, tako da su projektovani nezavisni regulatori za oba kraka manipulatora. Razmatrani problem praćenja zadate reference je preformulisan u problem regulacije (error-based structure), čime je pojednostavljena standardna struktura ADRC regulatora. Detaljna simulaciona analiza je pokazala uticaj izbora parametara nelinearnog regulatora na performanse upravljanja.

AU1.2

STABILNOST LINEARNIH DINAMIČKIH SISTEMA SA VREMENSKIM KAŠNJENJEM

*Vukan Turkulov, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Serbia*
*Milan Rapaić, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Serbia*
*Rachid Malti, University of Bordeaux, France*

U ovom radu bavimo se problemom određivanja oblasti stabilnosti linearnih, vremenski invarijantnih sistema sa višestrukim vremenskim kašnjenjima. Prikazani metod je iterativan, a zasniva se na primeni Rošeove teoreme i fundamentalne teoreme matematičke analize. Izlaganja su ilustrovana primerom.

AU1.3

PODEŠAVANJA DINAMIKE KLIZNIH REŽIMA VIŠEG REDA KOD LINEARNIH SISTEMA SA JEDNIM ULAZOM

*Boban Veselić, University of Niš, Faculty of Electronic Engineering, Serbia*
*Čedomir Milosavljević, University of Istočno Sarajevo, Faculty of Electrical Engineering, Bosnia and Herzegovina*
*Branislava Draženović, University of Sarajevo, Faculty of Electrical Engineering, Bosnia and Herzegovina*
*Senad Huseinbegović, University of Sarajevo, Faculty of Electrical Engineering, Bosnia and Herzegovina*

U radu se razmatra problem podešavanja dinamike u kliznom režimu višeg reda kod linearnih sistema sa jednim ulazom. Predložena je metoda izbora klizne površi koja istovremeno obezbeđuje neophodni relativni red klizne promenljive za željeni klizni režim višeg reda, kao i željenu dinamiku po uspostavljanju datog kliznog režima. Pokazano je da je rešenje ovog problema jedinstveno i dat jednostavan način za njegovo nalaženje. Teorijski dobijeni rezultati su potvrđeni na numeričkim primerima i ilustrovani simulacionim rezultatima.

AU1.4

## PREPOZNAVANJE GOVORA IZ OGRANIČENOG REČNIKA PRIMENOM NEURALNE MREŽE

*Emilija Kisic, School of Electrical Engineering and Computer Science of Applied Studies, Serbia*
*Slobodan Draskovic, School of Electrical Engineering and Computer Science of Applied Studies, Serbia*
*Vera Petrovic, School of Electrical Engineering and Computer Science of Applied Studies, Serbia*

Cilj ovog rada je da se pokaže kako se jednom efikasnom i kompleksnom obradom govornih signala i pravilnim izborom arhitekture neuralne mreže može napraviti sistem za prepoznavanje govora iz ograničenog rečnika koji će raditi sa velikom tačnošću. U ovom radu prikazan je kompletan postupak pravljenja sistema za prepoznavanje reči iz ograničenog rečnika i pokazano je da su neuralne mreže u kombinaciji sa poznatim metodama za modelovanje i obradu govornog signala jedan veoma moćan alat za prepoznavanje govora.

AU1.5

## MREŽNO UPRAVLJANJE POZICONIM SERVOMEHANIZMOM UPOTREBOM METODE UPRAVLJANJA AKTIVNIM POTISKIVANJA POREMEĆAJA

*Dragan Kondic, Ministarstvo odbrane, Serbia*

This paper is presented networking control system, with using method Active Disturbance Rejection Control (ADRC). Paper presents theoretical review of networking control and ADRC method. On positioning servomechanism through simulation will presented behavior of regulated system by ADRC through communication networks. In order to compare behavior of ADRC with PD, there will presented NCS with PD regulator. As a software tool there is used True Time, which is on very realistic way simulate communication networks.

AUI3.1

## FPGA-BASED QUADROTOR ATTITUDE ESTIMATION USING EXPERIMENTAL RESULTS FROM 9DOF IMU SENSOR

*Taki Eddine Lechekhab, Military academy, University of Defence in Belgrade, Serbia*
*Stojadin Manojlović, Military academy, University of Defence in Belgrade, Serbia*
*Slobodan Simić, Military academy, University of Defence in Belgrade, Serbia*
*Davorin Mikluc, Military academy, University of Defence in Belgrade, Serbia*

In order to build quadrotor prototype and apply different control algorithms, in this paper, experimental results from Inertial Measurement Unit (IMU) sensor fixed on a quadrotor test bench, mounted on the 3-axis platform, are analyzed and discussed. A Field Programmable Gate Array (FPGA) platform is used to control the 3-axis platform and process the measurements. The raw data are analyzed and processed by two algorithms: Kalman filter (KF) and Complimentary Filter (CF) to estimate the attitude angles of quadrotor, combining the measurements from the gyroscopes and the accelerometers.

AUI3.2

## A 5 GHZ LOW-NOISE AMPLIFIER WITH SLIDING MODE BASED PHASE CONTROL LOOP

*Darko Mitić, University of Niš, Faculty of Electronic Engineering, Serbia*
*Goran Jovanović, University of Niš, Faculty of Electronic Engineering, Serbia*
*Tatjana Nikolić, University of Niš, Faculty of Electronic Engineering, Serbia*
*Dragan Antić, University of Niš, Faculty of Electronic Engineering, Serbia*

The paper considers a tunable Low-Noise Amplifier (LNA) incorporating a phase loop with sliding mode control (SMC). Phase control loop forces a resonant frequency to be equal to an input signal frequency by tuning the amplifier resonant constituents. Thanks to the sliding mode

control, LNA is robust to parameter perturbations in the full operating range, possesses maximum gain at the resonant frequency and attain input signal frequency faster than in [1]. The 0.13 micro-m SiGe BiCMOS technology was used for LNA design and validation. LNA has ~30 dB gain, quality factor Q ~ 41 and resonant frequency from 5133 up to 5783 MHz.

# Biomedical Engineering/
# Biomedicinska tehnika (BT)

## SESSION BTI1: BIOMEDICAL ENGINEERING

Sreda/Wednesday, June, 5th, 14:30 – 16:30, Sala 4/Hall 4

**Chair: Dejan Popović, Serbian Academy of Sciences and Arts**

BTI1.1

### TECHNOLOGY-SUPPORTED THERAPEUTIC APPROACHES FOR STROKE REHABILITATION: FROM DESIGN TO CLINICAL TRANSLATION (INVITED PAPER)

*Emilia Ambrosini, NearLab, Department of Electronics, Information and Bioengineering, Politecnico di Milano, Milan, Italy*

Stroke is the third most common cause of death and the main cause of acquired adult disability in high-income countries. Hemiparesis, which is motor impairment of one side of the body, affects about 80% of stroke survivors. Restoration of gait and gait-related activities is one of the main goals of stroke rehabilitation, while the recovery of arm functions is crucial for the capability to perform activities of daily life (ADL), which increases independence and quality of life.

Neuroplasticity is the basic mechanism for functional recovery after stroke. Rehabilitative interventions should make effective use of neuroplasticity, proposing high-intensity, repetitive, task-specific, interactive and individualized training. Technology-supported therapeutic approaches are emerging as a solution to support therapists in providing such training for a long duration, allowing the participants to progress in task difficulty, so as to increase their motivation.

In the last thirty years, several robotic devices for both lower and upper-limb rehabilitation have become commercially available. Robot-assisted gait training, supporting (partially or totally) the body weight and the movement of patients, allow intensive and highly repetitive training of complex gait cycles, with a reduced effort for the therapists. A recent Cochrane review showed that robotic gait training in combination with physiotherapy might improve recovery of independent walking in stroke survivors. Leg cycling training may represent a low-cost and safe alternative to robot-assisted gait training. Indeed, cycling shares a similar locomotor pattern with walking and can be performed safely with a sufficient intensity soon after stroke since it does not require standing balance.

Robotic devices have been strongly proposed also to support upper limb stroke rehabilitation and recent systematic reviews demonstrated that stroke patients who receive electromechanical and robot-assisted arm and hand training might improve ADL, arm and hand function and strength.

To increase the therapeutic benefits of robotic rehabilitation, other approaches have been combined with robots, such as Functional Electrical Stimulation (FES) and Virtual Reality (VR); these combined approaches can make robotic based-interventions more functional and engaging. FES has been strongly used to enhance functional recovery of the paretic arm or leg. The combination of FES with robotic devices helps overcome one of the main limits of FES, e.g., the early onset of muscle fatigue. VR is instead used to provide an interactive and individualized training modality, which can provide sensorimotor training in enriched environments, so as to maximize patient's engagement.

This talk will provide an overview of the main technology-supported therapeutic approaches for upper and lower limb stroke rehabilitation. The main training elements, which technology should guarantee in order to maximize cortical plasticity and consequently motor re-learning, will be summarized. Interventions for both upper and lower limb recovery will be mentioned. Special

focus will be given to active-assistive control modalities of robotic devices which implement “assisted-as-needed" rehabilitation therapy aimed at maximizing patient’s involvement and self-esteem. Finally, the importance of the design of randomized controlled trials (RCT) to evaluate the efficacy of technology-supported therapeutic approaches with respect to usual care will be highlighted. The examples of two RCTs recently conducted by our group will be also provided. Specifically, one RCT recruited a population of 68 subacute stroke survivors and evaluated the effects of a biofeedback training involving FES-augmented cycling training and balance exercises on motor recovery and walking ability. The second RCT was a multi-center clinical trial conducted within the European project RETRAINER and evaluated the efficacy of training with the support of a hybrid robotic system, consisting of an anti-gravity arm exoskeleton combined with EMG-triggered FES, on a sample of 68 post-acute stroke patients.

BTI1.2

## RULES FOR ESTIMATION OF GAIT PHASES FROM DATA ACQUIRED BY THE GAIT TEACHER INSOLES (YOUNG INVESTIGATOR)

*Vladimir Džepina, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*
*Aleksandar Gogić, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*
*Dejan Popović, Serbian Academy of Sciences and Arts, Belgrade, Serbia and Aalborg University, Aalborg, Denmark*

The task of this study was to develop a user-friendly method for estimation of gait events from the sensor's data integrated into the wearable system called Gait Teacher. Ten pressure sensors and two six-axis inertial measurement sensors built into a pair of insoles wirelessly send signals to the host computer sampled at 100 Hz. We collected and processed data by a custom-designed software developed in LabVIEW. We heuristically segmented the gait cycle to the phases typically used for the gait analysis (Toes off, Terminal swing, Heel contact, Foot flat and Heel off,) and then applied the automatic segmentation of data. The performance of the method was tested by comparing the heuristic and automated segmentation. The results suggest that the averaged accuracy of the segmentation reached almost 100% for all four healthy subjects who participated in the study. These results indicate that Gait Teacher could be used for evaluation of the gait performance in sports, recreation, and rehabilitation.

BTI1.3

## MULTI-SENSOR ACQUISITION SYSTEM FOR NONINVASIVE DETECTION OF HEART FAILURE (YOUNG INVESTIGATOR)

*Aleksandar Lazović, University of Belgrade, Belgrade, Serbia*
*Lana Popović-Maneski, The Institute of Technical Sciences, Belgrade, Serbia*
*Ljupčo Hadžievski, Vinča Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia*

To research the possibility of noninvasive detection of heart failure we developed an acquisition system with multiple sensors. The system synchronously measures cardiovascular pulsations, heart sounds and ECG using different types of sensors positioned only on the patient’s body. The system has a modular structure with five modules: 1. Module for controlling the light source (MWLS) 2. Module for data acquisition from fiber optical sensors (FBGA) with the compact optical spectral analyzer 3. Module for the acquisition of hearth sounds (PCG) with four ports for microphones; 4. Module for the acquisition of standard ECG signals; 5. Module for data acquisition from three accelerometers and three photoplethysmography sensors (ACC/PPG).

BTI1.4

## DROWSINESS DETECTION USING MACHINE LEARNING APPROACHES BASED ON CARDIOPULMONARY SIGNALS (YOUNG INVESTIGATOR)

*Anita Lupšić, NovelIC L.L.C., Belgrade, Serbia and University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*
*Predrag Tadić, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*
*Veljko Mihajlović, NovelIC L.L.C., Belgrade, Serbia*
*Milica M. Janković, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*

Drowsiness detection systems can be behavioralbased (e.g. tracking face/eyes expressions, vehicle-based measuring) or physiological-based (monitoring features of physiological signals such as electroencephalography, electrooculography, respiration rate, electrocardiography). The aim of this paper is the development of an algorithm for the detection of drowsiness based on the variability of heart rate and breathing rate features. A group of ten healthy adults participated in the experiment in which they were exposed to multimedia content. The measurement of electrocardiography (ECG) and the respiration curve was performed using Smartex Wearable Wellness System (Pisa, Italy). The video of the subject's face was recorded as the reference signal for drowsiness. All data were acquired while subjects were awake, sleepy and in the early stage of sleep. Time, frequency and fractal feature extraction of heartrate variability and breathing rate was performed. Machine learning approaches (Support Vector Machines (SVM), k-nearest neighbors (kNN) and ensemble methods) were implemented for the multinomial classification with three output classes: "awake", "drowsy" and "fallen asleep". Unequal risks of different error types were considered because the consequences are significantly higher if the "drowsy" and "fallen asleep" classes are not properly detected, in comparison to the "awake" class. The upper accuracy of 77% and 80% was obtained in the validation and test process, respectively.

BTI1.5

## ANALYSIS OF PVC MICROFLUIDIC SYSTEM FOR ANTIBACTERIAL SOLUTIONS DELIVERY IN DENTISTRY (YOUNG INVESTIGATOR)

*Anđela Stojanović, Faculty of Medicine, University of Novi Sad, Novi Sad, Serbia*
*Jovana Jevremov, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*
*Bojan Petrović, Faculty of Medicine, University of Novi Sad, Novi Sad, Serbia*
*Sanja Kojić, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*
*Jovana Lazarević, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*
*Goran Stojanović, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

Microfluidic systems can be used for oral diagnostics but they can also provide a new approach for effective drug delivery. The aim of this investigation was to evaluate the applicability of PVC microfluidic setup for the purposes of controlled release of two antibacterial mouthwashes commonly used in dentistry and to evaluate basic physical properties of liquids within the channel of microchips. Eight PVC chips were fabricated, they were Y-channel chips without any obstacles, with the input channels set at an angle of 60 °, and the width of 500-700 μm. The analyzed parameters included the passage, speed and necessary pressure for the laminar flow of solutions. The liquid diffusion was observed with a USB camera. All chips were crossable for both tested solutions. A laminar flow for both liquids was achieved with a pressure of 40 mbar. The minimum pressure on which flow was possible was 1 mbar for Eludril and 5 mbar for Curasept. The obtained data indicate that controlled drug delivery for routine use in dental clinical practice utilizing microfluidic setups require additional preclinical confirmation, calibration of all relevant parameters and the improvement of merge of existing medical and engineering technologies.

BTI1.6

## PERFORMANCES OF MICROFLUIDIC MIXING REGULATED USING ACTIVE PRESSURE CONTROLLER (YOUNG INVESTIGATOR)

*Jovana Jevremov, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*
*Ivana Podunavac, BioSense Institute, University of Novi Sad, Serbia*
*Jovana Lazarević, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*
*Sanja Kojić, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*
*Vasa Radonić, BioSense Institute, University of Novi Sad, Serbia*
*Goran Stojanović, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

Microfluidics studies show fluid dynamic changes at the microscale level. Interest in microfluidic technologies has been driven by associated developments in bio-related fields such as cell biology, genomics, drug delivery, high-throughput screening and diagnostics, as well as a recognized need to perform fast and efficient experiments on small-sample volumes. Fluid behaviour in the microfluidic channel depends on channel geometry, fluids inside the channels, used material for chip fabrication, chip complexity, presence of external force (passive or active) and many other factors. Rapid and uniform mixing are fundamental principles on which effective design and development of micro-mixer relies on. In this paper COMSOL Multiphysics simulation software was used to investigate the flow characteristics within Y shaped microfluidic channel model for different pressure signals (sin, ramp, step), their periods (1 and 1.5 s) and amplitudes (10 mbar, 50 mbar and 100 mbar). Results were compared with experimentally gained data obtained using commercial flow control system. The results confirm that the best mixing performance was achieved with step signal shape, on shorter periods, and with the higher pressure.

# Power Engineering/
# Elektroenergetika (EE)

## SESSION/SESIJA EEI1: POWER ENGINEERING (7 PAPERS)

Utorak/Tuesday, June 4th, 09:00 – 11:00, Sala 4/Hall 4

**Chair: Prof. dr Slobodan Vukosavić, University of Belgrade - School of Electrical Engineering, Serbia**
**Doc. dr Marko Rosić, University of Kragujevac - Faculty of Technical Sciences Čačak, Serbia**

EEI1.1

INCREASE OF THE ENERGY EFFICIENCY OF AN URBAN TYPE WIND TURBINE IN A SMART ENERGY BUILDING (INVITED PAPER)

*Christos Mademlis, Faculty of Electrical and Computer Engineering, Aristotle University of Thessaloniki, Greece*

This paper presents an efficiency increase control strategy for an urban type wind turbine in a nearly zero energy building (nZEB). The efficiency increase is attained by employing the flux-weakening control technique for the electrical generator and the maximum power point tracking control for the wind turbine. Thus, maximum power harvesting from the whole wind energy conversion system (WECS) is achieved and additionally expansion of the exploitable wind speed region towards the lower-speed range is accomplished. Specifically, the developed control technique has been based on previous research work of the author and it is properly adjusted so as, it can be utilized as generic method for any urban type wind turbine for smart energy buildings. Therefore, the developed control method can narrow the advantage of the permanent magnet synchronous generator with respect to the energy efficiency and therefore, a low cost and high efficiency wind generation system can be provided. The usability of the developed wind system is highly important, since the urban type wind turbines have not been widely spread as a renewable energy source in nZEBs, due to the higher cost compared to the photovoltaic systems. It should be noted that, although the proposed control system has been developed with a squirrel cage induction generator (SCIG), due to the advantage of the low cost; it can be applied to a permanent magnet synchronous generator, as well. In the developed control method, a Minimum Electric Loss (MEL) controller is introduced in order to minimize the generator electric loss and a Maximum Power Point Tracking (MPPT) controller is used in order to maximize the wind turbine output power. Common input to the two optimal controllers is only the generator speed, while the measurement of the wind speed is not required. The two controllers determine the optimal d and q-axis stator current components of the SCIG through optimal conditions and therefore, fast dynamic response of the WECS is accomplished. An experimental procedure is proposed to determine the MEL and MPPT controller parameters. Therefore, neither the knowledge of SCIG loss model nor the characteristic curves of the wind turbine are required. The effectiveness and the operational improvements of the suggested optimal control scheme have been verified experimentally

EEI1.2

## PROPAGATION OF ELECTROMECHANICAL WAVES IN CONVENTIONAL POWER GRIDS

*Ruzica Cvetanović, School of Electrical Engineering, University of Belgrade, Serbia*
*Filip Cvejić, School of Electrical Engineering, University of Belgrade, Serbia*
*Slobodan Vukosavić, School of Electrical Engineering, University of Belgrade, Serbia*

The paper reinstates the impact of distributed generation, consumption and accumulation on the dynamic response and transient stability of the electric power system. Modern power systems consist of distributed loads and power generation with both conventional synchronous generators and grid-side inverters. In comparison to the discrete model, the continuum model, discussed here, offers the opportunity to gain insight into the spatial aspects of transient stability and therefore has the potential to play a role of great importance in stabilizing the modern, distributed power system. In the paper, the phenomenon of electromechanical power waves in a string of conventional synchronous generators is considered and studied. Disturbance waves propagate considerably slower than electromagnetic waves and exhibit multiple reflections at the points of inhomogeneity. There are cases where the interference of direct, indirect and reflected waves can drive the system to instability. The paper considers the practical implementation of the simplified form of the previously proposed wave-quenching control law which is based on local measurements. The requirements point out that the practical implementation of the wave-quenching control law strongly relies on power electronic devices.

EEI1.3

## A FAULT-TOLERANT DC UPS SYSTEM BASED ON A BATTERY CHARGER WITH AN AUTOMATIC LOAD TRANSFER FUNCTION

*Vladimir Vukić, Electrical Engineering Institute "Nikola Tesla", University of Belgrade, Serbia*

A direct current uninterruptible power supply (DC UPS) system, designed for operation in a hydro power plant, is presented in this paper. Standard DC power supply configurations for large power plants consist of two AC/DC converters with accompanying storage batteries. To improve the system's reliability, an active fault tolerant control system (FCTS) was utilised. Aside from the two primary AC/DC converters, a third device was implemented with the same nominal characteristics, albeit with some additional advanced functions. This secondary AC/DC converter has two high-power contactors on its output, enabling it to operate (either manually or automatically) in parallel with one of the primary rectifiers. In order to achieve the high reliability of this facility, a serial communication was not established between battery chargers. Instead, a procedure for the turnout detection of a remote battery charger was utilised, based only on data from the auxiliary contacts of its main switch and the input contactor. Based on these logic conditions, an algorithm for the automatic load transfer was devised for implementation in cases when some of the inoperative primary battery chargers would automatically be replaced by a secondary AC/DC converter operating in a "hot reserve".

EEI1.4

## AUTOGENERATED POWER DISTRIBUTION NETWORK MODEL (YOUNG RESEARCHER)

*Lazar Prodanović, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Darko Čapko, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Aleksandar Erdeljan, Faculty of Technical Sciences, University of Novi Sad, Serbia*

This research paper covers the development of a smart greedy algorithm, used for autogeneration of a test distribution network model, with predetermined parameters. Autogeneration is done using input data set, which is first clustered in order to reduce its size and thereby simplify the given task. Each cluster provides one representing object that is later used in the optimization algorithm. Proposed optimization algorithm chooses the objects needed to create a network

model that is optimal in size and creates a resulting data set. The algorithm is tested with real life data set, extracted from an existing CIM-based distribution network model, and results in a new distribution network model created using the same specification

EEI1.5

## CURRENT SAMPLING TECHNIQUES FOR DIGITALLY CONTROLLED INVERTERS

*Filip Filipović, Faculty of Electronic Engineering, University of Niš, Serbia*
*Milutin Petronijević, Faculty of Electronic Engineering, University of Niš, Serbia*
*Nebojsa Mitrović, Faculty of Electronic Engineering, University of Niš, Serbia*
*Bojan Banković, Faculty of Electronic Engineering, University of Niš, Serbia*
*Vojkan Kostić, Faculty of Electronic Engineering, University of Niš, Serbia*

The purpose of this paper is to describe common problems that influence accurate current sampling in the case of power inverters. The current sampling is observed for nominal and low load of the inverter. Considered problems include dead time of power switches and small load time constant. Techniques considered for minimization of the influence of these problems are synchronized sampling method, multisampling method and antialiasing filter. The common algorithms for obtaining a single current value in the multisampling method are also considered. Effects of reviewed techniques on current sampling are examined in the case of one power inverter that supplies passive load in isolated grid. The results confirm the necessity of careful current sampling method consideration with respect to the application. Model of the inverter with all considered techniques for accurate current sampling is built using MATLAB/Simulink.

EEI1.6

## PRACTICAL IMPLEMENTATION OF VOLTAGE DIP, SWELL AND INTERRUPTION DETECTION ALGORITHM ACCORDING TO IEC 61000-4-30 STANDARD

*Lazar Sladojević, Faculty of Electronic Engineering, University of Niš, Serbia*
*Miodrag Stojanović, Faculty of Electronic Engineering, University of Niš, Serbia*
*Vladeta Milenković, Faculty of Electronic Engineering, University of Niš, Serbia*

This paper describes a practical implementation of a part of IEC 61000 standard for Electromagnetic compatibility, part 4-30 which considers Power quality measurement methods for various power quality parameters. The developed algorithm implements real-time digital signal processing techniques for accurate detection and evaluation of the supplying voltage dips, swells and interruptions as key power quality parameters. Necessary prerequisites for this process such as frequency evaluation and hardware configuration are also briefly explained. The signal processing algorithm is written in Python programming language which is open-source and easy to use. Experimental results are evaluated to give some insights on practical problems that should be addressed in the future.

# SESSION EEI2+EE2: POWER ENGINEERING/ ELEKTROENERGETIKA (5+3 PAPERS)

Utorak/Tuesday, June 4th, 14:30 – 16:30, Sala4/Hall4

**Chair: Prof. dr Vladimir Katić, University of Novi Sad - Faculty of Technical Sciences, Serbia**
**Doc. dr Marko Rosić, University of Kragujevac - Faculty of Technical Sciences Čačak, Serbia**

EEI2.1

## ROTOR BARS SKEWING IMPACT ON ELECTROMAGNETIC PULSATIONS IN CAGE INDUCTION MOTOR

*Gojko Joksimović, Faculty of Electrical Engineering, University of Montenegro, Podgorica, Montenegro*
*Aldin Kajevic, Faculty of Electrical Engineering, University of Montenegro, Podgorica, Montenegro*
*Sasa Mujovic, Faculty of Electrical Engineering, University of Montenegro, Podgorica, Montenegro*
*Tatjana Dlabac, Maritime Faculty, University of Montenegro, Kotor, Montenegro*
*Vanja Ambrozic, Faculty of Engineering, University of Ljubljana, Ljubljana, Slovenia*
*Alberto Tessarolo, Department of Engineering and Architecture, University of Trieste, Trieste, Italy*

An alternative way of integral skew factor derivation that provides a deep insight into electromagnetic processes in machine and clearly demonstrates the basic idea behind the skewing of rotor bars in cage induction motors is presented in the paper. Detailed analysis of impact of skewing of rotor bars on elimination of stator slot harmonics in rotor bar currents is conducted. Additionally, by using the multiple coupled circuit model of cage induction motor impact of rotor bar skewing on electromagnetic torque pulsations in steady state condition is conducted in natural frame of reference. Impact of skewing of rotor bars on motor starting ability in case of inadequate stator slot/rotor slot combination is illustrated, too.

EEI2.2

## MECHANICAL AND ELECTRICAL FAULTS DETECTION IN UNCONTROLLED DRIVES WITH AC MOTORS (YOUNG RESEARCHER)

*Bratislav Trojić, Faculty of Electronic Engineering, University of Niš, Serbia*
*Vladislav Lazić, Faculty of Electronic Engineering, University of Niš, Serbia*
*Uroš Ilić, Faculty of Electronic Engineering, University of Niš, Serbia*
*Milutin Petronijević, Faculty of Electronic Engineering, University of Niš, Serbia*

This paper shows new and contemporary possibilities for faults detection and operation conditions estimation of electric drives. The implementation of the machine learning and the artificial intelligence is technique that is increasingly represented in the recent times. Here it was dealt with theoretical and practical support for the implementation of machine learning for the purpose of mechanical and electrical faults detection in uncontrolled drives. The sequence of work and data flow is shown through several stages, from data processing through the developing classification technique, i.e. optimal machine learning algorithm to the evaluation of that algorithm. All development phases of the algorithm were made in MATLAB.

EEI.2.3

## DETECTION OF SUPPLY VOLTAGE UNBALANCE CONDITION IN INDUCTION MOTOR USING MACHINE LEARNING (YOUNG RESEARCHER)

*Vladislav Lazić, Faculty of Electronic Engineering, University of Niš, Serbia*
*Uroš Ilić, Faculty of Electronic Engineering, University of Niš, Serbia*
*Bratislav Trojić, Faculty of Electronic Engineering, University of Niš, Serbia*
*Milutin Petronijević, Faculty of Electronic Engineering, University of Niš, Serbia*

This paper presents possibilities of detecting supply voltage unbalance condition in induction motor using machine learning algorithms. Supply voltage unbalance condition can be dangerous for motor and can invoke bigger faults. Early detection of this condition is important in order to prevent costly outages. This paper aims to show results and analyze the performance of these algorithms, using MATLAB application Classification Learner. Mechanical vibration and stator current measurements have been taken into consideration, as they are easily accessible for measuring and hold a lot of important information. These signals were preprocessed in an appropriate way in order to gain valuable features, which are then used in the algorithm. Results were analyzed and displayed in the paper.

EEI2.4

## CLASSIFICATION MODELS OF MACHINE LEARNING FOR VIBRATION ANALYSIS OF INDUCTION MOTOR (YOUNG RESEARCHER)

*Uroš Ilić, Faculty of Electronic Engineering, University of Niš, Serbia*
*Bratislav Trojić, Faculty of Electronic Engineering, University of Niš, Serbia*
*Vladislav Lazić, Faculty of Electronic Engineering, University of Niš, Serbia*
*Filip Filipović, Faculty of Electronic Engineering, University of Niš, Serbia*

The main aim of writing this paper is the idea to use machine learning techniques to recognize possible faulty operating modes of induction motor drives using only mechanical vibrations. In this paper, the vibrations of one induction motor were recorded for different operation modes: normal, soft foot, rotor imbalance, angle and parallel misalignment. Recorded data is transferred from the time into a frequency domain using Discrete Fourier Transformation (DFT) to be used as an input for machine learning algorithms. The input into the algorithm consists of ten components of frequency spectra (peaks) with the highest amplitude and corresponding frequencies in frequency range up to 300 Hz. Classification models of machine learning obtained in the end, have a very good ability to easily classify unlabeled data.

EEI2.5

## DESIGN AND ANALYSIS OF THE DROOP CONTROL METHOD FOR PARALLEL INVERTERS OPERATION IN THE AUTONOMOUS MICROGRID (YOUNG RESEARCHER)

*Bojan Banković, Faculty of Electronic Engineering, University of Niš, Serbia*
*Nebojsa Mitrović, Faculty of Electronic Engineering, University of Niš, Serbia*
*Milutin Petronijević, Faculty of Electronic Engineering, University of Niš, Serbia*
*Filip Filipović, Faculty of Electronic Engineering, University of Niš, Serbia*
*Vojkan Kostić, Faculty of Electronic Engineering, University of Niš, Serbia*

This paper evaluates the stability of the autonomous low inertia low voltage microgrid. Tested microgrid consists of two inverters connected to the load via power lines of different impedance. The decentralized control of the inverters is realised through the application of the conventional and opposite droop method. For both control methods dynamic phasor model is derived for stability analysis. Validation of initially selected and then retuned droop control parameters for both methods is done by simulation in order to show credibility of stability analysis method. Dynamic and steady state active and reactive power sharing is shown along with the roots of the

characteristic equation. Simulation of the autonomous microgrid operation with applied droop control strategies is performed in MATLAB/Simulink software.

**ЕТРАН – радови послати за национални део конференције (3 рада)**

EE1.1

## ОБРАЗОВНА ЛАБОРАТОРИЈСКА ПОСТАВКА ПУМПНОГ СИСТЕМА СА МОГУЋНОШЋУ РЕГУЛАЦИЈЕ ПРИТИСКА И ПРОТОКА (МЛАДИ ИСТРАЖИВАЧ), (ЕДУ)

*Војислав Вујичић, Факултет техничких наука у Чачку, Универзитет у Крагујевцу, Србија*
*Марко Шуњуровић, Факултет техничких наука у Чачку, Универзитет у Крагујевцу, Србија*
*Милош Божић, Факултет техничких наука у Чачку, Универзитет у Крагујевцу, Србија*
*Марко Росић, Факултет техничких наука у Чачку, Универзитет у Крагујевцу, Србија*
*Мирослав Бјекић, Факултет техничких наука у Чачку, Универзитет у Крагујевцу, Србија*

У овом раду представљен је пумпни систем реализован на Факултету техничких наука у Чачку. Систем се састоји од резервоара, трофазне вишестепене центрифугалне пумпе, фреквентног претварача, преливног (бајпас) и пригушног вентила. Помоћу сензора притиска и протока који су постављени на цевоводу врши се аквизиција на основу које се могу одредити параметри пумпног система, и помоћу којих се може вршити регулација протока и притиска. Процедура извођења лабораторијских вежби и добијени резултати са коментарима приказани су у експерименталном делу рада.

EE1.2

## OPTIMIZACIJA PRIMENE V2G TEHNOLOGIJE U MIKROMREŽI SA OBNOVLJIVIM IZVORIMA ENERGIJE (MLADI ISTRAŽIVAČ)

*Dario Javor, Elektronski fakultet, Univerzitet u Nišu, Srbija*
*Nebojša Raičević, Elektronski fakultet, Univerzitet u Nišu, Srbija*

U radu je prikazan postupak optimizacije funkcije troškova električne energije u slučaju korišćenja obnovljivih izvora energije u mikromreži povezanoj s mrežom za napajanje. Mikromreža ima mogućnosti punjenja i pražnjenja električnih vozila tj. omogućena je efikasna upotreba njihovih baterija za skladištenje energije. U slučajevima korišćenja vetrogeneratora i fotonaponskih panela ostvaruju se različite uštede troškova. Za rešavanje optimizacionih problema korišćen je program Lingo.

EE1.3

## OSETLJIVOST GREŠKE DINAMIČKE ESTIMACIJE STANJA NA PROMENE POJEDINIH PARAMETARA KALMANOVOG FILTRA

*Dragan Ćetenović, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Srbija*
*Aleksandar Ranković, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Srbija*

U kvazistacionarnom režimu rada distributivne mreže matrica kovarijansi grešaka dinamičkog modela Q obično se modeluje kao vremenski nepromenljiva u dijagonalnoj formi sa svim elementima na dijagonali međusobno jednakim, što dovodi do jednoparametarskog modela matrice. U tom slučaju se podešavanje matrice kovarijansi Q svodi na podešavanje jednog jedinog parametra q . Tačnost dinamičke estimacije stanja uslovljena je izborom vrednosti ovog parametra, ali i izborom inicijalnog rešenja, gde se pod inicijalnim rešenjem podrazumeva inicijalni vektor stanja 0 + x i njemu pripadajuća matrica kovarijansi 0 + P . Cilj ovog rada je detaljno ispitati simultano dejstvo parametra q i inicijalnog rešenja na kvalitet dinamičke estimacije. Analize su sprovedene na modifikovanom IEEE distributivnom test sistemu sa 13 i 123 čvora korišćenjem EKF i UKF algoritma dinamičke estimacije stanja.

# Electric circuits and systems, and signal processing/ Električna kola, električni sistemi i obrada signala (EK)

## SESSION EK1: ELEKTRIČNA KOLA, ELEKTRIČNI SISTEMI I OBRADA SIGNALA

Utorak/Tuesday, June 4th, 09:00 – 10:00, Sala 2/Hall 2

**Chair: Branimir Reljin, The Academy of Engineering Sciences of Serbia (AESS) and School of Electrical Engineering, University of Belgrade, Belgrade, Serbia**

EK1.1

### GROUP DELAY EQUALIZATION OF DISCRETE BUTTERWORTH TAN FILTERS IN THE CONTINUOUS DOMAIN

*Negovan Stamenković, University in Pristina-Kosovska Mitrovica, Faculty of Science, K. Mitrovica, Serbia,*
*Nikola Stojanović, Faculty of Electronic Engineering, Niš, Serbia*
*Milan Savić, University in Pristina-Kosovska Mitrovica, Faculty of Science, K. Mitrovica, Serbia*

We present new techniques to approximate the magnitude response of discrete Butterworth tan filters with the delay characteristic which is constant in a maximally flat sense. The algorithm is used to obtain stable allpass filter, which acts as a group delay equalizer, with the aim to equalize group delay of the discrete tan filter in a maximal flat sense. The proposed method relies on a set of nonlinear equations, derived directly from the flatness conditions of the group delay response of the equalized filter at the origin in the analog domain, in order to obtain the unknown coefficient values of the discrete allpass filter. The algorithm implemented in the symbolic Matlab platform returns the coefficients of allpass filter. In the given example, firstly we design an discrete tan filter with a maximally flat magnitude at origin, and secondly, we augment the system with cascade connection of non-minimum phase allpass discrete filter, in order for the group delay response of the whole filter to equalize in a maximally flat sense.

EK1.2

### ANALIZA ZNAČAJA DCT KOEFICIJENATA U OBJEKTIVNOJ PROCENI KVALITETA SLIKE ZASNOVANOJ NA PROMENI KONTRASTA

*Nenad Stojanović, Vojna akademija, Univerzitet odbrane u Beogradu, Beograd, Srbija*
*Boban Bondžulić, Vojna akademija, Univerzitet odbrane u Beogradu, Beograd, Srbija, i*
*Ivana Stojanović, Telekom Srbija a.d., Beograd, Srbija*

U radu je dat predlog metode za procenu kvaliteta slike koji se zasniva na poređenju originalne i test slike. Prilikom određivanja vrednosti kvaliteta slike koristi se diskretna kosinusna transformacija, pri čemu se na lokalnom nivou određuje kontrast koji daljim usrednjavanjem daje krajnju vrednost kvaliteta. U radu je pokazano da prilikom proračuna, na krajnju procenu kvaliteta utiče broj korišćenih koeficijenata diskretne kosinusne transformacije. Performanse predložene mere date su kroz linearnu korelaciju i korelaciju rangova sa subjektivnim skorovima kvaliteta nakon testiranja na četiri javno dostupne baze slika, pri čemu su tri baze slika sa višestrukim degradacijama.

EK1.3

### POREĐENJE ZAVISNOSTI VEROVATNOĆE LAŽNOG ALARMA I FAKTORA SKALIRANJA CA-CFAR I OSCFAR DETEKTORA ZA RAZLIČITE TIPOVE KLATERA

*Dušan Ristić, Vojna akademija, Univerzitet odbrane, Beograd, Srbija i*
*Slobodan Simić, Vojna akademija, Univerzitet odbrane, Beograd, Srbija*

U ovom radu je napravljena komparativna analiza CA-CFAR i OS-CFAR detektora. Upoređivali smo odzive CACFAR i OS-CFAR detektora pod identičnim uslovima u različitim tipovima klatera. Pokazali smo koji detektor ima manju verovatnoću lažnog alarma u zavisnosti od vrednosti faktora skaliranja. Poređenje detektora je prikazano na graficima. Za potrebe ovog rada kreirana je GUI aplikacija u programskom paketu MATLAB.

EK1.4

### ФРЕКВЕНЦИЈСКЕ КАРАКТЕРИСТИКЕ ДВА ТОПОЛОШКА УОПШТЕЊА ФРАКЦИОНЕ ЈЕДНАЧИНЕ ТЕЛЕГРАФИЧАРА

*Стеван Цветићанин, Универзитет у Новом Саду, Факултет техничких наука, Нови Сад, Србија,*
*Душан Зорица, Математички институт Српске академије наука и уметности, Београд, Србија*
*Милан Рапаић, Универзитет у Новом Саду, Факултет техничких наука, Нови Сад, Србија*

Једначина телеграфичара уопштена је модификацијом Хевисајдовог елементарног кола тако да се узму у обзир мемориски ефекти феномена поларизације и магнетизације медијума, што је постигнуто фракционим калемом и фракционим кондензатором у елеменентарном колу, уместо класичних. Такође, разматрана су и два тополошка уопштења једначине телеграфичара, која су последица додавања кондензатора у редну грану елементарног кола, а чиме је узет у обзир ефекат нагомилавања наелектрисања дуж вода. Урађена је фреквенцијска анализа модула и аргумента функције преноса, добијене из уопштених фракционих једначина телеграфичара које су последица поменутог тополошког уопштења, укључивањем паралелно и редно додатног кондензатора у редну грану елементарног кола вода.

## SESSION EKI2: ELECTRIC CIRCUITS AND SYSTEMS AND SIGNAL PROCESSING

Utorak/Tuesday, June 4th, 10:00 – 11:00, Sala 2/Hall 2

**Chair: Ana Gavrovska, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia**

EKI2.1

### MULTIFRACTAL IMAGE FORGERY USING LOGISTIC REGRESSION

*Natasa Milosavljevic, State university of Novi Pazar, Serbia*
*Aleksandra Pavlovic, School of Electrical and Computer Engineering of Applied Studies, Serbia*

This paper presents multinomial logistic regression (MLR) using multifractal image data for prediction forgery detection. Multifractal analysis it gives a much smaller number of parameters which are sufficient to describe the image and which in this paper serve for further analysis in order to better forensics. On the basis of these parameters, a MLR method is proposed that will predict the blocks at which the change occurred in the picture.

EKI2.2

## LOW COST SOLUTION FOR LABORATORY CLASS ON FUNDAMENTALS OF WIRELESS COMMUNICATION LINK DESIGN (EDU)

*Milutin Nešić, School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*
*Slavica Marinković, School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*
*Ivan Pavlović, School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*
*Amela Zeković, School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

It is known that drift occurs when the pan/tilt gyro stabilization is turned on. On multi-sensor camera systems, drift is the reason why after a while the observed object is no longer in the centre of the screen and it has a tendency to disappear from the screen. The conclusion is that gyro stabilization is unusable when the field of view is narrow. In this paper, a method for pan/tilt drift detection and its measurement is developed. IMU sensor, which consists of a 3-axis MEMS gyroscope and a 3-axis MEMS accelerometer is used for measuring the system's angular position. Kalman filter is implemented to compensate for the MEMS inertial sensor flaws by combining a gyroscope and accelerometer data.

EKI2.3

## HEALTHCARE IOT MONITORING USING PHOTOPLETHYSMOGRAPHY

*Milan Milivojević, University of Belgrade, ETF, Serbia*
*Ana Gavrovska, School of Electrical Engineering, University of Belgrade, Serbia*
*Irini Reljin, School of Electrical Engineering, University of Belgrade, Serbia*
*Branimir Reljin, School of Electrical Engineering, University of Belgrade, Serbia*

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EKI2.4

## DASH VIDEO USER INTERFACE BASED ON GPU BACKGROUND SUBTRACTION AND OPENCL C++ FRAMEWORK

*Katarina Popović, School of Electrical Engineering, University of Belgrade, Serbia*
*Ana Gavrovska, School of Electrical Engineering, University of Belgrade, Serbia*
*Irini Reljin, School of Electrical Engineering, University of Belgrade, Serbia*

Digital images and video signals are used in everyday life. By developing software, it has become easy to change the content of an existing image, so we can not be sure of the originality of what we see. One of the most famous methods for changing the content of the image is image spilcing. It means that two or more images are created in a new image, or that the content of another image is added to the original image. The use of the inverse multifractal spectrum has proved successful in detecting such changes in the images. The method is tested on images from existing bases, as well as on images generated for research purposes.

# SESSION EKI1: ELECTRIC CIRCUITS AND SYSTEMS AND SIGNAL PROCESSING

Tuesday/Utorak, June 4th, 2019, 14:30 - 16:30, Sala 2/Hall 2

**Chair: Dragana Perić, Vlatacom Institute, Belgrade, Serbia**

EKI1.1

## MRTD MEASUREMENTS ROLE IN THERMAL IMAGER QUALITY ASSESSMENT

*Dragana Perić, Vlatacom Institute, Belgrade, Serbia and*
*Branko Livada, Vlatacom Institute, Belgrade, Serbia*

The MRTD is defined as thermal imager basic parameter that could be theoretically modelled and experimentally assessed in laboratory. The subjective MRTD measurement procedure that is practically implemented is presented. The MRTD theoretical models, possibilities for objective measurements, and alternative MRTD measurement methods are discussed. MRTD measurement results for selected thermal imagers and measurement results post processing for thermal imager range determination are presented.

EKI1.2

## FPGA IMPLEMENTATION OF SELECTIVE PSEUDO COLORING OF THERMAL IMAGE

*Petar Marin, Vlatacom Institute, Belgrade, Serbia,*
*Igor Beracka, Vlatacom Institute, Belgrade, Serbia,*
*Nikola Latinović, Vlatacom Institute, Belgrade, Serbia,*
*Miloš Pavlović, Vlatacom Institute, Belgrade, Serbia, and*
*Miroslav Perić Vlatacom Institute, Belgrade, Serbia*

In this paper we describe Field Programmable Gate Array (FPGA) implementation of a new method for selective pseudo coloring of thermal image. Pseudo coloring is a digital image processing method of coloring gray scale images, imparting a visual appeal and highlighting specific features in the image. Our selective pseudo coloring method colors only features with thermal emissivity in certain range that is controlled within thresholds. Since pseudo coloring is memory intensive task for many embedded video processing platforms our method of pure FPGA implementation has the advantage in execution speed and reduction of processing delay. Experimental results on selected scene have shown improvement in operator ability to spot objects of interest on image when using our pseudo coloring method.

EKI1.3

## REAL-TIME DEAD PIXELS REMOVAL IN THERMAL IMAGING

*Miloš Pavlović, Vlatacom Institute, Belgrade, Serbia,*
*Nataša Vlahović, Vlatacom Institute, Belgrade, Serbia,*
*Miroslav Perić, Vlatacom Institute, Belgrade, Serbia,*
*Aleksandar Simić, Vlatacom Institute, Belgrade, Serbia,*
*Srđan Stanković, School of Electrical Engineering, University of Belgrade and Vlatacom Institute, Belgrade, Serbia*

Video enhancement techniques are very important part of long-range multi-sensor surveillance systems. Infrared sensors are typically affected by nonresponsive pixels, or “dead pixels.” These dead pixels can severely degrade the quality of images and often have to be replaced before subsequent image processing and display of the imagery data. Conventional dead pixel replacement methods (methods for ’salt’ noise reduction) take a lot of processor time and cannot be employed in real-time applications. This paper proposes a real-time infrared imaging dead pixels removal algorithm, applicable to SWIR sensor. Dead pixels reduction is based on Inverse

Distance Weighting (IDW) algorithm applied only on positions of dead pixels. Also, paper provides comparison of IDW algorithm with the most commonly used techniques in literature - median filtering. All the techniques are tested on experimental data.

EKI1.4

## A NOVEL APPROACH FOR PAN/TILT DRIFT DETECTION IN GYRO STABILIZED SYSTEMS USING IMU SENSORS

*Petar Milanović, Vlatacom Institute, Belgrade, Serbia,*
*Marko Nerandžić, Vlatacom Institute, Belgrade, Serbia,*
*Medhat Abdelrahman Mohamed Mostafa, European University of Belgrade, Belgrade, Serbia*
*Ilija Popadić, Vlatacom Institute, Belgrade, Serbia,*
*Miroslav Perić, Vlatacom Institute, Belgrade, Serbia.*

It is known that drift occurs when the pan/tilt gyro stabilization is turned on. On multi-sensor camera systems, drift is the reason why after a while the observed object is no longer in the centre of the screen and it has a tendency to disappear from the screen. The conclusion is that gyro stabilization is unusable when the field of view is narrow. In this paper, a method for pan/tilt drift detection and its measurement is developed. IMU sensor, which consists of a 3-axis MEMS gyroscope and a 3-axis MEMS accelerometer is used for measuring the system's angular position. Kalman filter is implemented to compensate for the MEMS inertial sensor flaws by combining a gyroscope and accelerometer data.

EKI1.5

## REQUIREMENTS ANALYSIS FOR ADAS PERCEPTION IN BAD VISIBILITY CONDITIONS

*Nedeljko Padjen, Vlatacom Institute, Belgrade, Serbia,*
*Nikola Latinović, Vlatacom Institute, Belgrade, Serbia,*
*Dragana Perić, Vlatacom Institute, Belgrade, Serbia,*
*Milan Milosavljević, Singidunum university, Belgrade, Serbia*

In this paper we elaborate on requirements that are imposed on the vision system that should be used for ADAS perception. In order to fulfill its task of perception under all visibility conditions, we are taken into consideration bad visibility scenarios, that can be met due to fog, rain, snow etc. We analyze the range and the resolution issues of solution based on sensor fusion of different type of sensors like LWIR, SWIR imagers, SWIR LIDARs supported by MIMO Radar. The goal of this analysis is to set the guidelines for selection of appropriate system components.

EKI1.6

## ADAPTIVE KALMAN FILTERING USING M-ROBUST DYNAMIC STOCHASTIC APPROXIMATION COMBINED WITH ROBUST MEDIAN ESTIMATION

*Zoran Banjac, Vlatacom Institute, Belgrade, Serbia*
*Željko Đurović, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*
*Branko Kovačević, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia.*

One of the most significant achievement of the linear estimation theory is the Kalman filtering. In this paper, the problem of robustifying the Kalman filter in the presence of unknown noise statistics has been considered starting from the equivalence between the linear estimation problem and a specific form of dynamic stochastic approximation, M-robust statistical approach is used to robustifying the Kalman filter. The proposed approach includes the modified M-robust performance index based on the mean square optimal prediction of the expected changes in the system states, together with the given output measurements. The M-robust dynamic stochastic approximation algorithm is derived from step-by-step minimization of the adopted criterion. In order to improve the convergence rate, the gain matrix of the algorithm is derived from step-by-step minimization of the prespecified mean square error criterion. In addition, robust median

estimations are derived for adaptive estimation of the unknown state and observation noise statistics, simultaneously with the system states. A real life examples of maneuvering target tracking is presented to demonstrate the practical robustness of the proposed adaptive robustifying Kalman filter.

EKI1.7

## DESIGN, ANALYSIS, VALIDATION, AND REPORTING OF CONTINUOUS-TIME SYSTEMS USING CAS

*Miroslav Lutovac, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia,*
*Maja Lutovac-Banduka, RT-RK Computer Based Systems, Novi Sad, Serbia,*
*Aleksandra Pavlović, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

The automated symbolic manipulations are presented according to user preferences in such a way that all representations (mathematical, graphical, as net-list, software code, or time-domain and frequency domain responses) are obtained from the same visual system description using computer algebra system (CAS) as add-ons for extending software environment. The paper is devoted to researchers and scientist using basic electrical engineering tasks, so that time-consuming tasks are automated in software and the properties of the systems can be discovered, and optional conditions or discovered properties can be used for synthesis, verifications, simulations, and optimization with real parameters. All derived properties are available as closed-form relations, which can help the faster design of robust systems.

EKI1.8

## IMPLEMENTATION OF IIR DIGITAL FILTERS WITH VARIABLE CHARACTERISTICS IN GNU OCTAVE

*Darko Vračar, School of Electrical Engineering, University of Belgrade, Serbia, Huawei Technologies Duesseldorf GmbH, Munich, Germany,*

Implementation of IIR digital filters with variable characteristics in GNU Octave software is presented. The method for tuning the cut-off frequency with one parameter is based on series expansion of the low-pass-low-pass frequency transformation. The filter structure is a parallel connection of real or complex all-pass sections. The simulation results are matched with results in the references. In addition, simulation of the example filters in time domain is shown which verifies their design.

# Electronics/
# Elektronika (EL)

## SESSION/SESIJA ELI 1 – ELECTRONIC CIRCUITS AND APPLICATIONS

Wednesday/Sreda, June, 05th, 11:15 – 13:30, Sala 2/Hall 2

**Chair: Bramko Dokić, University of Banja Luka, Faculty of Electrical Engineering, Banja Luka, Bosnia and Herzegovina**
**Paul P. Sotiriadis, School of Electrical and Computer Engineering, National Technical University of Athens, Greece**

ELI1.1

ADVANCES IN SIGMA-DELTA MODULATION FOR ALL-DIGITAL TRANSCEIVERS (INVITED PAPER)

*Paul. P. Sotiriadis, School of Electrical and Computer Engineering, National Technical University of Athens, Greece*

All-digital radio frequency (RF) circuit design is a modern architectural trend aiming at replacing the classical analog RF blocks with purely-digital or almost-digital ones, taking advantage of the many attractive design and operating properties of digital circuits. A major aspect in all RF systems is signal generation which is done traditionally using phase-locked-loops, direct digital synthesizers and high-speed digital-to-analog converters. Removing the analog and mixed-signal circuit blocks and converting classical architectures to all-digital ones, or inventing new all-digital ones directly, depends on one fundamental aspect: the representation of information in single-bit digital form. Sigma-delta modulation (SDM) with single-bit quantization is the right tool to achieve it. Recent advances on SDM for all-digital transceivers will be presented including Homodyne SDM, Phase and Polar SDM, Multi-Step Look-Ahead SDM and their applications in baseband and RF signal generation.

ELI1.2

THE IMPLEMENTATION OF PEAK WINDOWING TECHNIQUE

*Borisav Jovanović, Faculty of Electronic Engineering Niš, University of Niš, Serbia*
*Srđan Milenković, Faculty of Electronic Engineering Niš, University of Niš, Serbia*

The implementation of Peak Windowing method for Peak to Average Power Reduction (PAPR) is presented in the paper. The architecture is based on a FIR filter. The results of PAPR measurement are presented for Long-Term Evolution (LTE) and Wideband Code Division Multiple Access (WCDMA) waveforms

ELI1.3

DESIGN SPACE EXPLORATION IN ADVANCED CMOS PROCESS: IIR FILTER CASE STUDY

*Dejan Mirković, Faculty of Electronic Engineering Nis, University of Nis, Serbia*
*Milena Stanojlović Mirković, Innovation Centre of Advanced Technologies, Serbia*

This paper deals with ever increasing complexity of digital integrated circuits design in advanced CMOS process. Concretely, hardware synthesis of IIR filter in 45nm CMOS process is considered. Filter synthesis procedure, starting form specs all the way to the generation of HDL code, is exemplified though the design of simple, third order, all-pole, selective IIR filter. Two options for standard cells under worst case conditions are examined with the help of custom

written tcl scrip for early design space exploration. Obtained results gives valuable information crucial for searching of optimal synthesis solution in target CMOS process.

ELI1.4

## CLASSIFICATION OF NONLINEAR LOADS USING CURRENT SPECTRUM

*Marko Dimitrijević, Faculty of Electronic Engineering Niš, Serbia*
*Miona Andrejević Stošović, Faculty of Electronic Engineering, Serbia*
*Dejan Stevanovic, Innovation Centre, School of Electrical Engineering in Belgrade (ICEF), Serbia*

One of the most prominent characteristics of nonlinear loads is existence of the higher harmonics in current spectrum. They cause losses and disturbance in power grid; thus, the power factor must be generalized to a total or true power factor where the apparent power, involved in its calculations, includes all harmonic components. Nevertheless, harmonic components of the current spectrum can be regarded as specific "signature" of some nonlinear load, therefore providing the means for identifying classes of nonlinear loads connected to the power grid. In this paper, we will present the method for identifying and classification of nonlinear loads using harmonics' amplitudes as inputs for the artificial neural network.

ELI1.5

## A FLEXIBLE FPGA-BASED DATA ACQUISITION SYSTEM WITH INTEGRATED ADCS AND 32-BIT RISC-V SOFTCORE

*Nikola Petrović, School of Electrical Engineering, University of Belgrade, Serbia*
*Vladimir Milovanović, Faculty of Engineering, University of Kragujevac, Serbia*

A general purpose low-cost data acquisition system which includes integrated 12-bit analog-to-digital data converters (ADCs) and a 32-bit RISC-V soft microprocessor implemented on an FPGA-fabric is presented. Major part of the proposed system is not conceived as an instance, but rather as a design generator and is hence described in Chisel hardware construction language. The use of such a modern generator-oriented language enables extreme flexibility through comprehensive set of parameters and rapid system customization approach. The open instruction set architecture core that can be exploited for custom data processing is also obtained from the free Rocket System-on-Chip generator together with a standard set of peripherals thus supporting various connectivity interfaces and protocols. A prototype data acquisitioner is built around commercially-available Arty development platform which features internal 1$\,\text{MSPS}$ dual-channel ADC and its operation as a low-end oscilloscope is demonstrated.

ELI1.6

## STRESSING ISSUE OF A PIEZOCERAMIC CYLINDER WITH RADIAL POLARIZATION

*Igor Jovanović, University of Niš, Faculty of Electronic Engineering, Serbia*
*Ljubiša Perić, Regional Chamber of Economy Niš, Serbia*
*Ugljesa Jovanovic, University of Niš, Faculty of Electronic Engineering, Serbia*
*Dragan Mančić, University of Niš, Faculty of Electronic Engineering, Serbia*

This paper presents a general case of stressing a circular-ring cross-sectional cylinder with a radial type of polarization. It is assumed that the cylinder is infinitely long in direction of the z-axis and that the componential strain in that direction is equal to zero. By applying the equations of electroelasticity in polar-cylindrical coordinates as well as satisfying electrical boundary conditions for the electric potential and mechanical boundary conditions for the mechanical stress of a cylinder with a radial type of polarization, componential displacements in radial direction are determined for the piezoceramic cylinder made from PZT4 piezoceramic material.

ELI1.7

IMPROVING THE PRODUCTION EFFICIENCY BY USING THE INFINITYQS - A REAL-TIME SPC SOFTWARE

*Miljana Milic, University of Nis, Faculty of Electronic Engineering, Serbia*
*Zoran Milic, bul. Nikole Tesle 21/16, Nis, Serbia, Serbia*
*Alex Crittenden, 6133 Timberwood Lane, Texarkana, AR 71854, USA, United States*

Statistical process control (SPC) is a method of production process quality control which employs statistical calculations to monitor the manufacturing process, and keep it under control. InfinityQS is a software solution which enables implementation of a real-time SPC. The idea is to collect a real-time data obtained from sensors and statistically process it in order to obtain a real-time image of the process. This software is spatialized in this field allowing for and easy data connectivity, and a real-time reporting/charting. Among numerous features, the most useful are basic SPC control charts. Control limits, specification limits, target values, mean values, and process capability indicators are measured/calculated and displayed on the control chart. This allows for a very effective visual recognition of situations where process is out of control, and immediate detection and action can be initiated to prevent catastrophic failures in machinery, and minimization of scrap. The software also facilitates actions which will eliminate special i.e. systematic causes of variations in parameters of the process, and make it stable and predictive, i.e. under control.

## SESSION/SESIJA ELI 2 – ELECTRONIC CIRCUITS AND APPLICATIONS

Wednesday/Sreda, June, 05th, 14:30 – 16:30, Sala 2/Hall 2

**Chair: Predrag Petković, University of Niš, Faculty of Electronic Engineering, Serbia**
**Ivan Popović, School of Electrical Engineering, University of Belgrade, Serbia**

ELI2.1

SENSOR NODE ARCHITECTURE FOR NETWORK CONTROL APPLICATIONS

*Ivan Popović, School of Electrical Engineering, University of Belgrade, Serbia*
*Aleksandar Rakić, School of Electrical Engineering, University of Belgrade, Serbia*
*Wenjun Zhang, School of Communication and Information Engineering, Shanghai University, China*
*Minrui Fei, School of Mechatronic Engineering and Automation, Shanghai University, China*
*Chen Peng, School of Mechatronic Engineering and Automation, Shanghai University, China*
*Dajun Du, School of Mechatronic Engineering and Automation, Shanghai University, China*

A novel architecture for sensor nodes is presented for specific application in networked control systems, where basic sensing and data acquisition functionalities are tied to several other and equally important functionalities regarding time-related services and middleware support for data transfer over the network. The main benefits of the proposed service-oriented architecture can be found in the domain of simplified design of the sensor node as well as its integration within the networked control systems.

ELI2.2

EXPLORING THE LIMITS OF HARDWARE/SOFTWARE CO-DESIGN

*Haris Turkmanović, School of Electrical engineering, Serbia*
*Filip Mijušković, School of Electrical engineering, Serbia*
*Ivan Popović, School of Electrical engineering, Serbia*

Various software and hardware techniques have been developed to improve operational properties of an embedded system. In this paper we investigate the potential of hardware/software

co-design in the domain of system execution performance. As a target application domain, we selected a class of multimedia applications characterize with extensive number of memory operations. In order to analyze the effectiveness of hardware/software co-design we introduced embedded system metric parameters for the quantification of system execution performance and its hardware complexity. The profiling of system performance was conducted for different hardware configurations build on FPGA platform while executing several characteristic control flow structures. The analysis has revealed the significant potential of hardware/software co-design in the domain of embedded system optimization.

ELI2.3

## ANALYZING THE THERMAL IMAGING HISTOGRAM USING FPGA

*Igor Beracka, Vlatacom, Serbia*
*Petar Marin, Vlatacom, Serbia*
*Nikola Latinović, Vlatacom, Serbia*
*Ilija Popadić, Vlatacom, Serbia*
*Miroslav Perić, Vlatacom, Serbia*

In this paper we have described a practical implementation in Field Programmable Gate Array (FPGA) technology of histogram calculation for thermal image. Thermal image shows the infrared radiation of the objects so we can see them in complete darkness. Separating the objects of interest in thermal image can be achieved by correcting the brightness and contrast of the raw image. The information from the histogram of image can be used for good adjustment of the correction parameters. Histogram also shows us which part of the picture contains most information, so it is very important for good implementation of picture compression. We have shown practical results from laboratory testing.

ELI2.4

## DESIGN AND REALIZATION OF A CLASS EF2 POWER AMPLIFIER WITH GAN FET

*Zoran Zivanovic, IMTEL KOMUNIKACIJE AD, Serbia*
*Vladimir Smiljakovic, IMTEL KOMUNIKACIJE AD, Serbia*

This paper presents the design of a high frequency class EF2 switch-mode power amplifier optimized for 50 ohm load at 13.56MHz. The amplifier basics are briefly explained, including simplified schematics. The prototype has been built and experimental results are presented to support theoretical analysis and to demonstrate the amplifier performance. This practical realization utilizes the newest GaN FET in a low inductance package with small parasitic capacitances capable of switch mode operation up to 50MHz. Previously, the GaN transistors have become widely used in high frequency switching power converters.

# Metrology/
# Metrologija (ML)

## SESIJA ML1

Ponedeljak/Monday, June, 3rd, 09:00 – 11:00, Sala 4/Hall 4

**Predsedavajući: Platon Sovilj, Fakultet Tehničkih Nauka, Novi Sad, Srbija**

ML1.1

### SISTEM ZA DETEKCIJU POŽARA ZASNOVAN NA MIKROPROCESORSKIM MERNIM MODULIMA

*Milan Šaš, Faculty of Technical Sciences, Serbia*
*Đorđe Novaković, Faculty of Technical Sciences, Serbia*

Ovaj rad prikazuje sistem za detekciju požara, zasnovan na mikroprocesorskom razvojnom sistemu EasyPIC Pro v7, sa mikrokontrolerom PIC18F87K22. Kao senzore za detekciju odabranih parametara koriste se SMOKE click (MIKROE-2560) baziran na MAX30105 senzoru za detektovanje dima, FLAME click (MIKROE-1820) baziran na PT334-6B senzoru za detektovanje dima i CO click (MIKROE-1626) koji koristi MQ-7 senzor za merenje koncetracije ugljen-monoksida.

ML1.2

### MEASURING EMG SIGNAL WITH EMG CLICK AND ARDUINO UNO

*Nemanja Peruničić, Faculty of Technical Sciences, Serbia*
*Đorđe Novaković, Faculty of Technical Sciences, Serbia*

This paper gives an insight into the basics of gathering and processing of bioelectric signals generated by our skeletal muscles. Two-part system is used as a technical solution, and the end result is shown on a computer. Signal acquisition is done with a specially designed EMG click board, and its digitization using Arduino UNO's ATmega328P microcontroller. When programming Arduino it is vital to pay attention to the hardware elements and theoretical principles on which the measurement is based; otherwise, false results will be presented – so a part of the paper is dedicated to overcoming them. The third chapter includes the complete code for running Arduino.

ML1.3

### ACQUISITION OF BCG SIGNAL BY PIEZOELECTRIC SENSOR

*Jovana Jevremov, Faculty of Technical Sciences, Serbia*
*Đorđe Novaković, Faculty of Technical Sciences, Serbia*
*Platon Sovilj, Faculty of Technical Sciences, Serbia*

The main idea of this paper was to construct very simple device whose function would be an acquisition of a signal obtained by piezoelectric sensor placed on a pulsating blood vessel. This would enable the simple solution for tracking the number of heartbeats in a period of time. Tracking the number of heartbeats in a period of time is a wide spread functionality used by a great number of sporting aids such as smart bracelets and smart watches, as well as many click boards and even mobile applications.

ML1.4

## SMART HOME SISTEM ZASNOVAN NA MIKROPROCESORSKIM MERNIM MODULIMA

*Duško Gajinović, Faculty of Technical Sciences, Novi Sad, Serbia*

Ovaj rad prikazuje sistem, koji vrši očitavanje nekoliko senzorskih modula koristeći microBUS koji je baziran na I2C protokolu, kao i očitavanje vrednosti sa analognih senzora. Sistem je realizovan na EasyPIC Pro V7 ploči sa PIC18F87K22 mikrokontrolerom. Senzorski moduli u ovom sistemu su Weather Click koji je baziran na senzoru BME-280 za očitavanje temperature, atmosferskog pritiska i vlažnosti vazduha, kao i Proximity Click koji koristi VCNL4010 za detektovanje korisnika ispred glavne konzole. Takodje se koriste i analogni senzori LM35 za merenje temperature u pojedinačnim prostorijama. Zatim mikrokontroler vrši obradu svih očitanih signala, i prikazuje ih na 128x64 GLCD ekranu sa TouchPanel-om. Osim prikazivanja očitanih podataka, GLCD služi i za upravljanje rasvetom u pojedinačnim prostorijama kuće, kao i otključavanje i zaključavanje ulaznih vrata.

ML1.5

## AMPLIFIER FOR MEASUREMENT OF EMG VOLTAGE

*Natalija Vukosavljević, Faculty of technical sciences, Serbia*
*Đorđe Novaković, Faculty of technical sciences, Serbia*

Measurement of low-level voltages is one of the challenges in metrology. The representatives of these voltages in biomedical measurement problems are EEG, ECG, EOG and EMG voltages. Focus of this paper will be the structure and the functioning of an amplifierintended for measurement of EMG voltage, as a representative of low-level voltage. First, the principles and functions of electromyography will be described, then the components of the EMG amplifier, practical realization of the amplifier and its connecting with a microcontroller.

ML1.6

## ANALYSIS, CIRCUIT AND FIRMWARE DESIGN FOR GSR SIGNAL ACQUISITION

*Rosa Ružičić, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Đorđe Novaković, Faculty of Technical Sciences, University of Novi Sad, Serbia*

In this paper we propose analysis and analog circuit design for GSR (galvanic skin response), microcontroller firmware used for data acquisition which communicates data to the computer via UART line for the further processing as well as the potential GSR use case.

ML1.7

## IMPLEMENTACIJA PID REGULATORA POMOĆU MIKROPROCESORSKIH MERNO-REGULACIONIH MODULA

*Žarko Dubajić, FTN, Serbia*
*Đorđe Novaković, FTN, Serbia*

Ovaj rad prikazuje implementaciju PID regulatora u mikroelektronici, koristeći razvojni sistem EasyPIC Pro v7, sa mikrokontrolerom PIC18F87K22. Vrši se regulacija brzine obrtanja elektronotora. Kao senzor za detekciju okretanja osovine elektromotora koristi se inkrementalni enkoder. Za generisanje PWM signala za upravljanje koristi se DC MOTOR 4 click.

## SESIJA ML2

Ponedeljak/Monday, June, 3rd, 11:15 – 13:30, Sala 4/Hall 4

**Predsedavajući: Nemanja Gazivoda, Faculty of Technical Sciences, Novi Sad, Serbia**

ML2.1

### MEASUREMENT IN FOURIER DOMAIN – A NATURAL METHOD OF BIG DATA VOLUME REDUCTION

*Vladimir Vujicic, Entrepreneur Consultant in Electrical Engineering and Energetics, Novi Sad, Serbia, Serbia*
*Matija Sokola, University of Warwick, Warwick Manufacturing Group, Warwick, United Kingdom*
*Aleksandar Radonjic, Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Serbia*
*Platon Sovilj, University of Novi Sad, Serbia*

The paper presents an idea of a measurement in a Fourier domain by a means stochastic digital measurement method (SDMM) as a natural and logical way to reduce the amount of big data in for processing in real time. The measurement method is explained and its application to the power and energy measurements in the power grid is briefly described.

ML2.2

### LABVIEW-ARDUINO UNO TEMPERATURE MEASURING SYSTEM

*Josif Tomić, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Miodrag Kušljevic, Termoelektro Enel AD,Uralska 9, Beograd, Serbia*
*Platon Sovilj, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Vladimir Rajs, Faculty of Technical Sciences, University of Novi Sad, Serbia*

Today's modern measuring technique is based on the implementation of microprocessor-supported measurement and information systems. The low price of computing and electronic components has led to measuring devices becoming software-oriented. The main emphasis is placed on the realization of complex mathematical algorithms, over sampled physical signals that were converted into electricity or voltage. The same case applies to temperature measurements. The temperature is undoubtedly the most widely measured physical size and there is a very large number of measuring methods and sensors that can precisely measure this size. Unfortunately, many temperature sensors have non-linear characteristics, so complex numerical formulas need to be applied to get the exact values. This paper presents a microprocessor measuring device for measuring and calibrating temperature sensors from silicon. The system is characterized by simplicity, low price and satisfactory accuracy. The device was realized with the Arduino UNO card and the program is written in the LabVIEW software package, using the LIFA library of functions.

ML2.3

### PRILOG ETALONIRANJU SILOTERMOMETARA

*Ivan Gutai, Faculty of Technical Sciences, Novi Sad, Serbia*
*Bojan Vujičić, Faculty of Technical Sciences, Novi Sad, Serbia*
*Nemanja Gazivoda, Faculty of Technical Sciences, Novi Sad, Serbia*

U ovom radu se daje jedan primer postupka etaloniranja silotermometara, koje se sprovodi na objektu na terenu. Prikazane su najbolje mogućnosti merenja, opisana je priprema za merenje, navedena je merna oprema koja se koristi, opisani su postupci merenja koje treba sprovesti i prikazana je obrada dobijenih rezultata.

ML2.4

## PRILOG ETALONIRANJU POKAZNIH NAPRAVA TERMOMETARA SA OTPORNIM SONDAMA

*Stefan Mirković, University of Novi Sad, Serbia*
*Nemanja Gazivoda, University of Novi Sad, Serbia*
*Bojan Vujičić, University of Novi Sad, Serbia*
*Đorđe Novaković, University of Novi Sad, Serbia*
*Platon Sovilj, University of Novi Sad, Serbia*

U radu je izložen primer postupka etaloniranja pokaznih naprava termometara sa otpornim sondama metodom poređenja u uslovima unutar i u uslovima van metrološke laboratorije. Prikazane su najbolje mogućnosti merenja, opisana je priprema za merenje, navedena je merna oprema koja se koristi, opisani su postupci merenja koje treba sprovesti i prikazana je obrada dobijenih rezultata

ML2.5

## A CONTRIBUTION TO THE CALIBRATION OF DIRECT READING THERMOMETERS IN THE LABORATORY/PRILOG ETALONIRANJU TERMOMETARA SA DIREKTNIM OČITAVANJEM U LABORATORIJSKIM USLOVIMA

*Marina Bulat, FTN Novi Sad, Serbia*
*Nemanja Gazivoda, FTN Novi Sad, Serbia*
*Ivan Gutai, FTN Novi Sad, Serbia*
*Bojan Vujicic, FTN Novi Sad, Serbia*
*Djordje Novakovic, FTN Novi Sad, Serbia*
*Platon Sovilj, FTN Novi Sad, Serbia*

The paper presents an example of the procedure for the calibration of direct reading thermometers in the Laboratory. It demonstrates the optimal ways of measuring. In addition, it offers a description of the preparation for measuring and lists the measuring equipment that has been used. It also features a description of the measuring procedures that need to be applied and it shows the processing of the measurement results. It provides the examples illustrating the application of this instruction manual. All the terms and definitions meet the requirements of SRPS ISO/IEC 9000:2001, SRPS ISO/IEC 17025:2006 and follow International Vocabulary of Basic and General Terms in Metrology. U ovom radu je dat primer postupka etaloniranja termometara sa direktnim očitavanjem u Laboratoriji za metrologiju Fakulteta tehničkih nauka u Novom Sadu (u daljem tekstu samo Laboratorija). Prikazane su najbolje mogućnosti merenja, opisana je priprema za merenje i navedena je merna oprema koja je korišćena. Opisani su postupci merenja koji treba da se sprovedu i prikazana je obrada dobijenih rezultata. Dati su primeri koji ilustruju primenu ovog uputstva. Svi termini i definicije su u skladu sa SRPS ISO/IEC 9000:2001, SRPS ISO/IEC 17025:2006 i Međunarodnim rečnikom osnovnih i opštih termina u metrologiji.

ML2.6

## PRILOG ETALONIRANJU ČITAČA DOZIMETARA

*Marina Bulat, FTN Novi Sad, Serbia*
*Nemanja Gazivoda, Faculty of Technical Sciences, Serbia*
*Ivan Gutai, Faculty of Technical Sciences, Novi Sad, Serbia*
*Bojan Vujicic, FTN, Serbia*
*Dragan Pejić, Fakultet tehničkih nauka, Serbia*
*Marjan Urekar, Fakultet tehnickih nauka, Serbia*

U ovom radu je dat postupak etaloniranja čitača dozimetara u Laboratoriji za metrologiju Fakulteta tehničkih nauka u Novom Sadu. Prikazane su najbolje mogućnosti merenja, opisana je

priprema za merenje i navedena je merna oprema koja se koristi. Opisani su postupci merenja koje treba sprovesti, prikazana je obrada dobijenih rezultata i određena je forma procene merne nesigurnosti. Dat je primer etaloniranja čitača dozimetara. Svi termini i definicije su u skladu sa JUS ISO/IEC 9000:2001, SRPS ISO/IEC 17025:2017 i Međunarodnim rečnikom osnovnih i opštih termina u metrologiji.

ML2.7

## PRILOG ETALONIRANJU POKAZNIH NAPRAVA TERMOMETARA SA TERMOPAROVIMA

*Stefan Mirković, Faculty of Technical Sciences, Serbia*
*Nemanja Gazivoda, Faculty of Technical Sciences, Serbia*
*Bojan Vujičić, Faculty of Technical Sciences, Serbia*
*Đorđe Novaković, Faculty of Technical Sciences, Serbia*
*Platon Sovilj, University of Novi Sad, Serbia*

Ovaj rad opisuje postupak etaloniranja pokaznih naprava termometara sa termoparovima metodom poređenja u uslovima unutar i u uslovima van metrološke laboratorije. Prikazane su najbolje mogućnosti merenja, opisana je priprema za merenje, navedena je merna oprema koja se koristi, opisani su postupci merenja koje treba sprovesti i prikazana je obrada dobijenih rezultata

ML2.8

## WEB-BAZIRANI MERNI SISTEMI – PRIMER EDUKATIVNOG FRONT-ENDA

*Ivan Gutai, Faculty of Technical Sciences, Novi Sad, Serbia*
*Đorđe Novaković, Faculty of Technical Sciences, Novi Sad, Serbia*
*Platon Sovilj, Faculty of Technical Sciences, Novi Sad, Serbia*
*Dragan Pejić, Faculty of Technical Sciences, Novi Sad, Serbia*
*Marina Bulat, Faculty of Technical Sciences, Novi Sad, Serbia*
*Nemanja Gazivoda, Faculty of Technical Sciences, Serbia*

Metrološki lanac, razvojem informaciono-komunikacionih tehnologija i evolucijom merne instrumentacije od analognih mernih instrumenta do složenih merno-informacionih sistema, vremenom je usložnjen. Bitni segmenti tog lanca su različiti moduli merno-informacionih sistema, uključujući i front-end module. U ovom radu je prikazan primer front-end modula koji omogućava prikaz rezultata merenja sa sedam različitih senzora uz prilagodljiv dizajn koji omogućava preglednost i sa računara, ali i sa prenosnih uređaja. Svaki senzor ima zaseban panel, na visokim rezolucijama se prikazuju dva u istom redu, dok se na prenosnim uređajima slažu jedan ispod drugog. Svaki panel prikazuje listu svih rezultata merenja i vreme kada su merenja izvršena, a istovremeno se i radi lakšeg nadzora prikazuje i grafik sa svim vrednostima. Svaki od osnovnih primera koji sadrže programski kod u JavaScript-u, koji se daju kao dodatak uz ovaj rad, pored edukativnog karaktera su predviđeni i da se savladaju za manje od 15 minuta, što čini celu ovu zamisao kompatibilnom sa osnovnim principima tzv. Microlearning-a.

## SESIJA ML3

Ponedeljak/Monday, June, 3rd, 14:30 – 16:30, Sala 4/Hall 4

**Predsedavajući: Dragan Denic, University of Niš, Faculty of Electronic Engineering, Serbia**

ML3.1

### MEĐUPROVERA EMC ANALIZATORA SPEKTRA IZMEĐU DVA ETALONIRANJA

*Aleksandar Kovačević, Tehnički opitni centar, Serbia*
*Nenad Munić, Tehnički opitni centar, Serbia*
*Veljko Nikolić, Tehnički opitni centar, Serbia*
*Ljubiša Tomić, Vojnotehnički institut, Serbia*
*Ivana Kostić, Tehnički opitni centar, Serbia*

Međuprovera EMC analizatora spektra između dva etaloniranja prikazana je u ovom radu. Međuprovera je bila potrebna da bi se održalo poverenje u status etaloniranja EMC analizatora spektra. Pri tome, ta provera se obavlja u skladu sa utvrđenom procedurom.

ML3.2

### AUTOMATIZATION OF MEASUREMENT FOR IMMUNITY LEVEL TO CONDUCTED DISTURBANCES

*Nenad Munić, Technical Test Center, Serbia*
*Aleksandar Kovačević, Technical Test Center, Serbia*
*Vladimir Jokić, Technical Test Center, Serbia*
*Veljko Nikolić, Technical Test Center, Serbia*
*Ljubiša Tomić, MILITARY TECHNICAL INSTITUTE, Serbia*

Conducted susceptibility is the significant feature for the most of the weapons and military equipment. Requirements and methods for measuring the immunity level are defined by domestic military standards SORS 1029/89 and SORS 1762/89, respectively and there is necessary to modernize in accordance with current international standards in this field. The requirements and methods of domestic military standards for measuring for immunity level to conducted disturbances in the laboratory for the EMC measurements of Technical Test Center have been harmonized to the MIL-STD-461F standard. The measurement methods have been adapted to the available measuring laboratory's equipment. In this paper, the development of an automatization of measurement for immunity level to conducted disturbances will be gradually shown, through a special review of the following phases: calibration and testing.

ML3.3

### LINEARIZACIJA NTC TERMISTORA DVOSTEPENIM DEO-PO-DEO LINEARNIM A/D KONVERTOROM KOMPAKTNOG DIZAJNA

*Jelena Jovanović, University of Niš, Faculty of Electronic Engineering, Serbia*
*Dragan Denic, University of Niš, Faculty of Electronic Engineering, Serbia*

U ovom radu predstavljen je kompaktan dizajn dvostepenog deo-po-deo linearnog A/D konvertora koji je primenjen za linearizaciju NTC termistora. Preciznije, ovim A/D konvertorom linearizuje se napon na izlazu serijsko-paralelnog razdelnika napona koji sadrži NTC termistor. Kompaktnost ovog konvertora se odnosi na upotrebu manjeg broja komparatora, što za posledicu ima smanjenje dimenzija kola i manju potrošnju energije. Kompaktnost se postiže time što oba stepena konverzije obavlja jedan isti fleš A/D konvertor sa dve različite lestvičaste mreže otpornika, svaka upotrebljena za po jedan stepen konverzije. Dakle, ovaj dvostepeni A/D konvertor ima istu rezoluciju u oba stepena konverzije. Kompenzacija nelinearnosti pomenutog napona se vrši u prvom stepenu konverzije na taj način što je prenosna funkcija prvog stepena deo-po-deo linearna aproksimacija funkcije koja je inverzna zavisnosti izlaznog napona

razdelnika od temperature. Nakon primene predloženog 16-bitnog konvertora za linearizaciju termistora oznake NTSD0XV103FE1B0, proizvođača Murata, na opsegu od -40 do 120°C nelinearnost je iznosila 0.0022%.

ML3.4

## JEDNOSTAVAN I EFIKASAN NAČIN ZA GENERISANJE DVA ANSAMBALA SLUČAJNIH BROJEVA UNIFORMNE RASPODELE SA DEFINISANIM KOEFICIJENTOM KORELACIJE

*Đorđe Novaković, Faculty of technical sciences, Serbia*
*Dragan Pejić, Faculty of technical sciences, Serbia*
*Tatjana Grbić, Faculty of technical sciences, Serbia*
*Stefan Mirković, Faculty of technical sciences, Serbia*
*Marina Bulat, Faculty of technical sciences, Serbia*
*Nemanja Gazivoda, Faculty of technical sciences, Serbia*

U radu je dat prikaz jednostavne i efikasne metode za generisanje dva ansambla slučajnih brojeva uniformne raspodele sa zadatom vrednošću koeficijenta korelacije. Potreba za optimizacijom ovog problema se javlja u okviru primene monte karlo metode za određivanje merne nesigurnosti, u situacijama kada su uticajne veličine međusobno korelisane. S obzirom na vrlo veliki broj ponavljanja koja se zahtevaju radi što bolje ocene merne nesigurnosti primennom monte karlo metode, jasno je da svaka optimizacija doprinosi uštedi računarskih resursa i smanjenju trajanja simulacija.

ML3.5

## SIMULATION MODEL OF A STOCHASTIC FLASH A / D CONVERTER

*Nikola Petrović, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Dragan Pejić, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Marjan Urekar, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Đorđe Novaković, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Nemanja Gazivoda, Faculty of Technical Sciences, University of Novi Sad, Serbia*

Based on the needs for testing the performance of the created system at the Faculty of Technical Sciences, Department of Electrical Measurements, we designed and developed a simulation model of the existing system of stochastic flash A / D converter. A simulation was performed using the MATLAB programming language, which had the task of simulating the operation of the existing system, as well as a combination of various effects on it. Due to the need to simulate a large number of data, it was necessary to perform model optimization and adjustment to the available computer configurations, as well as to store the obtained data, parameters, results and graphics.

ML3.6

## PRIMENA NUMERIČKIH METODA INTEGRACIJE NA RAČUNANJE EFEKTIVNE VREDNOSTI / THE APPLICATION OF NUMERICAL INTEGRATION METHODS FOR DETERMINING THE ROOT MEAN SQUARE VALUE

*Marina Bulat, Fakultet tehnickih nauka, Serbia*
*Stefan Mirković, FTN Novi Sad, Serbia*
*Dragan Pejić, Fakultet tehničkih nauka, Serbia*
*Marjan Urekar, Fakultet tehnickih nauka, Serbia*
*Đorđe Novaković, Fakultet tehničkih nauka, Serbia*
*Nemanja Gazivoda, Faculty of Technical Sciences, Serbia*

Ovaj rad se bavi istraživanjem kvaliteta izračunavanja efektivne vrednosti primenom nekoliko numeričkih metoda u uslovima necelobrojnog odnosa učestanosti odmeravanja i učestanosti signala. Posmatrana su dva nezavisna problema istovremeno. Jedan je kvalitet numeričkog

određivanja integrala kako bi se odredila efektivna vrednost signala, dok je drugi problem necelobrojni odnos učestanosti. Diskretizacija po amplitudi nije razmatrana. This paper explores the quality of the calculation of the root mean square value using several numerical methods in the conditions of the non-integer ratio between sampling frequency and the frequency of the signal. Two independent problems were observed. One of them is the quality of the numerical assessment of integrals in order to determine root mean square. The other one is the non-integer ratio. The amplitude discretization has not been considered.

ML3.7

## PRILOG ETALONIRANJU TERMOMETARA SA DIREKTNIM OČITAVANJEM U TERENSKIM USLOVIMA/A CONTRIBUTION TO THE CALIBRATION OF DIRECT READING THERMOMETERS OUTSIDE THE LABORATORY

*Marina Bulat, Faculty of Technical Sciences, Novi Sad, Serbia*
*Nemanja Gazivoda, Faculty of Technical Sciences, Serbia*
*Ivan Gutai, Faculty of Technical Sciences, Novi Sad, Serbia*
*Bojan Vujicic, FTN, Serbia*
*Đorđe Novaković, Fakultet tehničkih nauka, Serbia*
*Marjan Urekar, Fakultet tehnickih nauka, Serbia*

U ovom radu je dat primer postupka etaloniranja termometara sa direktnim očitavanjem van Laboratorije za metrologiju Fakulteta tehničkih nauka u Novom Sadu (u daljem tekstu samo Laboratorija). Prikazane su najbolje mogućnosti merenja, opisana je priprema za merenje i navedena je merna oprema koju smo koristili. Opisani su postupci merenja koji treba da se sprovedu i prikazana je obrada dobijenih rezultata. Dati su primeri koji ilustruju primenu ovog uputstva. Svi termini i definicije su u skladu sa SRPS ISO/IEC 9000:2001, SRPS ISO/IEC 17025:2006 i Međunarodnim rečnikom osnovnih i opštih termina u metrologiji. The paper presents an example of the procedure for the calibration of direct reading thermometers outside the Laboratory. It demonstrates the optimal ways of measuring. In addition, it offers a description of the preparation for measuring and lists the measuring equipment that has been used. It also features a description of the measuring procedures that need to be applied and it shows the processing of the measurement results. It provides the examples illustrating the application of this instruction manual. All the terms and definitions meet the requirements of SRPS ISO/IEC 9000:2001, SRPS ISO/IEC 17025:2006 and follow International Vocabulary of Basic and General Terms in Metrology.

# Microelectronics and optoelectronics, nanosciences and nanotechnologies/ Mikroelektronika i optoelektronika (MO)

## SESIJA MOI1 + MO1: MICROELECTRONICS AND OPTOELECTRONICS

Ponedeljak/Monday, June, 3rd, 11:15 – 13:30, Sala 3/Hall 3

**Chair: Zoran Prijić, University of Niš, Faculty of Electronic Engineering, Serbia**

MOI1.1

SUN AND DISPLAYS: OLD STORIES AND NEW CHALLENGES

*Branko Livada, Vlatacom Institute, Serbia*

Display sun readability is very important in the case of the "mission critical" applications as avionic cockpit in harsh illumination environment, causing a lot of research and development leading to suitable, but expensive solutions. Wide display applications in mobile systems and vehicles require new cheap display solutions that should be readable in less demanding illumination conditions. Basic physical processes related to display readability are reviewed. The basic differences in display avionic and new mobile and vehicular applications are discussed. New application require still serious, but allow different approach and different technological solutions and measurement techniques.

MOI1.2

INFLUENCE OF HYDROGEN REDUCTION ON MICROCHANNEL PLATE PARAMETERS

*Aleksandra Stanković, Faculty of Electronic Engineering, University of Nis, Serbia*
*Ivan Zlatković, Faculty of Electronic Engineering, University of Nis, Serbia*
*Rade Nikolov, Photon Optronics, Serbia*
*Dragan Pantić, Faculty of Electronic Engineering, University of Nis, Serbia*
*Branislav Brindić, Sova HD, Serbia*

Hydrogen reduction is very important step in microchannel plate (MCP) technology, through this process to glass wafer is given conductive and secondary electron emission properties. In this paper, the effect of the temperature and the time of the hydrogen reduction process on the fixed pattern noise (FPN) threshold were examined, as well as obtaining optimal resistance of MCP. In order to see the effect of reduction experiments were made with MCP's from the same batch (the same thermal history).

MOI1.3

APPLICATION OF A LOW-VOLTAGE STEP-UP CIRCUIT FOR THERMAL ENERGY HARVESTING UNDER NATURAL CONVECTION

*Jana Vračar, University of Niš, Faculty of Electronic Engineering, Serbia*
*Miloš Marjanović, University of Niš, Faculty of Electronic Engineering, Serbia*
*Aleksandra Stojković, University of Niš, Faculty of Electronic Engineering, Serbia*
*Zoran Prijić, University of Niš, Faculty of Electronic Engineering, Serbia*
*Aneta Prijić, University of Niš, Faculty of Electronic Engineering, Serbia*
*Ljubomir Vračar, University of Niš, Faculty of Electronic Engineering, Serbia*

This paper describes the design and testing of a step-up circuit for thermoelectric energy harvesting application under natural convection conditions. Considered thermoelectric generator with a suitable heatsink at a temperature difference of about 30C provides a voltage of 60mV at the load. The voltage is boosted using the Meissner oscillator and voltage doubler circuit. For the

oscillator circuit, an analytical small signal model for the oscillation frequency estimation has been developed. The experimental characterization of the step-up circuit for thermoelectric energy harvesting was performed. It is shown that the voltage can be boosted up to 6V DC.

MO1.1

PROCEDURE MERENJA ELEKTRIČNIH KARAKTERISTIKA NAPREZANIH P-KANALNIH VDMOS TRANZISTORA SNAGE

*Snežana Đorić-Veljković, Univerzitet u Nišu, Građevinsko-arhitektonski fakultet, Serbia*
*Vojkan Davidović, Univerzitet u Nišu, Elektronski fakultet, Serbia*
*Danijel Danković, Univerzitet u Nišu, Elektronski fakultet, Serbia*
*Snežana Golubović, Univerzitet u Nišu, Elektronski fakultet, Serbia*
*Ninoslav Stojadinović, Univerzitet u Nišu, Elektronski fakultet, Serbia*

U ovom radu izvršena je komparativna analiza električnih karakteristika i parametara p-kanalnih VDMOS tranzistora snage, podvrgnutih NBT (negative bias temperature) naprezanju i naprezanju jonizujućim zračenjem, zavisno od primene različitih mernih procedura i konfigurisanih mernih uredjaja. Pokazano je da iako tokom NBT naprezanja postoji odlično kvalitativno slaganje u promenama napona praga, rezultati dobijeni merenjem u proceduri pri kojoj su korišćeni uređaji u konfiguraciji sa jednom SMU (source measure unit) u izvesnoj meri odstupaju od onih sa dve SMU, a odstupanje može iznositi i do 20% tokom 168h naprezanja.

MO1.2

PRIMENA TERMOGRAFIJE U RUDARSTVU

*Stevan Đenadić, Faculty of Mining And Geology, Serbia*
*Vesna Damnjanović, Faculty of Mining And Geology, Serbia*
*Ljubiša Tomić, Military Technical Institute, Serbia*
*Dragutin Jovković, Faculty of Mining And Geology, Serbia*

Danas, gotovo da nema oblasti u nauci i tehnici u kojoj se Infracrvena termografija ne primenjuje kao metoda za lociranje i praćenje zagrejanih objekata ili tela, beskontaktnu procenu temperature površina, i nedestruktivno ispitivanje materijala. U radu su prikazane mogućnosti i perspektive primene ove metode u oblasti rudarstva.

## SESIJA MOI2: MICROSYSTEMS AND NANOSCIENCES

Ponedeljak/Monday, June, 3rd, 14:30 – 16:30, Sala 3/Hall 3

**Chair: Ninoslav Stojadinović, Univerzitet u Nišu, Elektronski fakultet, Serbia**

MOI2.1

MICRO ELECTROMECHANICAL SYSTEMS (MEMS) BASED MICROFLUIDIC PLATFORMS (INVITED PAPER)

*Dana Vasiljević-Radović, ICTM CMT, University of Belgrade, Serbia*
*Milena Rašljić, ICTM CMT, University of Belgrade, Serbia*
*Milče Smiljanić, ICTM CMT, University of Belgrade, Serbia*
*Žarko Lazić, ICTM CMT, University of Belgrade, Serbia*
*Katarina Radulović, ICTM CMT, University of Belgrade, Serbia*
*Katarina Cvetanović-Zobenica, ICTM CMT, University of Belgrade, Serbia*

In this work an overview of Micro Electromechanical Systems (MEMS)-based microfluidic platforms for different applications is presented. Microfluidics refers to a set of technologies that control the flow of liquids or gases through miniaturized systems in typical amounts of nano- and pico- liters. Microfluidic devices are characterized by microchannels with characteristic dimensions in the micrometer range. The main techniques, technologies and materials used for

fabrication of MEMS microfluidic devices and systems are presented. The used materials and their properties are very important for the final characteristics and functionalities of devices. As an example, the design and fabrication of our opto-fluidic lab-on-a-chip device based on silicon and pyrex glass is given.

MOI2.2

## ANALYSIS OF THE FUNDAMENTAL DETECTION LIMIT IN MICROFLUIDIC CHEMICAL AND BIOLOGICAL SENSORS

*Ivana Jokic, University of Belgrade, Institute of Chemistry, Technology and Metallurgy, Center of Microelectronic Technologies, Serbia*
*Katarina Radulović, University of Belgrade, Institute of Chemistry, Technology and Metallurgy, Center of Microelectronic Technologies, Serbia*
*Miloš Frantlović, University of Belgrade, Institute of Chemistry, Technology and Metallurgy, Center of Microelectronic Technologies, Serbia*
*Zoran Djuric, Serbian Academy of Sciences and Arts, Institute of Technical Sciences of SASA, Serbia*
*Katarina Cvetanović Zobenica, University of Belgrade, Institute of Chemistry, Technology and Metallurgy, Center of Microelectronic Technologies, Serbia*
*Predrag Krstajić, University of Belgrade, Institute of Chemistry, Technology and Metallurgy, Center of Microelectronic Technologies, Serbia*

Detection limits in microfluidic chemical and biological sensors, which determine the range of analyte concentrations reliably detectable by the sensor, are important sensor parameters. The lower limit of detection, defined as the lowest concentration that can be distinguished from noise, has its minimum determined by the fundamental adsorption-desorption (AD) noise, inevitable in adsorption-based devices. In this work, we analyze this fundamental detection limit, particularly considering the influence of mass transfer processes in microfluidic devices. For that purpose, we derive the expression for the sensor's signal-to-noise ratio (SNR), which takes into account the AD noise, and then the equation for the minimal analyte concentration at which the SNR has a sufficiently high value for reliable analyte detection. Subsequently, we analyze the mass transfer influence on the sensor's maximal achievable signal-to-noise ratio and on the fundamental detection limit. The results of the analysis show a significant mass transfer influence on these important sensor performance metrics. They also provide guidelines for achieving the sensor's best possible detection performance through the optimization of the sensor design and operating conditions.

MOI2.3

## A CONSIDERATION OF USING THE ICTM SP-12 PRESSURE SENSOR FOR ULTRASOUND SENSING

*Jelena Stevanović, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Žarko Lazić, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Milče Smiljanić, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Katarina Radulović, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Danijela Randjelović, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Miloš Frantlović, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Milija Sarajlić, Institute of Chemistry, Technology and Metallurgy, Serbia*

A consideration study for the application of the pressure sensor SP 12 developed and produced by ICTM CMT as an ultrasound sensor is given. The interaction of ultrasound with the sensor's membrane was analytically described, but for the initial examination of its performance, Finite Elements Method simulation was applied. The sensor SP-12 has eigenfrequencies in the range from 200 kHz to the frequencies higher than 2 MHz. The amplitude of the output signal, which is proportional to Von Mises stress, is highest for the lowest frequency, and it exponentially decreases as the eigenfrequencies increase. This makes the sensor suitable for the ultrasound measurements in the range of hundreds of kHz.

MOI2.4

## CONSIDERATION OF THIN FILM IONIZATION VACUUM PRESSURE SENSOR

*Marko Bošković, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Danijela Ranđelović, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Milena Rašljić, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Katarina Cvetanović-Zobenica, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Žarko Lazić, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Milče Smiljanić, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Milija Sarajlić, Institute of Chemistry, Technology and Metallurgy, Serbia*

A novel concept of vacuum pressure sensor based on thin film technology is presented. The sensor is designed as a 1 μm thick aluminium film patterned as a structure of wedges facing each other along a sharp tip. The distance between the wedge tips is 3 μm. This structure is obtained by laser writing in vector mode. Parts of the sensor structure are fabricated and measured. Analytical consideration of the proposed structure is given together with the concept of the experimental set up for testing of the sensor.

MOI2.5

## ETCHED PARALLELOGRAM PATTERNS WITH SIDES ALONG <100> AND <N10> DIRECTIONS IN 25 WT % TMAH

*Milče M. Smiljanić, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Žarko Lazić, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Branislav Radjenović, Institute of Physics, Serbia*
*Marija Radmilović-Radjenović, Institute of Physics, Serbia*
*Vesna Jović, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Milena Rasljić, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Katarina Cvetanović Zobenica, Institute of Chemistry, Technology and Metallurgy, Serbia*
*Ana Filipović, Institute of Chemistry, Technology and Metallurgy, Serbia*

In this paper, we present and analyze etching of parallelogram patterns in the masking layer on a (100) silicon in 25 wt % TMAH water solution at the temperature of 80 0C. Sides of parallelogram islands in the masking layer are designed along <n10> and <100> crystallographic directions. A 3D simulation of the profile evolution from these patterns during etching of silicon using the level set method is also presented. We determined all crystallographic planes that appear during etching in the experiment and obtained simulated etching profiles of these 3D structures. A good agreement between dominant crystallographic planes through experiments and simulations is obtained.

MOI2.6

## REVERSED ELLIPSOIDAL TROUGHS SCULPTED IN PLASMONIC MULTILAYER NANOMEMBRANES

*Marko Obradov, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia*
*Zoran Jakšić, Institute of Chemistry, technology and Metallurgy, Serbia*
*Ivana Mladenović, Centre of Microel. Technologies; Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia*
*Dragan Tanasković, Centre of Microel. Technologies; Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia*
*Dana Vasiljevic Radovic, Institute of Chemistry, Technology and Mettalurgy, University of Belgrade, Serbia*

Nanomembranes represent a versatile novel building block in micro- and nanoelectromechanical systems, inspired by biological cell membranes. If built as quasi-2D multilayer metal-dielectric nanocomposites, they represent a natural choice for the use in plasmonics and optical metamaterials, ensuring a new degree of design freedom and thus a number of new applications.

In this contribution we consider surface sculpting of two types of three-layer nanomembranes – metal-insulator-metal (MIM) and insulator-metal-insulator (IMI) structures. The geometry we analyze represents troughs with ellipsoidal profiles sculpted in the multilayer nanomembranes, simultaneously acting as plasmonic waveguides and ensuring tailoring of frequency dispersion of the plasmonic nanomembranes. We determine frequency dispersions of the scattering parameters for the simulated nanomembranes, as well as the spatial ditribution of the optical near fields in and around them, both evanescent (plasmon-polariton based) and propagating. To this purpose we utilize finite element method simulations. The obtained results show that our IMI structures exhibit a behavior similar to that of the EOT arrays, resulting in optical transparency of the structure for resonant plasmonic modes. On the other hand, MIM structures offer an excellent confinement of electromagnetic radiation within the dielectric layer. We conclude that both MIM and IMI channels allow for additional degrees of freedom in customization the nanomembrane evanescent fields, making a way to numerous potential applications.

MOI2.7

## SOLUTION-PROCESSED SILVER NANOWIRES AS TRANSPARENT ELECTRODES IN SOLAR CELLS

*Vuk Radmilović, University of Belgrade, Faculty of Technology and Metallurgy, Serbia*

As with all optoelectronic devices like displays, touch panels, or light emitting diodes (LED), solar cells require materials with high electrical conductivity and optical transparency for creating high performance transparent electrodes. Conventional materials used for this purpose have numerous drawbacks mostly regarding demanding and expensive processing methods which is why alternatives are explored. Such are silver nanowires, easily synthesized and processed very cost effective nanostructures which are very cost effective. Our work consisted of utilizing silver nanowires as transparent electrodes in two types of solar cells - conventional silicon-based and new generation flexible organic-based. Results have shown that silver nanowire based transparent electrodes have exhibited optoelectronic properties comparable to conventional transparent electrodes and hence, solar cells utilizing silver nanowire based transparent electrodes have exhibited competitive power conversion efficiencies to ones utilizing conventional materials.

# Microwave technique, technologies and systems/ Mikrotalasna tehnika, tehnologije i sistemi (MT)

## SESIJA MTI1 + MT1

Ponedeljak/Monday, June, 3rd, 14:30 – 16:30, Sala 2/Hall 2

**Chair: Đurađ Budimir, University of Westminster, London, UK and ETF, Beograd, Srbija**

MTI1.1

### WIDEBAND ANTENNA ARRAY FOR MM-WAVE RADAR MODULES CHARACTERIZATION

*Siniša Jovanović, IMTEL Komunikacije, Belgrade, Serbia*
*Ivan Milosavljević, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia; NovelIC Microsystems, Belgrade, Serbia*
*Veselin Branković, NovelIC Microsystems, Belgrade, Serbia*

This paper outlines the design and realization of one type of antenna array developed for testing of integrated FMCW transmitter modules operating in the unlicensed 60-GHz band. All important features such are the type and design of the radiating elements of the array, the configuration of biasing network as well as the substrate stack-up are adjusted for achieving very wide operational frequency range with almost constant antenna gain from 50 to 70 GHz. To accommodate various test scenarios, four antenna versions are fabricated with low or high gain and with coaxial connector or waveguide input port. The fabricated antennas are employed in various test setups for characterization two versions of millimeter-wave FMCW chips realized in 0.13-µm SiGe BiCMOS technology: a transmitter module operating from 59.5 GHz to 70.5 GHz and a complete radar transceiver module operating from 54 GHz to 65 GHz

MTI1.2

### COMPARISON OF THE MEASURED CHARACTERISTICS OF SCHOTTKY DIODES FOR POWER HARVESTING APPLICATIONS

*Branka Milošević, Institut za fiziku, Univerzitet u Beogradu, Beograd, Srbija*
*Miloš Radovanović, Institut za fiziku, Univerzitet u Beogradu, Beograd, Srbija*
*Branka Jokanović, Institut za fiziku, Univerzitet u Beogradu, Beograd, Srbija*

This paper presents a new procedure for wide-band measurement of the Schottky diode impedance and rectified DC voltage. Two different Si Shottky diodes are measured, zero-bias SMS 7630 and low barrier MP 2005. Measurement is performed with Vector Network Analyzer (VNA) in the frequency range 0.5 - 5 GHz. The RF input power is varied from -28 to 2 dBm and several different values of load resistance are used. Since measurement required definite power levels at the diode ports, both S-parameter calibration and nonlinear power calibration of VNA were applied. Complex impedance and power conversion efficiency (PCE) of two diodes were compared. It was concluded that SMS 7630 is more sensitive in the almost whole power range. Also, it was noted that both diodes have similar complex impedance which means they can be used with the same antenna, that is designed to have an input impedance complexly conjugate in relation to the rectifying diode.

MTI1.3

## VHF GYSEL 3 DB POWER DIVIDER/COMBINER IN MICROSTRIP TECHNOLOGY

*Veljko Crnadak, IMTEL Komunikacije, Belgrade, Serbia*
*Siniša Tasić, IMTEL Komunikacije, Belgrade, Serbia*

In this paper, the theory and the design of the VHF Gysel 3 dB power divider/combiner are presented. The Gysel 3 dB power divider/combiner is designed as a microstrip circuit, for the frequency range from 150 MHz to 200 MHz, with the central frequency at 175 MHz. The Gysel divider/combiner is realized as a microstrip circuit on Rogers 4003 substrate, with the copper traces. Knowledge of the conditions, which must be satisfied by the Gysel divider/combiner, enables the determination of the dimensions of the Gysel divider/combiner, through the process of computer simulation. In order to verify the project, values of the S-parameters of the simulated Gysel divider/combiner are compared to the measured values of the S-parameters of the produced Gysel divider/combiner.

MTI1.4

## EM MODELLING OF MICROSTRIP T-JUNCTION WITH AN OPEN STUB PRINTED OVER A DIELECTRIC CYLINDER

*Tomislav Milošević, WIPL-D d.o.o., Belgrade, Serbia*
*Dušan Nešić, Centre of Microelectronic Technologies, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia*

This paper presents EM modelling of microstrip T-junction with open stub printed over a dielectric cylinder. Software tool used for modelling and simulations is a full 3D EM Method-of-Moments, Surface Integral Equation solver applied to quadrilateral mesh elements. The paper investigates the stability of simulation results with respect to various parameters. This includes settings of the numerical kernel, quality of cylindrical surface approximation using segments of bilinear surfaces, different modelling of microstrip edge effects, and comparison between various excitation configurations with and without de-embedding. The purpose of this comprehensive investigation was to establish the optimum calculation parameters for the case of the particular resonator structure. With the optimum parameter settings, the high numerical efficiency of the calculations has been confirmed.

MTI1.5

## A NEW TYPE OF MICROWAVE COAXIAL RESONANT PERMITTIVITY SENSOR

*Dušan Nešić, Centre of Microelectronic Technologies, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia*

A new type of microwave coaxial resonant permittivity sensor is introduced. It is constructed using only commercial SMA connectors: one T-junction and one jack-tojack adapter. The complete open stub is formed of a needle (the central conductor) and the hollow jack-to-jack adapter (the outer conductor). The hollow jack-to-jack adapter is container to be filled with the material under test. The sensor is simulated and preliminary measured in a wide dielectric constant range.

MTI1.6

## A SIMPLE ANALOG CONTROL SYSTEM FOR ELECTROMAGNETIC LEVITATION SMALL OBJECT

*Nenad Popović, IMTEL Komunikacije, Belgrade, Serbia*
*Predrag Manojlović, IMTEL Komunikacije, Belgrade, Serbia*
*Bojan Virijević, Military Technical Institute (VTI) Žarkovo, Belgrade, Serbia*

This paper describe an electromagnetic levitation system design for small iron sphere on a small distance from the electromagnet. The control wheel for controlling the distance between the metal ball and the elctromagnet consists of a switching electronics with electromagnetic and hall or optocoupler sensors.

MT1.1

## MODELOVANJE POJAČAVAČA SNAGE ZA LTE SISTEME PRIMENOM RVTDNN MREŽE

*Jelena Mišić, Elektronski fakultet, Univerzitet u Nišu, Niš, Srbija*
*Milan Čabarkapa, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*
*Vera Marković, Elektronski fakultet, Univerzitet u Nišu, Niš, Srbija*
*Đurađ Budimir, University of Westminster, London, UK and ETF, Beograd, Srbija.*

U ovom radu predstavljeno je modelovanje pojačavača snage za LTE sisteme primenom veštačkih neuronskih mreža. Za modelovanje pojačavča korišćena je dinamička neuralna mreža sa kašnjenjem koja ima realne ulazne vrednosti (eng. Real-Valued Time Delay Neural Network - RVTDNN). Prilikom modelovanja, ravijen RVTDNN model je optimizovan po broju skrivenih slojeva, neurnona u skrivenim slojevima, i dubini memorije ulaznog i izlaznog signala. Metrike koje su korišćene prilikom optimizacije su NMSE (Normalized Mean-Square Error) i NAMSE (Normalized Absolute Mean-Square Error). Optimalni model ima 12 i 15 neurona u skrivenim slojeva, i dubinu memorije izlaznog signala 3. AM/AM, AM/PM i spektralna karakteristika razvijenog modela na test skupu podataka, koji se razlikovao od trening skupa, imaju visok stepen podudaranja sa odgovarajućim merenim karakteristikama pojačavača.

# New Materials in Electrical and Electronic Engineering/ Novi Materijali (NM)

## SESIJA NMI1 + NM1: ELECTRONIC MATERIALS

Utorak/Tuesday, June, 4th, 9:00 – 11:00, Sala 1/Hall 1

**Chair: Vesna Paunović, University of Niš, Faculty of Electronic Engineering, Niš, Serbia**

NMI1.1

### INFLUENCE OF MECHANICAL ACTIVATION ON ELECTRICAL PROPERTIES OF CERAMIC MATERIALS IN VHF BAND (INVITED PAPER)

*Nina Obradović, Institute of Technical Sciences of SASA, Serbia*
*Antonije Đorđević, School of Electrical Engineering, and Serbian Academy of Sciences and Arts, Serbia*

Mechanical activation is commonly used as a pre sintering process in order to enhance the reactivity of materials, reduce the particle size, increase diffusion rates, accelerate the reaction, and lower the sintering temperature. The mechanical activation can affect the final electrical and mechanical characteristics. In this paper we consider the influence of the mechanical activation on the permittivity and the loss tangent. We outline methods for evaluation of these parameters, with emphasis on our coaxial-chamber technique for measurements in the VHF band

NMI1.2

### ELECTRICAL CHARACTERISTICS AND PHASE TRANSFORMATION OF Ho DOPED BaTiO3 CERAMICS

*Miloš Đorđević, University of Niš, Faculty of Electronic Engineering, Serbia*
*Vesna Paunović, University of Niš, Faculty of Electronic Engineering, Serbia*
*Vojislav Mitić, University of Niš, Faculty of Electronic Engineering, Serbia*
*Zoran Prijić, University of Niš, Faculty of Electronic Engineering, Serbia*

The dielectric characteristics and phase transformation of Ho doped $BaTiO_3$ ceramics is investigated in this article. The concentrations of $Ho_2O_3$ in doped samples were ranged from 0.05 to 1.0 at% Ho. The investigated samples were prepared by a conventional solid state sintering procedure and sintered at 1320°C for 4 hours. For low dopants concentration (0.05 at% Ho), SEM analysis shows abnormal grain growth with the average size range between 10 μm - 30 μm. With the increase of dopant amount in samples causes decrease of average grain size, and for samples doped with 1.0 at% Ho, grain size range from less than 1 mm - 2 mm. The dielectric characteristics was measured in temperature range from 30°C to 180°C at different frequencies, from 100 Hz to 1 MHz. The dielectric constant has higher values for samples with lower concentration of additives (εr=4250 for 0.05 at% Ho/$BaTiO_3$, while εr=990 for 1.0 at% Ho/ $BaTiO_3$ at Curie temperature). After initial high values at lower frequencies, εr decreases with frequency increase and reaches a constant value for f>20kHz. The Curie temperature at which the transition from the ferroelectric to the paraelectric region occurs ranges from 126°C to 130°C. For all investigated samples, it is characteristic that as the temperature increases, the tangent angle of losses increases. Curie-Weiss's law and modified Curie-Weiss law were used to calculate parameters such as Curie constant C and Curie temperature Tc, parameter g which describing the diffusion and degree of nonlinearity of the change εr of the temperature above the Curie temperature and parameter δ which describing change er of the temperature and frequency. In all the samples examined, a sharp transition from the ferroelectric to the paraelectric region at the Curie temperature is characteristic, which shows the value of the critical exponent of the nonlinearity γ from 1.01 to 1.07.

NMI1.3

## SURFACE PROPERTIES OF POLYCRYSTALLINE DIAMONDS FOR ADVANCED APPLICATIONS

*Sandra Veljković, University of Niš, Faculty of Electronic Engineering, Serbia*
*Vojislav Mitić, University of Niš, Faculty of Electronic Engineering, Serbia*
*Vesna Paunović, University of Niš, Faculty of Electronic Engineering, Serbia*
*Goran Lazović, University of Belgrade, Faculty of Faculty of Mechanical Engineering,, Serbia*
*Markus Mohr, University of Ulm, Institute of Functional Nanosystems FNS, Germany*
*Hans Fecht, University of Ulm, Institute of Functional Nanosystems FNS, Germany*

The development of new materials as well as improvement of already known materials characteristics, can significantly contribute to the progress in the development of different areas. In that sense, polycrystalline diamonds are becoming more and more interesting because of their wide application. Considering that this material has an extreme potential, the research in this area is intense, and in this paper are presented the most important applications related to engineering. Intensive research of surface structure can contribute to the better insight of polycrystalline diamonds properties. An analysis of surface structure of nanocrystalline diamonds obtained by chemical vapor deposition method is presented in this paper.

NMI1.4

## TRANSPORT PARAMETERS OF Ar+ IN Ar/$BF_3$ MIXTURES

*Zeljka Nikitovic, Institute of Physics, Pregrevica 118, 11080 Belgrade, Serbia*

In this paper we present a cross section set for Ar+ in Ar/$BF_3$ mixtures where existing experimentally obtained data are selected and extrapolated. A Monte Carlo simulation method is applied to accurately calculate transport parameters in hydrodynamic regime. We discuss new data for Ar+ ions in Ar/$BF_3$ mixtures where mean energy, flux and bulk values of reduced mobility and other transport coefficients are given as a function of low and moderate reduced electric fields E/N (E-electric field, N-gas density).

NM1.1

## NOVA METODA ZA ODGREVANJE UZORAKA AMORFNIH LEGURA POVORKOM PRAVOUGANIH STRUJNIH IMPULSA MODULISANOG TRAJANJA

*Jelena Orelj, Faculty of Technical Sciences Cacak, Serbia*
*Nebojsa Mitrovic, Faculty of Technical Sciences Cacak, Serbia*

Nalaženje optimalnih svojstava magnetno mekih amorfnih/nanokristalnih legura je neophodno radi dostizanja najboljih funkcionalnih karakteristika savremenih električnih naprava. Za postizanje ovog cilja neophodna je optimizacija termičkih tretmana koje je potrebno prilagoditi primenama ispitivanih legura. Magnetni senzori na bazi magnetoimpedansnog MI-efekta načinjeni od amorfnih / nanokristalnih žica - mikrožica zahtevaju potpuno specifične termičke tretmane, najvećim delom zasnovane na odgrevanju strujnim impulsima. U tu svrhu je razvijena nova metoda odgrevanja pomoću povorke pravougaonih strujnih impulsa modulisanog trajanja.

NM1.2

## MODELOVANJE FUNKCIONALNIH SVOJSTAVA BARIJUM-FERITA BAFE12O19 U ZAVISNOSTI OD PARAMETARA SINTEZE POLAZNOG PRAHA FEX(BATIO3)Y

*Srđan Divac, Faculty of technical Sciences in Čačak, Serbia*
*Nemanja Stojanović, Faculty of technical Sciences in Čačak, Serbia*
*Aleksa Maričić, Faculty of technical Sciences in Čačak, Serbia*
*Aleksandra Kalezić-Glišović, Faculty of techical sciences in Čačak, Serbia*

Smeše prahova Fe i BaTiO3, sa masenim odnosima 10% Fe, 20% Fe, 30% Fe, 50% Fe, 60% Fe i 70% Fe, aktivirane su u planetarnom mlinu u periodu od 30 min do 300 min. Tokom aktivacije

prah gvožđa apsorbuje kiseonik i nastaju oksidi gvožđa FeO, Fe2O3 i Fe3O4. Karakteristike praha određene su primenom XRD analize. Pokazano je da sa porastom vremena aktivacije dimenzije mikrokristalita opadaju od 138 nm do 37 nm. Istovremeno, gustina dislokacija u prahu se menja od 2,6•10-6 Å-2 do 2•10-5 Å-2 zavisno od vremena aktivacije polaznog praha 30% Fe i 70% BaTiO3. Aktivirani prahovi presovani su i zatim sinterovani, pri čemu je pokazano da magnetizacija sinterovanih uzoraka zavisi od vremena aktivacije i masenih odnosa komponenata u polaznom prahu. Takođe, pokazano je da realna dielektrična permeabilnost uzoraka dobijenih sintezom polaznih prahova 20% Fe i 80% BaTiO3, kao i 70% Fe i 30% BaTiO3, zavisi od vremena aktivacije.

## SESIJA NMI2: NEW MATERIALS

Utorak/Tuesday, June, 4th, 14:30 – 16:30, Sala 1/Hall 1

**Chair: Nebojša Mitrović, University of Kragujevac, Faculty of Technical Sciences, Čačak, Serbia**

NMI2.1

### IMPROVED ADHESION OF HYBRID ACRYLATE FILMS BY NANOCRYSTALLINE POLYHEDRAL OLIGO SILSESQUIOXANES (POSS)

*Nataša Tomić, Innovation center of Faculty of Technology and Metallurgy in Belgrade ltd, Serbia*
*Mustafa Kalifa, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Marija Vuksanović, the Vinča institute of nuclear sciences, Vinča, Belgrade, Serbia*
*Vesna Radojević, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Radmil Jančić Heinemann, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Aleksandar Marinković, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*

The objective of this study is to investigate the influence of the polyhedral oligo silsesquioxanes (POSS) structure on the adhesion behavior of composite films onto a metallic surface. The composite films consist of UV cured Bisphenol A glycidylmethacrylate/triethylene glycol dimethacrylate (Bis-GMA/TEGDMA) as matrix and reactive POSS structures as adhesion enhancers. Composites are made with 1, 3 and 5 wt. % of POSS particles. Adhesion is evaluated using the micro Vickers hardness testing method. The contact angle of hybrid films to the brass substrate is measured and compared to the adhesion parameter from micro hardness measurements. The shape and size of the indent are analyzed and correlated to the adhesion quality. Methods used in this paper for estimation of adhesion strength and quality clearly indicate that the best adhesion enhancer of Bis-GMA/TEGDMA matrix is POSS reagent containing both hydroxyl and allyl functional group.

NMI2.2

### SYNTHESIS AND CHARACTERIZATION OF TI3C2 MXENE FILM

*Ivan Pešić, Faculty of technology and metalurgy, Serbia*
*Daniel Mijailović, Inovation centre Faculty of technology and metalurgy, Serbia*
*Vukašin Ugrinović, Inovation centre Faculty of technology and metalurgy, Serbia*
*Miodrag Mitrić, Vinča institute of nuclear science, Serbia*
*Petar Uskoković, Faculty of technology and metalurgy, Serbia*
*Vesna Radojević, Faculty of technology and metalurgy, Serbia*

Two-dimensional (2D) transition metal carbides are known asMXenes can offer large surface area, excellent electrical conductivity and chemical stability. MXenes have shown great potential in a broad spectrum of applications such as photothermal cancer therapy, antibacterial effect, the improved electrical conductivity of polymers, hydrogen evolution reaction, energy storage, etc. Herein we report a successful synthesis and characterization of Ti3C2 MXene material. Properties of the material are tracked via scanning electron microscopy (SEM), X-ray diffraction

(XRD), cyclic voltammetry (CV) and galvanostatic charge/discharge (GCD) experiments. SEM and XRD analysis revealed lamellar delaminated MXene structure, while XRD patterns showed the presence of Mxenes 312 structure, CV and GCD showed as electrode material for aqueous supercapacitors.

NMI2.3

## SOFT POLYMERIC NETWORKS BASED ON POLY(METHACRYLIC ACID), ITACONIC ACID, CASEIN AND LIPOSOMES FOR TARGETED DELIVERY AND CONTROLLED RELEASE OF POORLY WATER-SOLUBLE ACTIVE SUBSTANCE

*Maja Marković, Innovation Center of Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Vesna Panić, Innovation Center of Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Sanja Šešlija, Institute of Chemistry, Technology and Metallurgy, University of Belgrade, Serbia*
*Pavle Spasojević, Faculty of Technical Sciences, University of Kragujevac, Serbia*
*Vukašin Ugrinović, Innovation Center of Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Nevenka Bošković-Vragolović, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Rada Pjanović, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*

Soft polymeric networks based on poly(methacrylic acid) (PMAA) are attractive candidates for targeted and control drug release due to their non-toxicity, biocompatibility and pH-sensitivity. The highly hydrophilic nature of PMAA networks enables transport only of hydrophilic drugs. This limitation has been overcome in present work by PMAA modification with casein and liposomes. Casein is natural amphiphilic protein which enabled the encapsulation and targeted and control release of model drug- caffeine. The FTIR spectra showed that the hydrophobic interactions and hydrogen bonds were established between the casein and caffeine. The caffeine in vitro release was monitored in two media at 37°C: phosphate buffer pH=6.8, which simulated the pH environment in the human intestines and 0.1M HCl pH=1.2, which simulated the pH environment in the human stomach. The presence of liposomes with the encapsulated caffeine in the carriers caused the decrease in the speed of caffeine release. Introduction of itaconic acid (IA) as hydrophilic and pH-sensitive substance with two carboxylic groups resulted in a non-regular structure of the carriers with large voids which caused the increase in swelling rate of the carriers and increase in speed of caffeine release. All obtained results showed that the targeted and control release of poorly water-soluble substance was achieved.

NMI2.4

## SWELLING AND BIOACTIVITY OF POLY (METHACRYLIC ACID)/ HYDROXYAPATITE / BIOACTIVE GLASS COMPOSITE HYDROGELS

*Vukasin Ugrinovic, Innovation Center of Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Vesna Panic, Innovation Center of Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Sanja Seslija, Centre of Excellence in Environmental Chemistry and Engineering, University of Belgrade, Serbia*
*Pavle Spasojevic, Innovation Center of Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Ivanka Popovic, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Djordje Janackovic, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Djordje Veljovic, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*

The goal of the study was to examine the influence of bioactive glass (BG) particles incorporation on properties of poly(methacrylic acid)/hydroxyapatite (HA) composite hydrogels. Composite hydrogels were synthesized by free-radical polymerization. Theoretical amount of incorporated

inorganic fillers was 60 wt%, while BG/HA ratio was varied. Composites were characterized by Scanning Electron Microscopy, and swelling behavior was determined in distilled water. During 28 days of in vitro bioactivity test, pH changes were constantly monitored. Equilibrium swelling increased by 110.9 % as the content of BG in composites increased. pH values of SBF were significantly higher in the case of the sample with higher amount of BG. Morphological investigations revealed localized bioactivity of the sample with 40 wt% of BG, while the one with 10 wt% exhibited no significant bioactivity.

NMI2.5

## SINTHESIS AND CHARACTERIZATION OF HYDROXYAPATITE AND FLUORAPATITE POWDERS

*Željko Radovanović, Innovation Center of the Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Abdulmoneim Mohamed Kazuz, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Predrag Vulić, Faculty of Mining And Geology, University of Belgrade, Serbia*
*Lidija Radovanović, Innovation Center of the Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Đorđe Veljović, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Rada Petrović, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Đorđe Janaćković, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*

The biomaterial powders of hydroxyapatite (HAp) and fluorapatite (FAp) were synthesized by a hydrothermal method. Powders were analyzed by energy-dispersive X-ray spectroscopy (EDS), field emission scanning electron microscopy (FESEM), and X-ray powder diffraction analysis (XRPD). EDS analysis shows the presence of non-stoichiometric FAp and HAp with molar ratio Ca/P <1.67. FESEM analysis of both powder indicate the presence of agglomerates of micrometric dimensions, while primary nanoparticles are rod-like. The Rietveld refinement of XRPD data showed that the single phase powders of FAp and HAp were synthesized. The results showed that obtained nanomaterials can be potentially applied in dentistry.

NMI2.6

## THE FABRICATION OF DENTAL INSERT BASED ON MAGNESIUM DOPED HYDROXYAPATITE AND ITS SHEAR BOND STRENGTH WITH MAXCEM DENTAL CEMENT

*Tamara Matic, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Maja Ležaja Zebić, School of Dental Medicine, University of Belgrade, Serbia*
*Vesna Miletić, School of Dental Medicine, University of Belgrade, Serbia*
*Sanja Jevtić, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Rada Petrović, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Djordje Janaćković, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Djordje Veljović, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*

The polymerization shrinkage (PS) presents the cause of the secondary caries, one of the most common reasons for high failure rate of dental restorations. In order to lower PS and improve the lifespan of dental restorations, inorganic dental inserts based on hydroxyapatite (HAP) have been proposed. The aim of this study was to fabricate dental inserts based on hydroxyapatite doped with 5 mol. % of magnesium ions (Mg-HAP) and investigate its bonding ability with commercially available dental cement for possible application in restorative dentistry. The Mg-HAP inserts were characterized using X-ray diffraction (XRD) analysis, energy dispersive X-ray (EDX) analysis and scanning electron microscopy (FE-SEM). Bonding ability of the untreated inserts with Maxcem cement was measured by shear bond strength (SBS) test, and the type of fracture was analysed. The obtained average SBS value of the untreated Mg-HAP inserts with Maxcem cement was 3.1 MPa, with "adhesive" fracture type.

# Nuclear engineering and technology/ Nuklearna tehnika (NT)

## SESSION NTI1: METHODS FOR THE ENVIRONMENTAL MEASUREMENTS

Sreda/Wednesday, June, 5th, 11:15 – 13:30, Sala 1/Hall 1

**Chair: Ištvan Bikit, Fakultet za fiziku, Univerzitet u Novom Sadu, Novi Sad, Srbija**

NTI1.1

METHODS OF COSMIC MUON IMAGING (INVITED PAPER)

*Istvan Bikit, Department of Physics, Faculty of Sciences, University of Novi Sad, Serbia*
*Dusan Mrdja, Department of Physics, Faculty of Sciences, University of Novi Sad, Serbia*
*Kristina Bikit-Schroeder, Department of Physics, Faculty of Sciences, University of Novi Sad, Serbia*

Cosmic-ray muons can be used for imaging of large structures, or high-density objects with high atomic number. The first task can be performed by measurement of muon absorption within very thick material layers, while the second approach is based on muon multiple scattering. However, the muon imaging of small structures with low atomic number and density was not yet solved appropriately. Our research group has demonstrated recently completely new imaging method by cosmic-ray muons, based on the detection of secondary particles produced by muons in object material (I. Bikit et al, Novel approach to imaging by cosmic-ray muons, EPL 113 (2016) 58001). Novel imaging technique by cosmic-ray muons is based on the detection of secondary produced particles generated within materials and objects by passage of cosmic-ray muons. This method opens up possibility to obtain 2D and 3D images of small objects made of materials with low atomic number. The advances of "conventional" muon imaging systems based on muon absorption and scattering and detection of incoming and scattered muons will be presented, and compared with the new imaging technique. The possible applications of the new imaging technique will be discussed.

NTI1.2

THORON 220RN EXHALATION RATE MEASUREMENT: DEPENDENCE OF THE GRAIN SIZE

*Dunja Antonijević, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Luka Rubinjoni, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Andrija Janković, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Igor Čeliković, "Vinča" Institute of Nuclear Sciences, University of Belgrade, Serbia*
*Aleksandar Kandić, "Vinča" Institute of Nuclear Sciences, University of Belgrade, Serbia*
*Boris Lončar, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*

Radon, 222Rn with its progeny is considered as the second cause of lung cancer after smoking. On the other hand, thoron 220Rn was often neglected since its concentrations in the indoor environment were considered to be smaller compared to radon concentrations and due to its short lifetime compared to radon. Nevertheless, there are regions that have thoron concentrations higher or comparable to radon concentrations. In this contribution, measurements of thoron exhalation rate of different materials as a function of grain size is presented. Measurements were performed using RTM1688-2 of Sarad Company.

NTI1.3

## RADON EXHALATION FROM FLY-ASH GEOPOLYMER MORTAR

*Luka Rubinjoni, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*
*Igor Čeliković, Vinča Institute of Nuclear Sciences, University of Belgrade, Serbia*
*Gordana Tanasijević, Institute for Multidisciplinary Research, University of Belgrade, Serbia*
*Miroslav Komljenović, Institute for Multidisciplinary Research, University of Belgrade, Serbia*
*Boris Lončar, Faculty of Technology and Metallurgy, University of Belgrade, Serbia*

Geopolymers are a type of alcali activated binders, inorganic aluminosilicate polymers with amorphous cross-linked structure. Fly-ash is produced in abundance during coal firing, and poses an environmental and health risk in untreated powder form. Fly-ash geopolymer presents a sustainable alternative to Portlant cement, due to lower net greenhouse gas emissions. Presence of naturally occuring radioactive elements in fly-ash is one of the factors taken into account when estimating the safety of fly-ash based building materials. Radon, a radioactive noble gas originating from the decay of radium, can leave the material and contribute to internal dose in closed spaces, so radon exhalation is of special interest. Radon exhalation for a standard sample of fly-ash geopolymer mortar was measured.

NTI1.4

## DETERMINATION OF SURFACE CONTAMINATION WITH HANDHELD EQUIPMENT

*Marija M. Janković, Radiation and Environmental Protection Department, Vinca Institute of Nuclear Sciences, Serbia*
*Jelena D. Krneta Nikolić, Radiation and Environmental Protection Department, Vinca Institute of Nuclear Sciences, Serbia*
*Predrag M. Božović, Radiation and Environmental Protection Department, Vinca Institute of Nuclear Sciences, Serbia*
*Nataša B. Sarap, Radiation and Environmental Protection Department, Vinca Institute of Nuclear Sciences, Serbia*
*Milica M. Rajačić, Radiation and Environmental Protection Department, Vinca Institute of Nuclear Sciences, Serbia*

Surface contamination meters are used to detect the presence of radioactive substances on some surfaces. The level of contamination can be measured using portable handheld detectors. Factors that can affect the results are source to detector distance, source geometry. This paper presents the results of measuring alpha, beta and mixed alpha-beta surface contamination presented on printed spiked papers.

NTI1.5

## LEACHING KINETICS OF CS+ AND CO2+ UNDER DYNAMIC CONDITIONS

*Slavko Dimovic, Vinca Institute, Serbia*
*Dusan Nikezic, Vinca Institute, Serbia*
*Marija Sljivic-Ivanovic, Vinca Institute, Serbia*
*Ivana Jelic, Lola Institute, Belgrade, Serbia, Serbia*
*Vojislav Stanic, Vinca Institute, Serbia*
*Mirjana Radenkovic, Vinca Institute, Serbia*
*Boris Loncar, Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, Serbia*

The possibility of retaining Cs+ and Co2+ bound by immobilization processes in the cement matrix is defined as the subject of its investigation: the cement matrix formulation, the water / cement ratio, the amount of waste and the porosity of such a structure. Implementing the Standard Leaching Method by Hespe the comparing possibility of different author's results was achieved. Diffusion and semi-empirical model were used to investigate the transport phenomenon in order to predict the leaching level for a long period of time. Leaching of Co2+ and Cs+ ions under

dynamic conditions immobilized in the cement matrix dynamic conditions decreases with the increase of the sludge content, regarding to porosity increase. The effects of the diffusion and surface washing are equalized, and the contribution of the matrix dissolution to the Cs+ and Co2+ transport in the cement porous media increase, on average, for one order of magnitude. Semi-empirical model gives a better approximation for Co2+ and Cs+ leaching process for the duration of the experiment while both models significantly approximate leaching results in dynamic conditions.

NTI1.6

### THE EFFECTS OF X-RADIATION IN A QUASI-LOW-DROPOUT VOLTAGE REGULATOR

*Vladimir Vukić, Electrical Engineering Institute "Nikola Tesla", Serbia*

The aim of this paper was to test the possibility of implementation of the commercial-off-the-shelf (COTS) quasi-low-dropout voltage regulator in a harsh bremsstrahlung environment (in the case of a lifelong exposure to moderate total ionising doses). Results of examination of the LT1086CT5 voltage regulator, performed in the field of X-radiation, are presented in this paper. Biased and loaded circuits demonstrated acceptable characteristics in the bremsstrahlung radiation environment for total doses up to 433 Gy, but some samples of unbiased circuits demonstrated unacceptable decline of the output voltage even after absorption of ionising dose of 260 Gy. One-week room temperature annealing led to a further degradation of all of the irradiated voltage regulators, both unbiased and biased, during irradiation. All the examined samples remained functional, but pointed to numerous limitations for implementation of these COTS voltage regulators in an ionising radiation environment.

## SESSION NT1+NTI2: KNOWLEDGE MANAGEMENT

Sreda/Wednesday, June, 5th, 14:30 – 16:30, Sala 1/Hall 1

**Chair: Marina Šokčić-Kostić, NUKEM technologies, Alzenau, Germany**

NT1.1

### ULOGA PAVLA SAVIĆA U OTKRIĆU FISIJE (EDU)

*Dragoslav Nikezic, University of Kragujevac, Faculty of Science, Serbia*

U ovom radu je opisano otkriće nuklearne fisije i uloga Pavla Savića u ovom otkriću

NTI2.1

### START-UP APPROACH AND PROPOSAL FOR NUCLEAR SAFETY KNOWLEDGE MANAGEMENT STRATEGY IN THE REPUBLIC OF SERBIA (EDU)

*Koviljka Stankovic, University of Belgrade, Faculty of Electrical Engineering, Serbia*

The aim of this paper is to present the start-up approach and proposal for nuclear safety knowledge management strategy in the Republic of Serbia. The main role in maintaining and protecting existing nuclear knowledge has been taken by academic staff. In order to share nuclear safety knowledge, university teachers started with implementation of bilateral agreements on professional and technical cooperation between respective institutions. The main goals of such cooperation, but not limited to, are effective solving of problems that are met in practice at professional level as well as involving students in real nuclear safety practice. It should be pointed out that the initiators of such coordination are highly educated young professionals (in science and engineering) who have been well trained through international training courses. It could be suitable starting point for straightening approach and developing long-term nuclear knowledge safety strategy at national level.

NT1.2

## PRELIMINARNI PREGLED POČETAKA JUGOSLOVENSKOG NUKLEARNOG PROGRAMA (EDU)

*Maja Korolija, Institute for Multidisciplinary Research, Belgrade, Serbia*

Namera je da se u radu ukratko prikaže početak jugoslovenskog nuklearnog programa. U radu se ispituju kako specifičnosti konteksta Hladnog rata, tako i uloga i primena nauke, prvenstveno nuklearne fizike, u tom periodu. U radu se analizira geopolitički položaj FNRJ nakon prekida saradnje sa SSSR-om 1948. godine i fokus jugoslovenskog političkog vrha na razvoj nuklearnog programa, uz prikaz osnovnih podataka o institutima u kojima se on sprovodio. U ovom kontekstu prikazuje se dinamika odnosa između predstavnika vlasti i naučnika, i razmatra se značaj tih odnosa za jugoslovenski nuklearni program.

NT1.3

## UPOREDNA ANALIZA UTICAJA GAMA I X ZRAČENJA NA KARAKTERISTIKE MODELA GASNOG ODVODNIKA PRENAPONA U IMPULSNOM REŽIMU RADA

*Boris Loncar, Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, Serbia*
*Dusan Nikezic, Institut Vinca, Serbia*
*Katarina Karadžić, Технолошко-металуршки факултет Универзитета у Београду, Serbia*
*Luka Rubinjoni, Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, Serbia*
*Andrija Jankovic, Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, Serbia*

Cilj ovog rada je da se ispita uticaj gama i X zračenja na karakteristike modela gasnog odvodnika prenapona za tri materijala elektroda pri tri brzine impulse. Dobijeni rezultati su pokazali da i gama i X zraćenje dovode do privremenog poboljšanja karakteristika gasnih odvodnika prenapona. Najbolji rezultati se postižu upotrebom elektroda od aluminijuma, pri najbržim impulsima.

NTI2.2

## CHARACTERIZATION OF FAST-NEUTRON DETECTOR MODERATORS BASED ON MONTE CARLO SIMULATION

*Jovana Knežević, Faculty of Electrical Engineering, Serbia*
*Miloš Vujisić, Faculty of Electrical Engineering, Serbia*

In this paper, using the Monte Carlo method, a simulation of the response of fast neutron detectors with Bonner spheres has been performed, in terms of detection efficiency dependence on neutron energy in the range from 10^–8 MeV up to 10^2 MeV, taking into account different diameters of the moderator sphere (from 2 to 12 inch), as well as various moderator materials: polyethylene and paraffin. The simulation was conducted using a code developed for this purpose in the MATLAB software package. Approximations have been introduced to the physical models of neutron interactions that enable more efficient code execution. Results obtained in this manner are compared to the results obtained by a more detailed model, found in literature.

# Robotika i fleksibilna automatizacija/ Robotics and Flexible Automation (RO)

## SESSION ROI1

Sreda/Wednesday, June, 5th, 11:15 – 13:30, Sala 4/Hall 4

**Chair: Veljko Potkonjak**

ROI.1.1

ROBOT TASK EXTRACTION AND REPLICATION FROM RAW VIDEO USING REINFORCEMENT LEARNING

*Milivoje Majstorović, School of Electrical Engineering, University of Belgrade*
*Zaviša Gordić, School of Electrical Engineering, University of Belgrade*
*Kosta Jovanović, School of Electrical Engineering, University of Belgrade*

This paper presents the underlying concept behind an industrial robot replicating a task demonstrated by a human. The task is extracted from the raw sample video in order to obtain the overall goal. The data is prepared for reward function construction, after which a meaningful state of the agent is provided in order to choose the next action. To complete the cycle, the optimal policy for achieving the task is obtained and the task replication is evaluated. The initial tests are performed on a ball throwing motion task without an active gripping element with a set target for the ball – a basketball hoop.

ROI1.2

UNDERACTUATED FINGER DESIGN FOR FLEXIBLE GRASPING IN ROBOTIC ASSEMBLY

*Lazar Matijašević, Faculty of Mechanical Engineering, University of Belgrade*
*Petar B. Petrović, Faculty of Mechanical Engineering, University of Belgrade*

At present-day manufacturing and assembly lines, fairly simple mechanism grippers are used. On the other hand, growing demand for customized products that are mass produced, require flexible, multipurpose grippers that are capable of grasping complex objects of different sizes and shapes. In order for robotic hand to be industry acceptable it needs to be robust, easy to control and most importantly it needs to be affordable price wise. With that in mind concept of multifingered underactuated robotic hand appears as a good candidate to be optimal, general purpose solution. Underactuation as a concept allows robotic hands to grip arbitrary shaped objects without the need for complex control and sensory systems. Also, with less actuators than degrees of freedom multifingered underactuated robotic hand is more affordable and from robot arm carrying capacity standpoint, actuators with less weight allows robotic systems to move faster or to carry heavier loads. For this research linkage driven underactuated mechanisms are chosen because of their rigidity and that trait makes control system more reliable and easier to make thus making whole robotic system more robust and reliable. This paper presents some aspects of design and grasping force analysis of three degrees of freedom (3-DoF) underactuated robotic finger with linkage driven mechanism for CMSysLab Robotic Hand.

ROI1.3

## END-EFFECTOR CARTESIAN STIFFNESS OPTIMIZATION: SEQUENTIAL QUADRATING PROGRAMMING APPROACH

*Nikola Knežević, School of Electrical Engineering, University of Belgrade*
*Branko Lukić, School of Electrical Engineering, University of Belgrade*
*Kosta Jovanović, School of Electrical Engineering, University of Belgrade*
*Tadej Petrič, Jožef Stefan Institute, Ljubljana, Slovenia*
*Leon Žlajpah, Jožef Stefan Institute, Ljubljana, Slovenia*

Control of end-effector stiffness (or the whole mechanical impedance) is still a critical open issue in physical human-robot interaction. This paper presents an optimization approach for shaping the Cartesian stiffness of a robot endeffector. This research targets collaborative robots with intrinsic compliance - serial elastic actuators. Although robots with serial elastic actuators have constant joint stiffness, kinematic redundancy for a specific task (null-space) could be used for robot reconfiguration and shaping Cartesian stiffness matrixwhile still keeping the end-effector Cartesian position unchanged. The method proposed in this paper is Sequential Least SQuares Programming (SLSQP) algorithm, which presents an expansion of the quadratic programming algorithm for nonlinear functions with constraints. The method is tested in simulations for 4 DOF planar robot. Results are presented for control of the end-effector Cartesian stiffness initially along one axis, and then control of stiffness along both axis planarly - shaping the main diagonal of the end-effector Cartesian stiffness matrix.

ROI1.4

## EYE GAZE AND BODY MOTION SYNCHRONIZATION IN DYADIC INTERACTION

*Danilo Nikić, Faculty of Technical Sciences, University of Novi Sad*
*Nikola Ilić, Faculty of Technical Sciences, University of Novi Sad*
*Darko Todorović, Faculty of Electronic Engineering, University of Niš*
*Nuno Duarte, Instituto de Sistemas e Robótica / Instituto Superior Técnico, Portugal*
*José Santor-Victor, Universidade de Lisboa, Portugal*
*Branislav Borovac, Faculty of Technical Sciences, University of Novi Sad*
*Mirko Raković, Faculty of Technical Sciences, University of Novi Sad*

Understanding the behavior alignment in dyadic human-human interaction and human-in-the-loop control in human-robot interaction relies on reliable tracking of the human motion. The gaze tracking and motion capture are common techniques that are used nowadays, but they are usually used separately. In this work we combined two Pupil-labs gaze tracker with a Vicon optical motion capture system. To synchronize the recordings of all devices we developed the solution that utilized Lab Streaming Layer for unified collection of measurement time series in research experiments that handles both the networking, time-synchronization and (near-) real-time access of the data. The aim of the experimental setup is to study the interaction of two humans while performing a joint task that requires interpersonal motion coupling.

## ROI1.5 PARAMETERIZED OCCUPANCY GRID AS A BASE FOR PERCEPTION APPLICATIONS IN ROS ENVIRONMENT

*Stevan Stević, RT-RK Research Institute*
*Marko Krnjetin, RT-RK Research Institute*
*Nenad Četićm RT-RK Research Institute*
*Nives Kaprocki, RT-RK Research Institute*

Method to accomplish autonomous driving can be roughly described by three main capabilities of such vehicle, which are sensing, computing and actuation. Computing as a main component consists of number of different algorithms grouped by their functionalities such as: perception of environment, path planning and following, etc. These functions arose from well-studied approaches and architectures that proved best for self-driven vehicles. Larger community, mostly

because of the commercial nature of the subject, does not know more in-depth details of computing platforms and libraries. *Autoware* is a *Robot Operating System (ROS*) based platform that aims to simplify and optimize the development and prototyping of the autonomous systems and features by providing modules and functionalities of autonomous driving to open-source community. In this paper, we extended the perception module of *Autoware* by implementing occupancy grid as generalized and parametrized *ROS* package that can be used as a base for preprocessing in variety of real-time autonomous applications. We also implemented *Proof of Concept* (*PoC*) applications applying *Test Driven Development (TDD)* and *Clean Code* programming principles in context of cutting-edge *Agile* Automotive software development processes. Performances have been evaluated on embedded NVIDIA Xavier SoC and high-end laptops.

ROI1.6

## SIMULATION OF HUMANOID MOVEMENTS OF THE NAO ROBOT USING THE VIRTUAL ROBOT EXPERIMENTATION PLATFORM V-REP

*Slađan Kantar, School of Computing, University Union, Belgrade*
*Miloš D Jovanović, Institute Mihajlo Pupin, University of Belgrade*

This paper is based on the use of a free virtual robot experimentation platform (V-REP) in order to design and test humanoid movements of the NAO robot. The simulation platform contains a complete NAO-robot model with integrated sensors. The document lists the necessary configurations of the environment to simulate the behavior defined in the tabular document. In addition, several scenes have been implemented, in various ways, to illustrate the platform's capabilities used for simulation. All examples are freely available to readers.

ROI1.7

## BENEFITS OF RESIDUAL NETWORKS IN REINFORCEMENT LEARNING USING V-REP SIMULATOR

*Aleksandar Pluškoski, School of Computing, University Union,*
*Igor Ciganović, School of Computing, University Union,*
*Miloš D. Jovanović, Institute Mihajlo Pupin, University of Belgrade*

There are two major problems in the reinforcement learning. One is the stability of the training algorithm. The other is the limited accessibility of the real world training. Reinforcement learning algorithms are notoriously unstable while training because of the very complex loss functions. Residual networks offer smoother gradient descent and thus more stability while training. The other problem is the practicality of the real world training. The reinforcement learning is used for planning and problem solving. While game-like environments are enough for the proof of concept algorithm benchmarks, practical implementation usually requires highly specialized and usually very expensive equipment. It is not practical to have the agent train on the equipment that can easily be damaged. Also the speed and the parallelizability of the physical robots are the additional limiting factors. All these limitations can be addressed by using the simulator. However, setting up the simulator to be used with the external reinforcement learning agent is not a simple task. The solution presented in this paper illustrates the process of setting up the V-rep simulator and presents the results of testing the residual network versus the simple convolutional network.

ROI1.8

## THE STRATEGY OF BUILDING AND USING SIMPLIFIED ROBOTIC MODELS IN ENGINEERING PROJECTS

*Zorica Dodevska, Research and Development Institute Lola Ltd.*
*Vladimir Kvrgic, Institute Mihajlo Pupin, University of Belgrade*
*Marko Mihic, Faculty of Organizational Sciences, University of Belgrade*

Building robotic models for the purposes of achieving goals in engineering projects, and its usage as a strategy advantage of such projects, are the main topics of this paper. Also, implementation of innovative technologies, like augmented reality (AR) and internet of things (IoT), on simplified robotic models (SRM) are at the focus in the paper. The authors find that the strategy of building and using SRM concept in complex engineering projects is fully justified, particularly before construction of the real objects that can be very expensive and time consuming. The fact that developed solutions (for example, AR apps) can be transferred to the final objects with necessary testing and modification strongly supports the authors' standing in this paper. Uniqueness of this work is reflected in the use of LEGO elements for building physical model of a centrifuge for pilot training, according to the project requirements, and developing an AR/IoT mobile app that could be applied to the real centrifuge. In addition to the strategy based on SRM, the authors stress the importance of such AR development strategy.

ROI1.9

ROS AS A RAPID PROTOTYPING PLATFORM FOR LIDAR BASED STOPPING DISTANCE MONITOR

*Marko Dragojević, RT-RK Research Institute*
*Momčilo Krunić, University of Novi Sad Faculty of Technical Sciences*
*Ninoslav Jovanov, RT-RK Research Institute*
*Nemanja Lukić, University of Novi Sad Faculty of Technical Sciences*

Automotive industry is on the rise in last couple of years, and it's most notable goal is producing fully autonomous vehicles. To achieve this goal, complex software systems are introduced. Development of such systems can be very costly, and possible mistakes made in early stages of system design can be hard to amend. That's why different prototyping methods are used to solve potential problems in early stages of development. Different rapid prototyping platforms are used to achieve this. In this paper we will present one prototype solution for obstacle detection application which uses LiDAR to sense vehicle's environment and perform those detections, and also take appropriate actions to warn driver about possible collision. Technologies used for this solution involve, C++ as a language of choice, ROS and Autoware as a framework and GTest/ROStest which are utilized for verification and validation.

## SESIJA: RO1

Sreda/Wednesday, June, 5th, 14:30 – 16:30, Sala 4/Hall 4

**Predsedavajući: Aleksandar Rodić, Institut Mihajlo Pupin, Univerzitet u Beogradu**

RO1.1

NEVER-ENDING ONTOLOGY LEARNING APPROACH APPLIED TO BIOMOLECULAR FUNCTION PREDICTION

*Nenad Petrović, Faculty of Electronic Engineering, University of Niš*
*Milorad Tošić, Faculty of Electronic Engineering, University of Niš*

Biomolecular function prediction is an important task in biomedical sciences. However, most of the existing solutions for automated function prediction are based onstructural sequence similarity methods that do not always give satisfying results, as structural similarity does not necessarily lead to functional similarity. In this paper, we propose a semantic approach for biomolecular function prediction based on never-ending learning paradigm applied to ontology learning and knowledge extraction. PubMed biomedical literature repository is used for this purpose with objective to refine the results returned by BLAST that is performing the calculation of similarity using local sequence alignment. For the refinement of results, the molecule similarity on semantic level is also considered. The implementation of ontology learning and knowledge extraction modules is presented, while the prediction-related module is still a prototype in progress.

RO1.2

## UPRAVLJANJE REDUNDANTNOM ROBOTSKOM RUKOM S VIŠESTRUKIM POGONIMA I POKRETANJEM SAJLAMA

*Aleksandar Rodić, Institut Mihajlo Pupin, Univerzitet u Beogradu*
*Miloš Jovanović, Institut Mihajlo Pupin, Univerzitet u Beogradu*
*Ilija Stevanović, , Institut Mihajlo Pupin, Univerzitet u Beogradu*

U radu se razmatraju aspekti projektovanja inteligentnog upravljanja redundantnom robotskom rukom pokretanom sajlama s višestrukim servo-pogonima. Na početku, biće prikazana konstrukcija robotske ruke redundantne kinematske strukture s 7 stepeni slobode kretanja, čiji je prototip mehanizma u fazi pripremem za izradu. Takođe, biće dat matematički model višestruko aktuirane robotske ruke na bazi kojeg je urađena simulacija sistema i sprovedena inkrementalna poboljšanja mehaničke strukture u fazi razvoja prototipa robotskog mehanizma. U radu se sintetizuje fuzzy kontroler robotske ruke, na višem hijerarhijskom nivou, s zadatkom upravljanja višestrukim pogonima I pokretanjem mehanizma posredstvom sajli. Verifikacja performansi sintetizovanog inteligentnog kontrolera urađena je korišćenjem simulacionih eksperimenta. Rezultati će biti analizirani i prikazani u poslednjem odeljku rada. Budući pravci istraživanja i razvoja biće istaknuti na kraju rada kao i neki aspekti primene redundantne robotske ruke s višestrukim pogonom.

RO1.3

## UTICAJ EDGE RAČUNARSTVA NA INDUSTRIJSKU AUTOMATIZACIJU

*Stevan Stankovski, Fakultet tehničkih nauka, Univerzitet u Novom Sadu*
*Gordana Ostojić, Fakultet tehničkih nauka, Univerzitet u Novom Sadu*
*Igor Baranovski, Fakultet tehničkih nauka, Univerzitet u Novom Sadu*
*Miloš Stanojević, Fakultet tehničkih nauka, Univerzitet u Novom Sadu*
*Mladen Babić, , Fakultet tehničkih nauka, Univerzitet u Novom Sadu*

Povećanje performansi svih računarskih komponenti omogućava da se razvijaju nove arhitekture i platforme za obradu, razmenu, distribuciju i skladištenje podataka. Brzina, sigurnost i pouzdanost prenosa podataka su bitni parametri u industrijskoj automatizaciji i zbog toga samo one arhitekture/koncepti koje uspešno zadovoljavaju ove parametre imaju šansu da uspeju u industrijskom okruženju. Sve opšta potreba za razmenom podataka, učinila je da se količina podataka koja se generiše/beleži značajno narasla i zbog toga se traže novi pristupi za rešavanje ovog problema. Jedan od prilaza je primena Egde računarstva. Edge računarstvo donosi nove mogućnosti u obradi i korišćenju podataka, koji se dobijaju u procesima industrijske automatizacije. U ovom radu su dati osnovni prilazi u primeni Edge računarstva.

# Computing and information engineering/ Računarska tehnika i informatika (RT)

## SESIJA RT1: MOBILNI SISTEMI I SERVISI

Ponedeljak/Monday, June, 3rd, 09:00 – 11:00, Sala 5/Hall 5

**Predsedavajući: Jelena Kovačević, Fakultet Tehničkih Nauka, Novi Sad, Srbija**
**Miodrag Đukić, Fakultet Tehničkih Nauka, Novi Sad, Srbija**

RT1.1

### AŽURIRANJE ANDROID OPERATIVNOG SISTEMA UPOTREBOM PUSH VOD TEHNOLOGIJE

*Milos Ivankovic, RT-RK, Serbia*
*Ilija Basicevic, The Faculty of Technical Sciences in Novi Sad, Serbia*
*Goran Stupar, RT-RK Institute for Computer Based Systems, Serbia*

U ovom radu prezentovano je jedno rešenje ažuriranja korisničkih Set-Top Box uređaja zasnovanih na Android operativnom sistemu u slučaju ograničenog pristupa ili potpune nemogućnosti pristupa internet mreži. Kao specifična okolnost koja se može javiti u slučaju distribucije digitalnog televizijskog signala, ovom prilikom je rešena prenosom podataka neophodnih za ažuriranje uređaja putem prenosnog toka kojim se distribuira digitalni televizijski signal. Ovaj rad predstavlja funkcionalno rešenje primenljivo i u drugim sličnim implementacijama obrade prenosnog toka digitalnog televizijskog signala

RT1.2

### AŽURIRANJE ANDROID BAZIRANOG DIGITALNOG TV PRIJEMNIKA U SLUČAJU ONEMOGUĆENE INTERNET KONEKCIJE

*Natasa Bogdanovic, Istrazivacko-razvojni Institut RT-RK, Serbia*
*Goran Stupar, Istrazivacko-razvojni Institut RT-RK, Serbia*
*Ilija Basicevic, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Serbia*

Ovaj rad predstaviće jedno od rešenja ažuriranja korisničkih Set-Top Box uređaja zasnovanih na Android operativnom sistemu u uslovima kada je internet konekcija ograničena ili onemogućena. Nedostatak kvalitetne internet konekcije predstavlja jedan od mogućih problema koji se javljaju prilikom distribucije digitalnog televizijskog signala. Rešenje koje je predstavljeno u ovom radu koristi specijalne kontrolne strimove koji sadrže signalne tabele kako bi se kontrolisalo vreme ažuriranja.

RT1.3

### APPLICATIONS FOR CONCURRENT MEDIA RECORDING AND PLAYBACK ON ANDROID DEVICES

*Marko Milovanovic, RT-RK, Serbia*
*Nikola Vranic, RT-RK, Serbia*
*Zoran Marceta, RT-RK, Serbia*
*Milan Acanski, RT-RK, Serbia*

Android is the most popular operating system and platform for mobile phones and tablets. Millions of mobile devices around the world today use Android as the primary software platform. Although primarily designed for touch screen devices, Android is becoming part of a broad spectrum of platforms, including digital receivers. Equipped with rich multimedia options and support for the installation of free Android applications, digital receivers are a great solution for upgrading a standard TV to Smart TV. Media recording, one of the functionalities of the Android

multimedia subsystem, is supported for multiple container formats, but Android currently does not support recording in the MPEG-TS format, the most popular format in the field of digital television. This paper describes the extension of the multimedia subsystem for recording TS streams, which is used in applications, whose main functionality is concurrent media recording and playback.

RT1.4

## REALIZACIJA UPRAVLJAČKE KORISNIČKE SPREGE ZA KONTROLU SOFTVERA ZA SNIMANJE I UREĐIVANJE ZVUKA

*Milan Vuletic, Istrazivacko-razvojni Institut RT-RK, Novi Sad, Srbija, Serbia*
*Sergej Furtula, Istrazivacko-razvojni Institut RT-RK, Novi Sad, Srbija, Serbia*
*Jelena Kovacevic, Fakultet Tehničkih Nauka, Novi Sad, Srbija, Serbia*

Ovim radom je predstavljen jedan od načina unapređenja ispitnog okruženja za ispitivanje uređaja namenjinih za dekodovanje, obradu i reprodukciju Audio sadržaja pomoću programskog alata Audacity. Ova ispitivanja se vrše u dve faze, prva faza na nivou procesora a druga na nivou proizvoda. Ispitno okruženje za ispitivanje obično koristi APx (Audio Precision) merni uređaj, a unapređenje zapravo pretstavlja integraciju Audacity programskog alata u ova okruženja. Takođe, za potrebe dodatne automatizacije ispitnih slučajeva, realizovano je automatsko izvršavanje komandi za reprodukovanje, snimanje, generisanje i analiziranje audio zapisa. Rezultat ovog unapređenja se ogleda u smanjenju greške tokom ispitivanja i analize, izazvane „ljudskim faktorom“ kao i smanjenju vremena potrebnog za izvršavanje celokupne procedure.

RT1.5

## JEDNO REŠENJE SIMULACIJE DASH PROTOKOLA ZA ANDROID MEDIA API

*Nikola Ječmenica, RT-RK, Serbia*
*Marija Jovanović, RT-RK, Serbia*
*Dusan Živkov, RT-RK, Serbia*
*Đorđe Glišić, RT-RK, Serbia*

U ovom radu je predstavljena realizacija aplikacije koja ima za cilj da reprodukuje multimedijalni sadržaj koristeći Android API niskog nivoa, pre svega MediaCodec i MediaExtractor. Ona takođe predstavlja teset aplikaciju za MediaExtractor koji kao izvor podataka koristi MediaDataSource interfejs. Aplikacija je pisana u Java programskom jeziku i predstavlja simulaciju DASH protokola prilagođenu Android TV platformi. Aplikacija ima jednostavan GUI (Graphical User Interface).

RT1.6

## AUTOMATIZACIJA RADNOG OKRUŽENJA ZA ISPITIVANJE SLOŽENIH AUDIO SISTEMA

*Filip Uzunović, Istrazivacko-razvojni Institut RT-RK, Novi Sad, Srbija, Serbia*
*Branko Đorđević, Istrazivacko-razvojni Institut RT-RK, Novi Sad, Srbija, Serbia*
*Nenad Pekez, Istrazivacko-razvojni Institut RT-RK, Novi Sad, Srbija, Serbia*
*Jelena Kovačević, Istrazivacko-razvojni Institut RT-RK, Novi Sad, Srbija, Serbia*

U ovom radu je predstavljeno automatizovano radno okruženje za ispitivanje složenih audio sistema, čijom upotrebom se smanjuje vreme neophodno za ispitivanje do 35 %. Kao precizan i pouzdan uređaj za efikasno ispitivanje ovih sistema koji zamenjuje skupa rešenja na tržištu, korišćen je RT-AG (RT – Audio Graber). RT-Executor koji omogućava automatsko izvršavanje ispitnih slučajeva, predložen je kao programska podrška ispitivanju. U radu je takođe navedeno i na koji način je unapređena sama procedura za ispitivanje.

RT1.7

GENERIC REPRESENTATION OF FUNCTIONALITIES AND STATES OF DEVICES IN IOT SYSTEMS

*Lana Salai, OBLO Living, Serbia*
*Igor Stefanović, OBLO Living, Serbia*
*Roman Pavlović, OBLO Living, Serbia*
*Ištvan Pap, OBLO Living, Serbia*
*Miloš Milanović, OBLO Living, Serbia*

This paper describes the concept of the solution for displaying the functionality of IP (stands for Internet Protocol) devices to end users of the home automation system in a simplified way. The solution implies a generic representation of the physical properties of the device, whereby device information is supplied using the WISE (stands for WiFi Sensors) protocol. By dividing the functionality of the devices by priority, it is possible to draw the control screens for functionally different devices in an intuitive way. This significantly facilitates the maintenance and expansion of smart home systems for new devices.

RT1.8

PODACIMA-VOĐENA ARHITEKTURA ZA PRILAGODLJIVE ENERGETSKE MREŽE ZASNOVANA NA IOT UREĐAJIMA

*Nenad Petrović, Faculty of Electronic Engineering, University of Niš, Serbia*
*Đorđe Kocić, Elektronski fakultet Niš, Serbia*

Povećanje potrošnje električne energije poslednjih godina donosi nove izazove i iziskuje promene. Postojeći sistemi i infrastruktura bi trebalo da postanu fleksibilniji, sa mogućnošću da rade u veoma dinamičnim uslovima, pri čemu treba da reaguju adekvatno na promene koje nastaju u okruženju. Iz tog razloga, u zadnje vreme se teži evoluciji energetske mreže prema takozvanoj pametnoj mreži. U ovom radu, istražuju se mogućnosti primene modernih informacionih i telekomunikacionih tehnologija u pametnim elektroenergetskim mrežama, oslanjajući se na pristupačne IoT uređaje. Kao rezultat istraživanja, predložena je podacima-vođena arhitektura za prilagodljive energetske mreže koja se oslanja na Internet of Things (IoT) uređaje i dat opis implementacije najbitnijih komponenti sa pojedinim aspektima evaluacije.

## SESIJA RTI1: IOT SYSTEMS

Ponedeljak/Monday, June, 3rd, 11:15 – 13:30, Sala 5/Hall 5

**Chair: Ivan Milentijević, Faculty of Electronic Engineering, University of Nis, Serbia**
**Miroslav Popović, University of Novi Sad, Faculty of Technical Sciences, Serbia**

RTI1.1

AUTOMATION OF IRRIGATION SYSTEMS USING THE INTERNET OF THINGS

*Vlado Krunić, PMF Banja Luka, Serbia*
*Momčilo Krunić, FTN Novi Sad, Serbia*
*Predrag Ranitović, Visoka poslovna škola strukovnih studija Novi Sad, Serbia*

Internet of Things (IoT) has led to major changes in the daily lives of people through application in cities, energy, business, education, medicine, industry, agriculture and other fields. The Internet of things allows the connection of a large number of users, devices, services and applications to the Internet, whereby each device is assigned a unique identifier. Interconnected devices and applications share data and forward them to remote servers so that end-users can access them as needed via mobile and / or web applications. The application of IoT in agriculture through the projected infrastructure with appropriate sensors, actuators, microcontrollers and

microcomputers enables continuous monitoring and automatic start of the appropriate processes. Key activities, that can be efficiently automated using IoT, refer to irrigation processes. The theme of the paper is the model of automation of irrigation systems using IoT.

RTI1.2

## DATA ACQUISITION, COLLECTION AND STORAGE IN SMART HOME SOLUTIONS

*Sandra Ivanović, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Marija Antić, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Ištvan Papp, Oblo Living, Narodnog fronta 21a, 21000 Novi Sad, Serbia*
*Neven Jović, RT-RK Research Institute, Narodnog fronta 23a, 21000 Novi Sad, Serbia*

In this paper, one solution for smart home IoT data collection and storage is presented. In the proposed solution, MQTT protocol is used to report changes in the system, while RabbitMQ, MongoDB, and NodeJS are used on cloud side to capture, process and store data. Processed data is stored in views that can be easily retrieved and presented on the client side. The proposed solution does not introduce significant deployment and maintenance costs, as it does not introduce technologies that are not otherwise already present in the system. Performance of the proposed solution is explored, and it is shown that the rate of changes that can be captured satisfies the needs of the medium sized IoT system.

RTI1.3

## USING ONLINE WEATHER DATA TO IMPROVE SMART HOME USER EXPERIENCE

*Milica Matić, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Milan Tucić, OBLO Living, Serbia*
*Marija Antić, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Roman Pavlović, OBLO Living, Serbia*

In this paper we present one solution for integrating online geolocation and weather services with the existing smart home system. The goal is to improve smart home user experience, by enabling automatic system reaction to different astronomical data parameters (sunrise, sunset, moon phase), or changes in weather forecast. The existing smart home system is extended to hold information about user location, and to monitor online weather data for this location. Details of the implementation and communication between components of the system are presented and functional and load testing of the implemented service are evaluated.

RTI1.4

## INDUSTRIAL FOG COMPUTING PLATFORM AND SYSTEM TESTING THROUGH GUI

*Rade Tišma, RT-RK Institute for Computer Based Systems, Bosnia and Herzegovina*
*Ivan Velikić, RT-RK Institute for Computer Based Systems, Serbia*
*Velibor Mihić, RT-RK Institute for Computer Based Systems, Serbia*

Fog Computing is next step in supporting industrial IoT. It offers solutions for harsh demands in modern industrial environment. Manipulation with enormous data generated on daily level in industry and enabled almost real time analysis with safeness always on mind, is supported by Fog Computing model. This paper shortly presents industrial IoT platform based on Fog Computing architecture. Basic functionality of available GUI components is described with some quick turn on system testing through available interfaces for users

RTI1.5

## DYNAMIC CONTROL OF SOFTWARE FEATURES IN AUTOMOTIVE VEHICLES (FEATURE ON THE FLY)

*Zarko Cesljarov, Fakulty of Technical Sciences , University of Novi Sad, Serbia*

Additional functionality implementation for systems already under exploitation is big requirement in automotive industry that can bring extra profit for manufacturer. In order to meet this requirement use of different cryptography methods is necessary. This paper shows one solution to implement function on demand software on Linux based platform without built in cryptographic support. Goal of the paper is to provide mechanisms to safely operate the protected functions, prevent unauthorized activation, and to disable usage of these functions on different platform of same kind.

RTI1.6

## ONE SOLUTION OF VEHICLE CONTROL SOFTWARE BASED ON CAMERA IN ROS ENVIRONMENT

*Maksim Egelja, Research Institute RT-RK, Serbia*
*Nikola Teslic, Research Institute RT-RK, Serbia*
*Nemanja Lukic, Faculty of Technical Sciences, University of Novi Sad, Serbia*
*Zvonimir Kaprocki, Research Institute RT-RK Osijek, Croatia*

Software in automotive industry today is a very popular branch and brings many new challenges to the world of engineering. Recently, autonomous driving became one of the biggest challenges of this field. Goal is to develop a system capable of controlling vehicle almost completely independently. Work presented in this paper defines several modern autonomous driving algorithms and simulate them on modern platform. These algorithms are working with sensors attached to vehicle, such as camera, radar, lidar, etc. and include functionalities such as keep lane, controlling vehicle when "Stop" sign is detected and adapting vehicle speed when speed limit sign occurs in front of camera sensor.

RTI1.7

## ADMINISTRATION TOOL FOR MULTI-SENSOR IMAGING SYSTEM

*Marko Nerandžić, Vlatacom Institute, Serbia*
*Petar Milanović, Vlatacom Institute, Serbia*
*Gardelito Hew A Kee, Vlatacom Institute, Suriname*
*Ilija Popadić, Vlatacom Institute, Serbia*
*Miroslav Perić, Vlatacom Institute, Serbia*

Rapid development in imaging technologies as well as computer science bring both software and hardware improvements to systems used in military and surveillance fields, but there is a constant trade-off between adding new software features and lowering the system's security. Every new feature implemented in such system can potentially be a weak point for individuals with malicious intent. Particularly in multi-sensor imaging systems, initialization process of system itself is the weakest point, when no IP address is acquired, but system is powered on. Also, worth mentioning is the necessary use of static IP addresses, to avoid any DHCP Offer or other magic packets. However, there is a need for remote administration, especially since these types of systems are often found on distant locations. This paper presents a solution applied in such system and gives comments about which programming language should be used, recommended tools for enabling remote administration itself, as well as security shortcomings of such approach.

RTI1.8

## ONE SOLUTION OF DTV SIMULATOR FOR PC PLATFORM

*Aleksandar Šuka, RTRK, Serbia*
*Đorđe Glišić, RTRK, Serbia*
*Aleksandar Plahćinski, RTRK, Serbia*
*Miodrag Đukić, RTRK, Serbia*

User requirements of digital TV receivers grows increasingly, so does the complexity of embedded development process. Current STB devices range from cheap low memory device to multi-core device with performance comparable to PC or mobile phones. Low cost devices present a specific challenge in development, as the stability and performance is more in focus than on high performance devices. Limitations in the development of software for digital television showed the need for the development of tools for analysis and testing. This paper presents one solution to overcome limitations of target platform. DTV software stack is taken and adjusted to be used on PC to get sophisticated development tools accessible.

RTI1.9

## REPRODUCTION OF HIGH QUALITY OBJECT-BASED AUDIO CONTENT USING GSTREAMER MULTIMEDIA FRAMEWORK

*Srđan Šuvakov, RT-RK Institute for Computer Based Systems LLC, Novi Sad, Serbia*
*Jelena Kovačević, Faculty of Technical Sciences, Trg Dositeja Obradovića 6, Novi Sad, Serbia,*
*Dejan Bokan, Faculty of Technical Sciences, Trg Dositeja Obradovića 6, Novi Sad, Serbia*
*Andrej Popović, RT-RK Institute for Computer Based Systems LLC, Novi Sad, Serbia*

The new generation of audio technology introduces significant increase in audio processing demands at playback device side. Implementation of such technologies for embedded devices represents a challenging task. Use of an existing multimedia framework, can speed up development process, but most of the state of the art multimedia frameworks do not support new types of audio stream formats such as object based audio. This paper describes a process of extending GStreamer multimedia framework with support for object-based audio stream playback. A new GStreamer plugin for rendering of audio objects, has been created. The plugin receives and prepares the object-based input stream, invokes the rendering function and after the rendering is finished, the plugin sends the rendered data to the next element in the GStreamer pipeline. A method for audio objects and metadata transfer between GStreamer modules is presented. Plugin is evaluated by using an ARM based SoC device running Linux OS.

RTI1.10

## SPECTRAL ANALYSIS OF MALE AND FEMALE SPEECH SIGNALS

*Omar Zelmati, Military Academy of Belgrade, Serbia*
*Boban Bondžulić, Military Academy of Belgrade, Serbia*
*Milenko Andrić, Military Academy of Belgrade, Serbia*
*Dimitrije Bujaković, Military Academy of Belgrade, Serbia*

In this paper a spectral analysis is applied on a male and female speech audio database. The effect of unsounded audio signal parts on the spectrum rate is studied and it is shown that silent parts disturb strongly the spectral analysis and these parts should be deleted. A comparison between different spectra is made based on correlation. For the case of the spectrums that origins from the same speaker, it is shown that these spectrums are strongly correlated, while the significant correlation between spectrums of the same gender speakers is highlighted. Finally, the effect of audio signal duration on the spectrums correlation is discussed. The obtained results are very promising and can be used in several fields of speech signal analysis such as speaker recognition and speaker gender identification.

# SESIJA RT2: PROGRAMSKI JEZICI I SOFTVERSKI SISTEMI

Ponedeljak/Monday, June, 3rd, 14:30 – 16:30, Sala 5/Hall 5

**Predsedavajući: Jelica Protić, Univerzitet u Beogradu, Elektrotehnički fakultet, Srbija**
**Vladimir Ćirić, Elektronski fakultet, Univerzitet u Nišu, Srbija**

RT2.1

## RAZVOJ MOBILNE APLIKACIJE ZASNOVAN NA TESTOVIMA KORIŠĆENJEM XCTEST OKRUŽENJA

*Drazen Draskovic, University of Belgrade - School of Electrical Engineering, Serbia*

U ovom radu opisana je implementacija mobilne aplikacije kviz znanja za iOS platformu sa akcentom na testiranju takve aplikacije. Aplikacija je projektovana kao sistem sa Model View Controler (MVC) arhitekturom. Tokom razvoja aplikacije korišćena je metodologija planiranja i izvršavanja testova u toku implementacije, a kao alat za pisanje testova korišćeno je XCTest okruženje. Razvoj aplikacija zasnovan na testovima je vrlo važna tehnika kod softverskih inženjera, pošto podiže kvalitet softvera i smanjuje nedostatke u softveru. U istraživanju su korišćene strategije bele kutije. Realizovani su jedinični testovi za testiranje logike aplikacije i jedinični testovi za testiranje korisničkog interfejsa. Dobijena pokrivenost koda realizovanim jediničnim testovima je 68.85%, a pokrivenost testovima korisničkog interfejsa je 75.02%.

RT2.2

## AUTOMATSKO GENERISANJE TESTOVA ZA AUTOMOTIVE SISTEME ZASNOVANE NA AUTOSAR MODELU

*Aleksandar Lukic, RT-RK, Serbia*
*Dragan Kukolj, RT-RK, Serbia*
*Milena Milošević, RT-RK, Serbia*
*Velibor Ilić, RT-RK, Serbia*

U radu je opisan postupak generisanja testova pomoću kojih se proverava da li se RTE (runtime environment) sprege izvršavaju kako je predviđeno na ugrađenoj (eng. embedded) automotive platformi za konkretne namenske kontrolne jedinice (eng. ECU - Electronic Control Unit). Predstavljen je jedan od načina za automatsko generisanje testova pomoću kojih se proverava rad softverskih komponenti koje pripadaju AUTOSAR modelu. Opisani su procesi od izvlačenja informacija potrebnih za pravljenje testova do samog izvršavanja testa. Za potrebe testiranja su implementirana dva moda, FreedomFromInterference i MiddlewareConnections. Za proveru funkcionalosti korištena je Autonomus driving platforma sa dva domaćina (eng. host) i VN89000 uređaj na kome je realizovan framework za komunikaciju između namenskog sistema i testnog računara uz pomoć ethernet veze.

RT2.3

## UNAPREĐENJE PROGRAMSKOG PREVODIOCA CLANG SA PODRŠKOM ZA STANDARD MISRA/AUTOSAR

*Đorđe Milićević, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia, Serbia*
*Mirko Brkušanin, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia, Serbia*
*Milena Vujošević Janičić, Faculty of Mathematics University of Belgrade, Serbia*
*Teodora Novković, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia, Serbia*
*Petar Jovanović, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia, Serbia*

Poštovanje standarda kodiranja je posebno važno u automobilskoj industriji jer greške u softveru automobila mogu imati fatalne posledice. U radu je predstavljeno unapređenje programskog prevodioca Kleng (eng. Clang) dodavanjem mogućnosti provere ispunjenosti 164 pravila iz standarda MISRA/AUTOSAR. Predstavljeni su opis i struktura standarda AUTOSAR, kompajlerske infrastrukture LLVM i programskog prevodioca Kleng, kao i detalji realizacije i

način integrisanja skupa podržanih pravila u prednji deo infrastrukture LLVM. U okviru realizacije, napravljene su različite vrste proširenja leksičkog, sintaksičkog i semantičkog analizatora. Evaluacijom je utvrđeno da realizovane dodatne analize usporavaju proces prevođenja za svega 19,15%, što čini ovu realizaciju izuzetno efikasnom.

RT2.4

## DODAVANJE PODRŠKE ZA ARHITEKTURU NANOMIPS U ALAT ZA DINAMIČKU ANALIZU PROGRAMSKOG KODA VELGRIND

*Dimitrije Nikolic, RTRK, Serbia*
*Aleksandar Rikalo, RT-RK, Serbia*
*Aleksandra Karadžić, RT-RK, Serbia*
*Petar Jovanovic, RT-RK, Computer based systems, Novi Sad, Serbia*

Pojava nove arhitekure mikroprocesorkih sistema pored hardverskog čipa podrazumeva i određene softverske alate, poput kompajlera i emulatora. Upotreba nove arhitekture, odnsosno kreiranje složenih aplikacija za novu arhitekturu, povlači potrebu za softverskim alatima koji bi olakšali detektovanje nepravilnog rada programa i lakše pronalaženje grešaka, poput debagera i profajlera. Ovaj rad opisuje izmene koje su potrebne za dodavanje podrške jednom softerskom alatu za analizu programa, Velgrindu, za novu arhitekturu MIPS Techologies grupe – nanoMIPS.

RT2.5

## UNAPREĐENJE PROGRAMSKOG PREVODIOCA ZA JEZIK P4 SA PODRŠKOM ZA ČITANJE MEĐUKODA U FORMATU JSON

*Jelena Vidakovic, RT-RK, Serbia*
*Enisa Hadzic, RT-RK, Serbia*
*Miodrag Dinic, RT-RK, Serbia*
*Dragan Samardzija, RT-RK, Serbia*

P4 je programski jezik visokog nivoa koji je dizajniran da omogući programiranje prosleđivanja mrežnih paketa nezavisno od vrste protokola. P4 prevodilac je otvorenog koda koji održava neprofitna organizacija pod nazivom ‘P4 Jezička Zajednica’. Jezik je prvobitno opisan u dokumentu ‘SIGCOMM CCR’ iz 2014. godine pod nazivom ‘Programming Protocol-Independent Packet Processors’ – odakle seže skraćenica P4. On radi zajedno sa kontrolnim protokolima softverski definisanog umrežavanja (SDN), kao što je ‘OpenFlow’. Koristimo apstraktni model prosleđivanja za definisanje jezika kako bi se opisao način na koji će se konfigurisati switch-evi i kako se paketi obrađuju.

RT2.6

## UNAPREĐENJE JEZIKA P4 IZRAZIMA ASSUME I ASSERT KAO POMOĆ U FORMALNOJ VERIFIKACIJI

*Enisa Hadžić, RT-RK, Serbia*
*Jelena Vidakovic, RT-RK, Serbia*
*Miodrag Dinic, RT-RK, Serbia*
*Miroslav Popovic, RT-RK, Serbia*

P4 je jezik otvorenog koda koji je dizajniran tako da se koristi za programiranje mrežnih uređaja. Razvoj P4 jezika uneo je veću fleksibilnost u mrežnom programiranju i omogućio da uređaj postane rekonfigurabilan i nezavisan od protokola. Osnovni tok podataka u P4 jeziku može da se podeli u 4 osnovne faze. Prva faza je parsiranje mrežnih paketa. Prilikom prijema paketa, polja paketa moraju biti procesirana i sačuvana u reprezentaciji koja je čitljiva narednim fazama. Druga i treća faza je primena podudaranja i akcija tabela na ulaznom i izlaznom toku kontrole. Njihovo izvršavanje predstavlja mehanizam obrade parsiranih podataka i manipulaciju informacija sadržanih unutar polja paketa. Kako bi paket mogao da se dalje prosledi ciljanom uređaju, neophodno je da prođe kroz poslednju fazu deparsiranja, koja će emitovati obrađeno stanje

paketa. U ovom radu biće predstavljen P4 jezik i način rada prevodioca, kao i način unapređenja novim izrazima assert i assume.

RT2.7

## ANALIZA VREMENSKIH SERIJA: METODE PREDVIĐANJA BUDUĆE POTRAŽNJE U VELEPRODAJI

*Aleksandar Stojčić, Univerzitet u Nišu, Elektronski fakultet, Serbia*
*Nevena Radosavljević, Univerzitet u Nišu, Elektronski fakultet, Serbia*
*Bratislav Predic, Faculty of Electronic Engineering, University of Nis, Serbia*
*Marko Kovačević, iCNT Inovacioni centar naprednih tehnologija, Serbia*
*Miloš Roganović, Univerzitet u Nišu, Fakultet zaštite na radu, Serbia*

Osnovna namena analize vremenskih serija jeste pojašnjenje korelacije i osnovnih karakteristika hronološki sortitanih podataka korišćenjem odgovarajućih matematičkih modela. Svoju primenu nalazi u najrazličitijim aspektima života i rada, te tako i u predviđanju buduće potražnje proizvoda, usluga, itd. Najzastupljeniji tip vremenske serije jeste onaj kod koga se opservacije uzimaju u jednakim vremenskim intervalima (dnevno, nedeljno, mesečno, itd.). Međutim, u ovom radu analizira se neuobičajena vremenska serija koja beleži trenutke kupovina nekog proizvoda od strane potrošača, i koja se, samim tim što ne postoje regularni periodi uzorkovanja, mora transformisati na odgovarajući način pre nego što se može krenuti sa tradicionalnim metodama analize. Nakon postupka transformacije, u modeliranju vremenske serije u okviru rada korišćen je opšte poznat ARIMA model za analizu nestacionarnih vremenskih serija, koji je odabran zbog izražene komponente sezonalnosti i pomoću koga se uspešno vrši predviđanje buduće potrošnje posmatranog proizvoda. Cilj ovakve analize jeste pravovremeno reklamiranje proizvoda potrošaču radi povećanja prodaje.

RT2.8

## ARHITEKTURA I IMPLEMENTACIJA SOFTVERSKOG SISTEMA ZA FLEKSIBILNO SPROVOĐENJE KORISNIČKI DEFINISANIH ANKETA

*Ognjen Milošević, University of Belgrade, School of Electrical Engineering, Serbia*
*Marko Misic, University of Belgrade, School of Electrical Engineering, Serbia*
*Jelica Protić, University of Belgrade, School of Electrical Engineering, Serbia*

Sprovođenje korisnički definisanih anketa je čest proces u današnjem poslovanju. Bilo da su u pitanju akademske ili marketinške potrebe, postavlja se pitanje na koji način ankete sprovesti tako da se na brz i jednostavan način dopre do ispitanika bez suvišnih koraka koji bi ga eventualno odvratili od popunjavanja zadatog upitnika. Sa druge strane, prikupljanje podataka treba da bude jednostavno i sa stanovišta onoga ko ispituje neku temu, bez potrebe za korišćenjem komplikovanih sistema. Rasprostranjenost mobilnih uređaja u današnjem svetu olakšava sprovođenje anketiranja sa strane ispitanika, a u radu su prikazani arhitektura i implementacija jednog sistema za fleksibilno sprovođenje korisnički definisanih anketa. Sistem se sastoji od mobilne, veb i serverske aplikacije, a ceo proces se sprovodi bez korišćenja baze podataka i sa relativno skromnom upotrebom resursa.

# SESIJA RT3: MULTIMEDIJALNI SISTEMI

Utorak/Tuesday, June, 4th, 9:00 – 11:00, Sala 5/Hall 5

**Predsedavajući: Marija Antić, Fakultet Tehničkih Nauka Novi Sad, Srbija**
**Bogdan Pavković, Institut za sisteme zasnovane na računarima RT-RK, Novi Sad, Srbija.**

RT3.1

## JEDNO REŠENJE DALJINSKOG UPRAVLJANJA STB PLATFORME PUTEM REST PROTOKOLA

*Milan Gvero, Institut RT-RK, Serbia*
*Ilija Bašičević, Fakultet Tehničkih Nauka Novi Sad, Serbia*
*Nikola Špirić, Institut RT-RK, Serbia*

Ovaj rad predstavlja jedno rešenje daljinskog upravljanja set top box (STB) platforme putem REST protokola. Rešenje je realizovano za već postojeću DTV aplikaciju te predstavlja njeno unapređenje. Rešenje omogućava korisniku da nastavi gledanje sadržaja sa mobilnog telefona, tableta i sličnih uređaja na STB uređaju tako što korisnik prevuče prstom na gore (eng. swype) dok konzumira multimedijalni sadržaj. Multimedijalni sadržaj se tada pauzira na telefonu, a nastavlja da se reprodukuje na STB uredjaju. Takođe rešenje dodaje podršku za simulaciju daljinskog upravljača, stoga korisik može da kontroliše STB putem mobilnog uređaja

RT3.2

## IMPROVEMENT OF THE ARCHITECTURE OF HARDWARE ABSTRACTION LAYER IN DTV MIDDLEWARE

*Lara Milovanović, Istraživačko-razvojni institut RT-RK, Serbia*
*Miroslav Bako, Istraživačko-razvojni institut RT-RK, Serbia*
*Milan Savić, Istraživačko-razvojni institut RT-RK, Serbia*

The DTV middleware is the most important part of the software for TVs, which contains almost complete DTV functionality and allows execution of applications. The dependence of the DTV middle layer on the physical architecture of the target platform has always been a barrier in the DTV medium layer. The aim of this paper is to describe the problem of porting the DTV middleware, precisely hardware abstraction layer, as well as the improvement of the architecture of this layer. By enhancing this feature, DTV middleware supports multiple HAL APIs at the same time, which greatly contributes to the portability of the DTV middle layer, and allows the development of a hybrid STB (Set-top box) device that can transmit OTT content as well as the content obtained from the DVB transport stream.

RT3.3

## PRIMENA TEHNOLOGIJE GOOGLE ASSISTANT U INTERAKTIVNOJ DIGITALNOJ TELEVIZIJI

*Aleksandar Lazic, Istrazivacko-razvojni Institut RT-RK, Novi Sad, Srbija, Serbia*
*Milan Bjelica, Istrazivacko-razvojni Institut RT-RK, Novi Sad, Srbija, Serbia*
*Dejan Nadj, Istrazivacko-razvojni Institut RT-RK, Novi Sad, Srbija, Serbia*

U današnje vreme, sve više i više korisnika koristi usluge virtuelnih asistenata na različitim platformama (Android, Windows, iOS) i oni postaju sve zastupljeniji u svakodnevnim životnim aktivnostima, bilo da je to asistencija u kupovini namirnica, u vožnji do posla ili pak, u svrhu zabave korisnika. U okviru ovog rada istražena je i realizovana mogućnost primene tehnologije Google asistent u interaktivnoj digitalnoj televiziji na prijemniku zasnovanom na operativnom sistemu Android. Jedan od ciljeva je unapređenje korisničkog iskustva u vidu komplementiranja osnovnih funkcionalnosti poput izmene kanala ili nivoa jačine zvuka glasovnim komandama, i dodatnim mogućnostima izbora tačnog kanala, događaja ili video sadržaja na zahtev sa

mogućnošću trenutnog ili naknadnog gledanja, zakazivanja snimanja i dr. Velika većina alata za prepoznavanje glasovnih komandi generiše rezultate naredbe u vidu slobodnog teksta ili struktuiranog objekta. Kako bi se taj rezultat iskoristio u postojećim TV aplikacijama, neophodno je detektovati šablone koji odgovaraju gore pomenutim naredbama.

RT3.4

## PROŠIRENJE TV INPUT RADNOG OKVIRA FUNKCIONALNOSTIMA PAKETA GOOGLE ASSISTANT U ANDROID OKRUŽENJU

*Radenko Banović, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Serbia*
*Milan Bjelica, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Serbia*
*Darko Dejanović, RT-RK d.o.o., Serbia*
*Milan Gvero, RT-RK d.o.o., Serbia*

U ovom radu je predstavljeno jedno rješenje proširenja TV input radnog okvira funkcionalnostima paketa Google Assistant. TV Input predstavlja programsku reprezentaciju jednog izvora odakle se prima TV sadržaj, te popunjava sadržaj u bazu podataka TV poslužioca. Proširenje TV Input radnog okvira se odnosi na prilagođavanje pretrage i prikaza EPG (electronic program guide) podataka smještenih u bazi podataka TV poslužioca tako da se oni nađu u Google Assistant rezultatima pretrage.

RT3.5

## ONE SOLUTION OF REPRODUCTION MULTIMEDIA CONTENT ON INTERNET OF THINGS DEVICE

*Marijana Gligoric, RT-RK, Serbia*
*Nikola Vranic, RT-RK, Serbia*
*Vladimir Nesic, RT-RK, Serbia*
*Djordje Glisic, RT-RK, Serbia*
*Milos Subotic, RT-RK, Serbia*

In the last ten years, the use of digital television has become increasingly widespread, technologies have been developed and new devices have emerged, as are the requirements for new functionalities by users. Developing an application for watching TV on a set-top is something we've already seen. As an excellent solution for innovation in this situation, a platform for the development of Internet of Things application for which the operating system itself was offered by Google itself - Raspberry Pi 3 Model B.

RT3.6

## JEDNO REŠENJE ZAŠTITE PODATAKA NA LINUX SET TOP BOX UREĐAJIMA

*Aleksandra Keča Despotović, RT-RK doo. Narodnog Fronta 23a, 21000 Novi Sad, Srbija, Serbia*
*Boris Mlikota, RT-RK doo. Narodnog Fronta 23a, 21000 Novi Sad, Srbija, Serbia*
*Mario Radonjic, RT-RK doo. Narodnog Fronta 23a, 21000 Novi Sad, Srbija, Serbia*
*Miroslav Bako, RT-RK doo. Narodnog Fronta 23a, 21000 Novi Sad, Srbija, Serbia*

U ovom radu je prikazano jedno rešenje implementacije zaštitnog sistema za Linux Set Top Box (STB) uređaje. Cilj ovog rada je da prikaže kako je moguće, korišćenjem Linux kontejnera (eng. Sandboxing), postići veći nivo zaštite uređaja, i na koji način je moguće izolovati kritične procese od neželjenog pristupa podacima. Dat je kratak osvrt na teorijske osnove korišćenja Linux kontejnera, predlog implementacije ove metode na STB-u, kao i prikaz uticaja korišćenja ove metode na ukupne performance sistema.

RT3.7

DALJINSKA OBRADA MAMOGRAFSKIH SLIKA KORIŠĆENJEM MATLAB WEB SERVISA

*Marina Milošević, Faculty of Technical Sciences, University of Kragujevac, Serbia*
*Dejan Vujičić, Faculty of Technical Sciences, University of Kragujevac, Serbia*
*Željko Jovanović, Faculty of Technical Sciences, University of Kragujevac, Serbia*
*Đorđe Damnjanović, Faculty of Technical Sciences, University of Kragujevac, Serbia*
*Maja Radović, Faculty of Technical Sciences, University of Kragujevac, Serbia*

U ovom radu predložena je metoda za daljinsku obradu mamografskih slika (mamograma) bazirana na primeni Matlab Web Servisa. Kreiran je udaljeni sistem za obradu slike u vidu Matlab aplikacije koja se izvršava na serveru. Grafički korisnički interfejs omogućava korisniku da učita mamografsku sliku koja se šalje na server, unese ulazne parametre neophodne za obradu slike i nakon obrade prikaže dobijene rezultate. Predstavljeni računarski sistem za obradu mamografskih slika baziran je na primeni metoda za segmentaciju mamograma kojima je moguće povećati vidljivost najranijih pokazatelja tumora - mikrokalcifikacija. Vidljivost mikrokalcifikacija značajno je poboljšana primenom Sobelove metode za izdvajanje ivica i metode za povećavanje kontrasta slike.

# SESIJA RTI2: COMPUTER SYSTEMS AND SERVICES

Utorak/Tuesday, June, 4th, 14:30 – 16:30, Sala 5/Hall 5

**Chair: Ivan Milentijević, Faculty of Electronic Engineering, University of Nis, Serbia**
**Miroslav Popović, University of Novi Sad, Faculty of Technical Sciences, Serbia**

RTI2.1 (INVITED PAPER)

pyHRV: DEVELOPMENT AND EVALUATION OF AN OPEN-SOURCE PYTHON TOOLBOX FOR HEART RATE VARIABILITY (HRV)

*Pedro Gomes, PLUX wireless biosignals, S.A., Portugal*
*Hugo Silva, Instituto de Telecomunicações, Portugal*
*Petra Margaritoff, Hamburg University of Applied Sciences, Germany*

Heart Rate Variability (HRV) is a continuously growing research sector, with increasing number of new measures being introduced over the recent decades, followed by a complementary software tool. However, many closed source HRV tools come with high license costs and prevent source code access for developers, limiting the possibilities of developing custom applications. Open-source solutions, on the other hand, face different limitations such as limited functionality, non-validated results, or full support for mainstream programming languages. The goal of this work is to provide a fully open-source Python toolbox named pyHRV for HRV R&D applications which is validated against a gold standard software. pyHRV computes state-of-the-art Time Domain (TD), Frequency Domain (FD), and Nonlinear (NL) HRV parameters. As for the evaluation, short-term parameters have been computed from 50 Normal-to-Normal Interval (NNI) series of 5 minutes in duration, with long-term parameters being computed from 50 NNI series of 60 minutes in duration. The results have been computed using the pyHRV toolbox and the KUBIOS HRV gold standard software, against which the pyHRV results have been compared. Overall, pyHRV computes a total of 78 HRV parameters (23 TD, 48 FD, 7 NL), from which 12 have achieved identical results as the gold standard software, 38 showing marginal and/or neglectable differences, and 26 showing significant differences questioning their reliability.

RTI2.2

## A SOLUTION OF CONCURRENT STACK ON PSTM

*Marko Popovic, University of Novi Sad, Faculty of Technical Sciences, Serbia*
*Branislav Kordic, University of Novi Sad, Faculty of Technical Sciences, Serbia*
*Miroslav Popovic, University of Novi Sad, Faculty of Technical Sciences, Serbia*
*Ilija Basicevic, Faculty of Technical Sciences, Serbia*

Nowadays developing concurrent data structures based on foundations of software transactional memory (STM), a.k.a. transactional data structures, is an area of intensive research. In this paper, we developed the concurrent stack on Python STM (CS-PSTM), and verified it using unit and system testing. For system testing we developed the five application workloads, namely: one producer - one consumer, nP producers, nP consumers, nP producers and nC consumers, and nP processes. The CS-PSTM successfully passed all of the unit and the system tests. We also used system tests to estimate CS-PSTM performance. Interestingly, and not unexpectedly, CS-PSTM provides better performance when used by more concurrent processes.

RTI2.3

## IMPLEMENTATION AND EVALUATION OF VIDEO CONFERENCING SYSTEM ON PUBLIC CLOUD

*Vladimir Ciric, Faculty of Electronic Engineering, University of Nis, Serbia*
*Oliver Vojinovic, Faculty of Electronic Engineering, University of Nis, Serbia*
*Ivan Milentijevic, Faculty of Electronic Engineering, University of Nis, Serbia*

With constant growth of capacity and bandwidth of computer networks, resource demanding network applications that emerged as concepts a long time ago got their chance to gain a word-wide popularity and widespread usage. It is not the question anymore whether we can implement such applications, but rather how easy they are to implement, and how much their usage costs. In cloud-centric world of today this becomes the matter of the amount of required resources. The aim of this paper is to present the resource requirements of a video conferencing system based on open source BigBlueButton platform, while it is implemented on the Amazon AWS public cloud. The system will be implemented as the part of blended learning system. In order to determine the system limits and to give recommendations for implementation of similar systems, the results of the stress test will be given.

RTI2.4

## AGILE METHOD AND ROS IN AUTOMOTIVE SOFTWARE DEVELOPMENT PROCESSES, PRACTICE, AND TEACHING

*Momcilo Krunic, RT-RK, Institute for Computer Based Systems LLC, Serbia*
*Vlado Krunic, Department of Mathematics and Informatics, Faculty of Natural Sciences and Mathematics, University of Banja Luka, Bosnia and Herzegovina*
*Milan Stankic, RT-RK, Institute for Computer Based Systems LLC, Serbia*
*Miroslav Popovic, Faculty of Tech. Sciences, University of Novi Sad, Serbia*

Software development in Automotive industry experiencing exponential ascent of complexity these days. This is a direct implication of leading trends such as ADAS (Advanced Driver Assistance Systems) and Autonomous vehicles. In order to achieve these goals, new technologies have been introduced in Automotive software industry that have not been traditionally present, such as: Machine learning, data mining, computer vision, object fusion, … This paper describes new approach that has been introduced in Automotive software development processes and practice, such as Agile methodology and Robot OS (ROS), which aim is to enable seamless integration of new technologies into the vehicles, since traditional approach didn't provide optimal results. Focus of the paper is implementation of such processes and practices in course: "Automotive Software Development Processes", at the Faculty of Technical Sciences (FTN), Novi Sad. The main idea behind this was to teach students about processes and practices, by

conducting them through lectures and exercises. For this purpose, it has been used Autoware open-source platform for self-driving vehicles, based on ROS, C++ language for implementation, and LeSS (Large-Scale Scrum) framework for agile development. Implemented solutions was developed using TDD (Test Driven Development) methodology and Google test framework (gtest).

RTI2.5

## CHURN PREDICTION IN TELCO INDUSTRY LEVERAGING CALL CENTER DATA

*Nenad Petrović, Faculty of Electronic Engineering, University of Niš, Serbia*

Identifying the customers that are likely to leave and move from one service provider to another (churners) is of utmost importance in telecommunications (telco) industry due to fact that it is several times more expensive to acquire a new customer than retaining an old one. Therefore, it is missioncritical for Business Intelligence (BI) systems to identify the churning customer timely in order to support the decisioning mechanisms within the customer relationship management (CRM) software and reduce the number of lost subscribers. In this paper, it is explored how the data about customers collected by mobile operator's call center software platform can be leveraged to identify churners together with other features. As an outcome, several experiments based on classification techniques are presented. Performance of two classification approaches is compared – k-NN and neural network. Moreover, for the second approach, CPU and GPU execution time is discussed.

RTI2.6

## AN IMPLEMENTATION OF THE ARINC 653 APEX API SERVICES

*Anja Veselinović, RT-RK Institute, Bosnia and Herzegovina*
*Branislav Todorović, RT-RK Institute, Serbia*
*Miloš Pilipović, RT-RK Institute, Serbia*

ARINC 653 is a specification used for integrating avionics system on a modern aircraft. The APEX (Application/Executive) interface, between the application software and the Core Software, defines a set of facilities which the system will provide for application software to control the scheduling, communication and status information of its internal processing elements. The interface and the behavior of the API (Application Program Interface) services are specified by ARINC 653. The ARINC 653 APEX API provides services to the applications. The aim of this paper is to present principles of ARINC 653 services implementation.

RTI2.7

## RAID 0 ON PAIRED MAGNETIC DISK ARRAYS

*Nikola Davidovic, Faculty of electrical engineering, University of East Sarajevo, Bosnia and Herzegovina*
*Borislav Đorđević, Institute Mihailo Pupin, University of Belgrade, Serbia*
*Valentina Timcenko, Institute Mihailo Pupin, Serbia*
*Slobodan Obradovic, Information Tehnology School, Serbia*
*Bojan Skoric, VISER, Serbia*

The connection of multiple secondary memory devices in RAID 0 aims to improve three performance parameters of the secondary memory system: greater storage capacity, the increase of the read data access speed and increase of the write data speed. This paper analyses the system for storing the data on the paired arrays of magnetic disks in RAID 0 formation, with the number of queue entries for overlapped I/O, where queue depth parameter has the value of 4. The paper presents a range of the testing results and analysis for RAID 0 series for defined workload characteristics. The tests were done in the Microsoft Windows Server 2008 R2 Standard operating system, using 2, 3, 4 and 6 paired magnetic disks and controlled by Dell PERC 6/i hardware RAID controller. For the needs of obtaining the measurement results, we have used the

ATTO Disk Benchmark. We have analysed the obtained results and compared to the expected behaviours.

# Telecommunications/
# Telekomunikacije (TE)

## SESIJA TE1: TELEKOMUNIKACIJE

Ponedeljak/Monday, June, 3rd, 09:00 – 11:00, Sala1/Hall 1

**Predsedavajući: dr. Nenad Milošević, Elektronski fakultet, Niš**

TE1.1

### IMPLEMENTACIJA TUNELOVANJA Q-SIG PREKO SIP U PRIVATNOJ TELEFONSKOJ MREŽI SA INTEGRISANIM USLUGAMA FUNKCIONALNOG KORISNIKA

*Sladjan Svrzić, Towersnet, Belgrade, Serbia*
*Zoran Čiča, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Zoran Miličević, Uprava za informatiku i telekomunikacije, GŠ VS, Beograd, Srbija*
*Zoran Perišić, Uprava za informatiku i telekomunikacije, GŠ VS, Beograd, Srbija*

U radu se daje objašnjenje za novi način povezivanja ISDN PABX i IP orijentisanih PABX (PINX) u Privatnoj automatskoj telefonskoj mreži integrisanih usluga funkcionalnog korisnika, primenom postupka tunelovanja mrežne Q signalizacije (Q-SIG) kroz privatnu IP mrežu (Intranet) sa SIP. Dat je kratak prikaz Standarda ECMA-355 za postupak tunelovanja Q-SIG kroz IP/SIP mreže i opisana je njegova praktična primena na delu automatske telefonske mreže integrisanih usluga, za međusobno povezivanje učesnika sa različitih krajnjih ISDN/Q-SIG PABX, preko tranzitnih IP/Q-SIG PINX, a pri čemu IP/SIP mreža ima ulogu Interventne mreže (Intervening Network, IVN).

TE1.2

### РОМИНГ У 802.11 МРЕЖАМА И ЊЕГОВА ЕКСПЕРИМЕНТАЛНА КАРАКТЕРИЗАЦИЈА

*Danilo Lazovic, Vojna akademija, Univerzitet odbrane u Beogradu, Srbija*
*Zoran Stankovic, Elektronski fakultet, Univerzitet u Nišu, Srbija*
*Jovan Bajcetic, Vojna akademija, Univerzitet odbrane u Beogradu, Srbija*

Главни циљ овог рада је овладавање основним принципима и вештинама експерименталне карактеризације бежичних рачунарских мрежа, као и развој метода и поступака мерења и анализе мерених резултата који се односе на праћење роминг догађаја клијента мреже и његовог утицаја на пакетски пренос података у IEEE 802.11 мрежном окружењу. У складу са тим, полазећи од неких постојећих решења за мерење handoff интервала, комбинацијом, надоградњом и прилагођењем реалним условима у мрежи, развијен је и примењен поступак мерења и анализе резултата који се односи на идентификацију, основну карактеризацију роминг догађаја и праћење његовог утицаја на перформансе пакетског преноса у реалном окружењу IEEE 802.11 мреже што је и главни допринос овог рада.

TE1.3

### ANALIZA UTICAJA ARHITEKTURE MREŽE NA KVALITET SIGNALA U OKVIRU LTE TEHNOLOGIJE

*Ivana Stojanović, Telekom Srbija, Beograd, Srbija*
*Mladen Koprivica, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Nenad Stojanović, Vojna akademija, Univerzitet odbrane u Beogradu, Srbija*
*Aleksandar Nešković, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

U radu je analiziran uticaj arhitekture mreže na kvalitet signala u okviru četvrte generacije javne mobilne mreže. Analiza je izvršena pomoću parametara RSRP (Reference Signal Received Power), RSRQ (Reference Signal Received Quality) i realno ostvarivog protoka podataka. Parametri kvaliteta signala su prikupljeni merenjem pomoću TEMS Investigation i TEMS Pocket softvera. Merenja su sprovedena na Elektrotehničkom fakultetu u prizemlju zgrade Tehničkih fakulteta za scenario makro i mikro ćelije. Ustanovljeno je da se bolji kvalitet signala obezbeđuje u mikro ćelijama. Kvalitet signala je razmatran i po različitim servisima koji se obezbeđuju korisniku.

TE1.4

## MODIFIKOVANI POSTUPAK ZA LOKALIZACIJU U WSN SA KOMBINACIJOM DV-HOP I CENTROID POSTUPAKA

*Gorana Crnobrnja, Telenor d.o.o. Beograd, Srbija*
*Kristina Josifović, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Goran Marković, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

Lokalizacija, kao postupak određivanja pozicije senzorskih čvorova u okviru bežičnih senzorskih mreža (WSN, Wireless Sensor Network), karakteriše se tačnošću i preciznošću estimacije prostornih koordinata (lokacija) na kojima se čvorovi nalaze. Predložen je veliki broj rešenja za potrebe lokalizacije u WSN, na osnovu različitih pristupa, u cilju poboljšanja kvaliteta lokalizacije. Jedno od predloženih rešenja je Distance Vector – Hop (DV-Hop) postupak lokalizacije. U ovom radu posmatran je originalan DV-Hop postupak, odnosno neke modifikacija ovog postupka zasnovane na kobinaciji DV-Hop postupka i Centroid postupka. Predložen je i novi modifikovani postupak ovog tipa u cilju unapređenja procene težinskih koeficijenata koji se koriste u procesu određivanja pozicije senzorskih čvorova WSN, a samim tim i smanjuje greška lokalizacije. Za potrebe analize performansi postojećih i ovde predloženog postupka lokalizacije u različitim scenarijima primene u okviru WSN razvijen je specifičan simulacioni model, u MatLab okruženju, čijom primenom su dobijeni rezultati koji pokazuju da se primenom predloženog modifikovanog postupka lokalizacije ostvaruju određena poboljšanja u odnosu na postojeće postupke.

TE1.6

## UPOREDNA ANALIZA KLASA RANGE-FREE POSTUPAKA ZA LOKALIZACIJU U BEŽIČNIM SENZORSKIM MREŽAMA

*Kristina Josifović, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Marko Matić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*
*Gorana Crnobrnja, Telenor d.o.o. Beograd, Srbija*
*Dragana Lemaić, Allied testing Serbia d.o.o. Beograd, Srbija*
*Goran Marković, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

Lokalizacija, kao postupak određivanja pozicije senzorskih čvorova u okviru bežičnih senzorskih mreža (WSN, Wireless Sensor Network), karakteriše se tačnošću i preciznošću estimacije prostornih koordinata (lokacija) na kojima se čvorovi nalaze. Predložen je veliki broj rešenja za potrebe lokalizacije u WSN, na osnovu različitih pristupa, u cilju poboljšanja kvaliteta lokalizacije. Jedno od predloženih rešenja je Distance Vector – Hop (DV-Hop) postupak lokalizacije. U ovom radu posmatran je originalan DV-Hop postupak, odnosno neke modifikacija ovog postupka zasnovane na kobinaciji DV-Hop postupka i Centroid postupka. Predložen je i novi modifikovani postupak ovog tipa u cilju unapređenja procene težinskih koeficijenata koji se koriste u procesu određivanja pozicije senzorskih čvorova WSN, a samim tim i smanjuje greška lokalizacije. Za potrebe analize performansi postojećih i ovde predloženog postupka lokalizacije u različitim scenarijima primene u okviru WSN razvijen je specifičan simulacioni model, u MatLab okruženju, čijom primenom su dobijeni rezultati koji pokazuju da se primenom predloženog modifikovanog postupka lokalizacije ostvaruju određena poboljšanja u odnosu na postojeće postupke.

TE1.7

SREDNJA VEROVATNOĆA GREŠKE PO BITU PRI PRENOSU MODULISANOG SIGNALA U FSO SISTEMU

*Jelena Todorović, Fakultet tehničkih nauka, Univerzitet u Prištini, Kosovska Mitrovica, Srbija*
*Branimir Jakšić, Fakultet tehničkih nauka, Univerzitet u Prištini, Kosovska Mitrovica, Srbija*
*Petar Spalević, Fakultet tehničkih nauka, Univerzitet u Prištini, Kosovska Mitrovica, Srbija*
*Mile Petrović, Fakultet tehničkih nauka, Univerzitet u Prištini, Kosovska Mitrovica, Srbija*
*Ana Tošković, Visoka tehnička škola strukovnih studija, Zvečan, Srbija*

U radu je izračunata i analizirana srednja verovatnoća greške po bitu (Average Bit Error Ratio) signala u Free Space Optical sistemu modulisanim sa Differential Phase Shift Keying i Binary Phase Shift Keying šemom. Srednja verovatnoća greške po bitu je određena za slučaj atmosferkog kanala modelovanim sa Gamma-Gamma raspodelom. Rezultati su osim u analitičkoj formi, predstavljeni i grafički, u zavisnosti od odnosa srednje optičke snage na prijemu i varijanse kanalnog šuma, a za različite dužine Free Space Optical linka i jačine atmosferske turbulencije. Analiziran je kvalitet signala na osnovu srednje verovatnoće greške po bitu za slabu, umerenu i jaku atmosfersku turbulenciju.

# SESSION TEI1: TELECOMMUNICATIONS

Monday, June, 3rd, 11:15 – 13:30, Hall 1

**Chair: dr Nenad Krajinović, Serbian Open eXchange, Belgrade, Serbia**

TEI1.1

HOW TO BUILD INTERNET EXCHANGE POINT FROM THE SCRATCH (INVITED PAPER)

*Nenad Krajinović, Serbian Open eXchange, Belgrade, Serbia*

Internet Exchange Points (IXPs) play a major role at the core of the Internet peering ecosystem. Because of that, IXPs functioning is of crucial importance for the Internet economy. IXPs should provide high availability in operation, high throughput and minimal latency. Typical IXP is built on layer 2 Ethernet switches. Using Ethernet switches has many challenges, such as how to implement redundant links in the network topology without using Spanning-tree protocol, or how to protect the network from broadcast storm, or how to prevent traffic leaking from IXP members. Choice of datacenters to be present in, and their number and connection topology should be coupled not only with technological, but also financial issues, yet with network neutrality approach always coming first. Besides Ethernet drawbacks, additional problem is how to achieve proper propagation of all routing prefixes toward IXP members. For solving this issue, all IXPs are using route-servers for simplification of route prefixes announcements among IXP members. And route-servers are based on using open-source software, such as BIRD, Quagga or OpenBGP, with all pros and cons of using open-source software. Since the Internet stability is of major importance, operator of an IXP is responsible for controlling route prefixes announcement of every IXP member. This is related with Internet Routing Registries which should have updated information about route prefixes that every Autonomous System (AS) is announcing. Unfortunately, IRR databases are not completely accurate which means the operator of IXP should find the approach to filter announcement in proper way. All those issues should be overcome to end up with fully functional IXP which is important milestone in Internet architecture. Besides global Internet, IXPs are also of major importance for every country. IXP provides that all local content stay local instead to go around the globe in case of IXP missing, which significantly reduce the expenses for ISPs, lower latency, improve stability, and introduce scalable capacity. This is very important taking into account the importance of Internet for

economy of every modern country. This paper presents experience and best practice implemented in building an Internet Exchange Point in the case of Serbian Open Exchange.

TEI1.2

## ONE SOLUTION FOR FAST REROUTE IN OPENFLOW NETWORKS

*Nataša Maksić, School of Electrical Engineering, University of Belgrade, Serbia*
*Aleksandra Smiljanić, School of Electrical Engineering, University of Belgrade, Serbia*

This paper presents a solution for fast reroute in the implementation of Ethernet switching fabric based on OpenFlow. This solution adds fast traffic protection by using OpenFlow Fast Failover groups. The paper presents our design for improved reliability in software defined networks (SDN), and describes its implementation.

TEI1.3

## IMPLEMENTATION OF THE MPLS LABEL SWITCHING PROCEDURE FOR THE HIGH-SPEED SOFTWARE ROUTERS

*Mihailo Vesović, School of Electrical Engineering, University of Belgrade, Serbia*
*Hasan Redžović, School of Electrical Engineering, University of Belgrade, Serbia*
*Aleksandra Smiljanić, School of Electrical Engineering, University of Belgrade, Serbia*

Software routers are preferred over the classical routers when high flexibility and low costs are the requirements. Software routers are usually developed for the general purpose computers, which run standard operating systems not optimized for high-speed packet processing. For this reason, the fast I/O frameworks are used to speed up the data plane. In this paper, we have implemented the MPLS label switching procedure using DPDK fast I/O. MPLS has a good synergy with the software routers as it is lightweight, scalable and protocol-independent. Our goal is to show its maximal forwarding speeds in such environment.

TEI1.4

## INTEGRATION OF THE NETCONF PROTOCOL IN THE INTERNET OF THINGS BY MEANS OF RESTFUL WEB SERVICES

*Dalibor Đumić, RT-RK Institute for Computer Based Systems, Bosnia and Herzegovina*
*Sretenka Došlić, RT-RK Institute for Computer Based Systems, Bosnia and Herzegovina*
*Marija Antić, RT-RK Institute for Computer Based Systems, Serbia*
*Boško Milić, RT-RK Institute for Computer Based Systems, Bosnia and Herzegovina*

Herein a new network management protocol called Network Configuration Protocol (NETCONF) will be introduced through an overview and empirical study. The features and capabilities of the NETCONF are a document-oriented approach based on Extensible Markup Language (XML) and the challenge will be an integration of the NETCONF capabilities in the Internet of Things (IoT) using REpresentational State Transfer web services (RESTful). In the end, the goal is to implement this integration through building a home automation server based on any single board computer supporting Linux operating system (OS) and RESTful web application as the client. The web application shall communicate with the server through the NETCONF protocol and allow a user to control devices in his home. In the end, the benefits of applying such these technologies in the home automation or domotics will be discussed and concluded.

TEI1.5

## SIMULATION AND ANALYSIS OF AODV ROUTING PROTOCOLS USING RANDOM WAYPOINT AND RANDOM WALK

*Hisham Hejaji, Alfa BK University, Belgrade, Libya*
*Negovan Stamenkovic, Alfa BK University, Belgrade, Serbia*

In the recent years Mobile ad-hoc network is getting publicity due to its versatile applications There are many factors that impact the performance of mobile networks. A mobility model is one of the factors affecting network in a very huge way. Inside the network the mobility model dictates the movement of the nodes. This research goal to study two type of mobility models that present mobile nodes whose movements are independent of each other. This paper will show the result of analysis between these models considering several performance metrics like end-to-end delay, throughput and energy level of each one using AODV routing protocol and 802.11 Mac protocol. AODV under Random Walk and Random Way Point Mobility models have similar results for similar inputs however as the pause time increases so does the difference in performance rises. They show that their motion, direction, angle of direction, speed is same under both mobility models.

## SESSION TEI2: TELECOMMUNICATIONS

Monday, June, 3rd, 14:30 – 16:30, Hall 1

**Chair: dr Predrag Petrović, Institute IRITEL, Belgrade, Serbia**

TEI2.1

### COMPARISON OF RCIED ACTIVATION RESPONSIVE AND ACTIVE JAMMING RELIABILITY

*Mladen Mileusnić, IRITEL, Belgrade, Serbia*
*Predrag Petrović, IRITEL, Belgrade, Serbia*
*Aleksandar Lebl, IRITEL, Belgrade, Serbia*
*Branislav Pavić, IRITEL, Belgrade, Serbia*

In this paper we compared the time required for the successful jamming of remote controlled improvised explosive devices activation using active and responsive jamming methods. As a representative of active jamming method we analyzed jamming signal generation using frequency sweep, whereas for the analysis of the possible activating signal presence based on responsive jamming procedures we supposed Fast Fourier Transform (FFT) implementation. Taking into account the current technology state, it is proved that the time required to achieve the successful jamming relied on FFT analysis may be less than in the case of active sweep jamming. When very fast specialized processors are applied to FFT estimation with the highest clock speed, the required time to achieve effective jamming may be up to several tens of times less based on FFT detection for responsive jamming than in the case of active sweep jamming.

TEI2.2

### DIRECT RANGING AND DIRECTION OF ARRIVAL ESTIMATION OF NON-COOPERATIVE RADIO TRANSMITTERS

*Dragan Golubović, School of Electrical Engineering, University of Belgrade, Serbia*
*Nenad Vukmirović, School of Electrical Engineering, University of Belgrade, Serbia*
*Miljko Erić, School of Electrical Engineering, University of Belgrade, Serbia*

A MUSIC type algorithm for direct one-step ranging and direction of arrival estimation of non-cooperative narrowband radio transmitters with antenna array is proposed. The method is applicable for far field or near field, single or multi-user non-cooperative signal scenario with planar or spherical waves on antenna array. Antenna array can be with distributed antennas but also it can be classical antenna array with co-located antennas on small distance. The proposed algorithm is suitable for application in massive MIMO systems for 5G. Properties and performance of the proposed algorithm are illustrated and evaluated by simulations. To reduce the computational cost of the algorithm, and provide valid results of simulation, adaptive searching grid in calculation of cost function is applied.

TEI2.3

## IMPLEMENTATION OF ALGORITHM FOR EXCISION OF POINT TARGETS FROM DISTRIBUTED RADAR DETECTIONS

*Pavle Petrovic, School of Electrical Engineering, University of Belgrade, Serbia*
*Nemanja Grbic, School of Electrical Engineering, University of Belgrade, Serbia*
*Nikola Stojkovic, School of Electrical Engineering, University of Belgrade, Serbia*
*Dejan Nikolic, VLATACOM Institute, Belgrade, Serbia*
*Nikola Lekic, VLATACOM Institute, Belgrade, Serbia*

With maximal range of 200 nmi HFSWR (High Frequency Surface Wave Radar) represents a very effective solution for remote sensing of wide maritime areas. Although HFSWR may be used for many purposes, in this paper the focus is on vessel detection. Since any vessel fits into one HFSWR resolution cell all of them are considered point-like targets. In some circumstances it was noticed that reflections from vessels are occupying multiple consecutive cells, thus forming falsely distributed targets. The paper proposes an algorithm which solves this anomaly by pinpointing vessels exact location within distributed area. The algorithm is tested on real data collected from HFSWR systems located in Gulf of Guinea.

TEI2.4

## ANALYSIS OF DIFFERENT WINDOW FUNCTION EFFECTS ON DBF IN HFSWR SIGNAL PROCESSING

*Nemanja Grbić, School of Electrical Engineering, University of Belgrade, Serbia*
*Pavle Petrović, School of Electrical Engineering, University of Belgrade, Serbia*
*Dejan Nikolić, VLATACOM Institute, Belgrade, Serbia*
*Nikola Stojković, School of Electrical Engineering, University of Belgrade, Serbia*
*Vladimir Orlić, VLATACOM Institute, Belgrade, Serbia*

In this paper a few implementations of Digital Beam-forming (DBF) technique used in High Frequency Surface Wave Radar (HFSWR) signal processing are examined. All of them are based on phase shifting principle, but differ in so called “window” functions used for preparation of the data during the beam-forming process. Three different sets of magnitudes of weights used to form Hamming, Blackman and modified Blackman, window functions will be evaluated in this paper. Although choosing an optimal window function is situational, in this paper it is shown that for HFSWR DBF algorithm, modified Blackman can be regarded as the optimal solution. Data used for this evaluation is obtained from HFSWR sites located in the Gulf of Guinea.

TEI2.5

## SIMULATION OF 16 CHANNELS WDM ERBIUM DOPED FIBER AMPLIFIER USING PUMPING WAVELENGTHS 980 NM AND 1480 NM

*Hisham Hejaji, Alfa BK University, Belgrade, Libya*
*Dejan Djukic, Alfa BK University, Belgrade, Serbia*

The paper will be in the field of the performance of a simultaneously fed 16 channels dense wave division multiplexing (DWDM) erbium-doped fiber amplifier (EDFA) using two different pump wavelengths (980 and 1480 nm) . The performance of the amplifier will be evaluate by means of simulation models in Optisystem software. The amplifier is characterized in term of its gain and noise figure under different pump wavelengths. A comparison study between the different schemes will investigate.

# Artificial Intelligence/
# Veštačka Inteligencija (VI)

## SESSION: VII1 + VI1: ARTIFICIAL INTELLIGENCE SYSTEMS AND DESIGNS

Sreda/Wednesday: 14.30-16.30, Sala3/Hall3

**Chair: Milan Milosavljević**

VII1.1

ACHILLES - MARS: MODULAR CHESS SYSTEM

*Vladan Vuckovic, Faculty of Electronic Engineering, Serbia*

This paper has intention to describe the original construction and infrastructure of the modular chess system Achilles (version 2019) - MARS consisting and connecting several complex subsystems. The central part of this system is high-performance 30 million per position distributed chess engine Achilles 2019. The system MARS is an old system renewed in 2014 and now connected to Achilles as the interactive module and option to play against professional chess players.

VII1.2

SEMANTIC TECHNOLOGY-BASED PLATFORM FOR AUTOMATED ASSESSMENT OF INFORMATION SYSTEMS COURSE PROJECT

*Nenad Petrovic, Faculty of Electronic Engineering, University of Niš, Serbia*
*Milorad Tosic, Faculty of Electronic Engineering, University of Niš, Serbia*
*Valentina Nejkovic, Faculty of Electronic Engineering, University of Niš, Serbia*

When it comes to computer science education, it has been recognized that practical programming assignments (projects and exercises) are essential element. However, in recent years, the number of students enrolled to bachelor degree computer science and information technology courses has increased dramatically, bringing new challenges for universities and educational institutions. Many problems in courses with huge number of participants are related to the quality of student assignment/exercise evaluation, as it is time-consuming and error-prone process. Therefore, the automation of student assignment evaluation is seen as a solution. While there are many existing tools and platforms that tackle this problem, most of them are limited only to exercises for introductory courses. In this paper, we focus on aspects of automated assessment of student projects based on Java and MySQL, developed in context of the third year bachelor degree Information Systems course at Faculty of Electronic Engineering, University of Nis in Sebia. As an outcome of this research, we propose the platform architecture based on semantic technology and present a tool for automated project assessment based on static code analysis aiming the usage in blended learning environments.

VII1.3

THE POTENTIAL OF USING EEG DATA IN EVALUATION OF VISUAL SHORT-TERM MEMORY TEST RESULTS

*Milos Antonijevic, Singidunum University, Serbia*
*Miodrag Zivkovic, Singidunum.ac.rs, Serbia*
*Sladjana Arsic, College of Applied Health Sciences, Cuprija, Serbia*
*Aleksandar Jevremovic, Singidunum University, Serbia*

In this research we tried to determine the possible correlation between participant' emotional state while doing the Visual short-term working memory test in regard to the test results he achieved.

We have analyzed data gathered from thirteen subjects doing the test with two images. First results show that, by analyzing EEG data, we can achieve accuracy of 61.66% in classifying instances in regard to Correctness of the answer class. Also, by comparing overall changes in participant's emotional state, we were able to conclude that there is a significant decrease in stress, engagement, relaxation and focus when participant switched from viewing the image to answering the questions.

VII1.4

## DEEP LEARNING IN DEVELOPMENT OF MODEL-DEPENDENT DIAGNOSTIC:

*Miroslava Jordović Pavlović, College of Applied Sciences Užice, Serbia*
*Marica Popović, INS "Vinca", Belgrade, Serbia*
*Dragan Markushev, Institute of Physics Belgrade, Serbia*
*Slobodanka Galović, INS "Vinca", Belgrade, Serbia*

Deep learning has successfully been implemented in various domains, including photoacoustics. The collection and creation of massive datasets creates new possibilities. Deep learning methods, when applied on massive datasets, are able to extract very useful patterns. This can lead to solutions to many problems. In this paper we discuss and develop deep learning application for the recognition of a detector influence pattern on recorded responses of a measurement chain in model-dependent experimental measurements. This enables the fast calibration of the method, which is necessary for its further application in the characterization or scanning of the examined objects with satisfactory accuracy. Frequency gas-microphone photoacoustic measurements were taken as the case study. The paper presents three models for the solution of instrument influence on true signals in photoacoustic experiments. We analyze the influence of neural network depth and the number of outputs on the prediction accuracy, and then we discuss the choice of the optimal solution

VII1.5

## SECRET KEYS GENERATION FROM MOUSE AND EYE TRACKING SIGNALS

*Milan Milosavljević, Singidunum University, Serbia*
*Saša Adamović, Singidunum University, Serbia*
*Aleksandar Jevremović, Singidunum University, Serbia*

This paper presents a new approach to generating cryptographic keys, based on local mutual randomness of mouse and eye move tracker sensor signals. The cross-correlation analysis of the longitudinal and transverse components of these sensor signals confirms a sufficient level of mutual randomness, which is originally the starting point for the protocol for generating secret cryptographic keys with the help of a public discussion. Experiments show that in this way one can generate random sequences of good cryptographic properties, with speed up to 200 bits/minute for the typical interaction with web pages.

VII1.6

## PLAYER SKILL MODELING AND FEATURE SELECTION FOR A VIDEO GAME

*Zoran Cirovic, School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*
*Natasa Cirovic, School of Electrical Engineering, University of Belgrade, Serbia*

E-sports has increased significance, with growing number of professional players and monetization potential, thus the player skill modeling in strategy games has long been a subject of interest for researchers. In this paper we use publicly available video game telemetry data from StarCraft 2 to explore the player skill modeling and development of expertise. The analysis includes selection of statistical features for original dataset and their application to a classifier. The statistical features are obtained from the original data, applying statistical functions: mean, standard deviation, minimum, maximum, inter-quartile range, skewness, kurtosis. On such obtained set of statistical features, we applied feature ranking using t-test hypothesis, then feature

subset selection is done using suboptimal searching techniques. We tested the obtained results on standard k-NN classifier.

VI1.1

## KLASIFIKACIJA AKVATIČNIH LARVI INSEKATA KORIŠĆENJEM DUBOKE KONVOLUCIONE NEURONSKE MREŽE I PRENESENOG UČENJA

*Aleksandar Milosavljević, Univerzitet u Nišu, Elektronski fakultet, Serbia*
*Đurađ Milošević, Univerzitet u Nišu, Prirodno-matematički fakultet, Serbia*
*Bratislav Predić, Univerzitet u Nišu, Elektronski fakultet, Serbia*

U radu je opisan metod za klasifikaciju tri vrste larvi hironomida (Chironomidae: Diptera, Insecta) na osnovu slika dobijenih pomoću mikroskopa i binokularne lupe. Kao klasifikator je iskorišćena duboka konvoluciona neuronska mreža ResNet-50 arhitekture koja je obučavana na 80% skupa slika, dok je preostalih 20% korišćeno za validaciju. S obzirom na relativno mali broj trening uzoraka, primenjena je tehnika prenesenog učenja (eng. transfer learning), tako da se krenulo od mreže koja je prethodno obučena na ImageNet trening skupu uz promenu vršnog klasifikatora mreže. Obučavanje je vršeno u dve faze. U prvoj fazi je obučavan samo vršni klasifikator na osnovu karakteristika ekstrahovanih propuštanjem slika kroz prethodno istrenirani konvolucioni deo mreže. Nakon toga je vršeno „fino podešavanje“ obučavanjem celokupne mreže. Da bi se dodatno anulirao problem male količine trening podataka, primenjene su tehnike proširivanja podataka (eng. data augmentation) i odbacivanja (eng. dropout). Primenom pobrojanih tehnika ostvarena je idealna klasifikacija kako trening tako i validacionog skupa. Odgovarajući rezultati su prezentovani u radu.

VI1.2

## IDENTIFIKACIJA NASLAGA SOLI NA SEIZMIČKIM SNIMCIMA KORIŠĆENJEM METODA DUBOKOG UČENJA ZA SEMANTIČKU SEGMENTACIJU

*Aleksandar Milosavljević, Univerzitet u Nišu, Elektronski fakultet, Serbia*

Nekoliko oblasti u svetu koje su bogate naftom i zemnim gasom takođe poseduju velike naslage soli ispod površine. Zbog ove veze, otkrivanje preciznih lokacija naslaga soli je izuzetno značajno za kompanije koje se bave istraživanjem nalazišta ovih energenata. Lociranje naslaga soli se vrši na osnovu profesionalnih seizmičkih snimaka koje kasnije analiziraju ljudski eksperti. Rezultati ovakve analize često variraju i podložni su subjektivnosti eksperta koji analizu sprovodi. U cilju automatizacije ovog procesa i postizanja bolje preciznosti, kompanija TGS je sponzorisala takmičenje na Kaggle platformi održano u drugoj polovini 2018. godine [1]. Takmičenje je okupilo 3234 pojedinaca i timova, a u radu su prezentovani rezultati i iskustva autorovog učešća (446 pozicija). Metod predložen u radu se zasniva na obučavanju duboke konvolucione neuronske mreže za semantičku segmentaciju. Arhitektura korišćene mreže je inspirisana U-Net modelom u kombinaciji sa ResNet i DenseNet arhitekturama.