



**PRELIMINARY/PRELIMINARNI PROGRAM**  
**IcETRAN & ETRAN 2018,**  
**Palić 11-14. 06. 2018.**

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# AK Acoustics/Akustika

## Session AKI1: Microphone array, Room acoustics, Speech, Hydro acoustics

Tuesday, June, 12<sup>th</sup>, 14:30 – 16:30, Hall 1

**Chair: Franz Zotter, Institute of Electronic Music and Acoustics, University of Music and Performing Arts Graz, Austria**

**Dejan Ćirić, Faculty of Electronic Engineering, University of Niš, Serbia**

### AKI1.1

#### A LINEAR-PHASE FILTER-BANK APPROACH TO PROCESS RIGID SPHERICAL MICROPHONE ARRAY RECORDINGS (Invited Paper)

*Franz Zotter, University of Music and Performing Arts Graz, Institute of Electronic Music and Acoustics, Austria*

Rigid spherical microphone arrays offer the technology to capture immersive 3D audio environments in higher-order Ambisonics. The processing of their signals elegantly splits into a frequency-independent spherical harmonic decomposition part converting microphone signals into coefficient signals and an analytic filtering part super-directionally processing the coefficient signals for either higher-order Ambisonic playback or beamforming. This paper proposes to improve robustness by a linear-phase FIR filter bank to modify the analytic filters: A suitable design of cross-over frequencies and filter slopes limits boosts of self-noise and array imperfection by a controlled increase of directional resolution over frequency. Useful for 3D audio applications, the proposed sub-band signal treatment moreover yields diffuse-field equalization and side-lobe suppression.

### AKI1.2

#### EFFECTS OF PHYSICAL PARAMETERS AND SAMPLING CONFIGURATIONS ON PERFORMANCE OF SMALL SPHERICAL MICROPHONE ARRAY

*Marko Ličanin, Faculty of Electronic Engineering, Univeristy of Niš, Serbia*

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*Ana Đorđević, Faculty of Electronic Engineering, Univeristy of Niš, Serbia*

Spherical microphone arrays play a very important role in tasks such as spatial sound recordings, beamforming and sound-field analysis. Performance of a microphone array strongly depends on its physical parameters as well as angular distribution of sensors (sampling configuration). The effects of these factors are investigated here. For that purpose, several quantities including frequency limits, mode strength, orthogonality and condition number are used. Besides, localization of dominant sources is also explored. Various sampling configurations like hyperinterpolation and t-design with different number of sensors are analyzed. The focus is on a spherical microphone array of small dimension built in a rigid sphere.

### AKI1.3

#### OPTIMIZATION OF THE OVERALL SCATTERING FACTOR FOR THE ACOUSTIC SIMULATION OF CLASSROOMS

*Dragan Novković, School of Electrical and Computer Engineering, Belgrade, Serbia*

*Stefan Dimitrijević, Structor Akustik AB, Stockholm, Sweden*

Educational facility used for lectures and multimedia presentations was acoustically measured and simulated in acoustic simulation software EASE. After processing the acquired data, large discrepancies between the results obtained by impulse response measurement and those obtained from the simulation were observed. All materials, whose data were entered into the simulation, were described solely by absorption coefficients, without any information about the scattering, which is common in such situations. Overall simulated

scattering factor was adjusted in such way to allow matching of measured and simulated results within a reasonable tolerance limits. As a result of this process, the authors have discussed the possible approaches for the optimization of this parameter in the process of software simulation of acoustically similar spaces.

#### AKI1.4

##### USAGE OF WAVELET DE-NOISING FOR ESTIMATION OF ROOM IMPULSE RESPONSE TRUNCATION TIME

*Dorđe Damjanović, Faculty of Technical Sciences Čačak, University of Kragujevac, Serbia*

*Dejan Ćirić, Faculty of Electronic Engineering, Univeristy of Niš, Serbia*

Nowadays, wavelet technique is widespread in different areas of science and research, especially in signal processing where wavelet transform can be as useful as the Fourier transform because of its advantages. The most common use of wavelets is in signal de-noising, but there are a number of other different cases where wavelets can be applied. One of possible usage of wavelets related to estimation of truncation time of a room impulse response (RIR) is presented here. In that regards, possibilities to apply wavelets for estimation of truncation time at the knee where main decay intersects noise floor of a RIR are analyzed. Different wavelets with different parameters are implemented on various simulated RIRs filtered in third-octave and octave bands. The results show that usage of adequate wavelets and their parameters can provide adequate estimation of RIR truncation time at the knee or in its vicinity.

#### AKI1.5

##### MEASUREMENT OF TRANSFER FUNCTION OF GAS MASK SPEECH MEMBRANE

*Miljan Miletić, College of Applied Technical and Technological Sciences, Kruševac, Serbia*

*Dejan Ćirić, Faculty of Electronic Engineering, Univeristy of Niš, Serbia*

*Ana Dorđević, Faculty of Electronic Engineering, Univeristy of Niš, Serbia*

*Marko Ličanin, Faculty of Electronic Engineering, Univeristy of Niš, Serbia*

Speech membrane is one of important components of a gas (oxygen) mask. Its main functions are to enable efficient transfer of speech from inside to outside, and to prevent transfer of materials (gases and fluids) from outside to inside of the mask. Considering its acoustic characteristics, the speech membrane should satisfy some pre-defined requirements typically related to frequency bandwidth, transfer function and distortion. In this study, the measurements of transfer function of a speech membrane are analyzed. Special attention is paid to the effects of the measurements system itself, and to reduction of these effects. In that regard, focus is on a device coupling the speech membrane and sound source (artificial mouth in this case).

#### AKI1.6

##### APPLICATION OF TEAGER ENERGY OPERATOR ON PLP FEATURE FOR WHISPER SPEECH RECOGNITION

*Branko R. Marković, School of Electrical Engineering, University of Belgrade, Serbia*

*Jovan Galić, Faculty of Electrical Engineering, University of Banja Luka, Bosnia and Herzegovina*

*Miomir Mijić, School of Electrical Engineering, University of Belgrade, Serbia*

This paper presents the results of normal and whispered speech recognition using the TEPLPCC (Teager Energy Perceptual Linear Prediction Cepstral Coefficients) feature. This feature is used at the front-end while the Dynamic Time Warping method is used at the back-end of an ASR system. All experiments were performed using the Whi-Spe database containing 10,000 words. Four training/test scenarios were analyzed: normal/normal, whispered/whispered, normal/whispered and whispered/normal in the speaker dependent mode. Also, CMS normalization was applied. The results confirmed substantial improvement in recognition when Teager Energy with normalization was used, especially for the mismatch scenarios.

#### AKI1.7

##### THE NEW HYDRO ACOUSTICS SYSTEM AS A CORRELATION RECEIVER

*Aleksandar Tomić, ETŠ Nikola Tesla, Belgrade, Serbia*

In this work have been described results which have been obtained during the development of the functional model of a new hydro acoustic system for detecting and processing hydro acoustical signals of floating objects. The basic idea at the development this system was the basic mathematical model of correlation receiver. This work include the basic concepts out of mathematical model of correlation receiver, block diagrams, parameters, as well as remarks.

## **Sesija AK1: Buka, Akustika prostorija**

Utorak, 12. Jun, 16:30 – 18:00, Sala 1

**Predsedavajući: Miomir Mijić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija**

**Iva Salom, Institut Mihajlo Pupin, Univerzitet u Beogradu, Srbija**

### AK1.1

#### REALIZACIJA AKUSTIČKE KAMERE NA PLATFORMI ZYNQ-7000

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Akustička kamera predstavlja uređaj za lokalizaciju, analizu i identifikaciju izvora akustičkih talasa, stoga pronalazi primenu u različitim oblastima. U ovom radu prikazani su projektovanje i realizacija akustičke kamere na razvojnoj ploči Digilent Arty Z7-10 baziranoj na čipu *Xilinx Zynq-7000*, tipa AP SoC (*All Programmable SoC*). Akvizicija i obrada akustičkih signala sa digitalnih MEMS mikrofona obavljaju se u realnom vremenu u FPGA (*Field Programmable Gate Array*) komponenti korišćene platforme. Razvijeni sistem tokom postprocesiranja podataka primenom *beamforming delay-and-sum* algoritma formira akustičke mape snimanog područja preklapajući sliku sa snimkom sa video kamere, koja je takođe deo sistema. Na realizovanom prototipu izvršena su merenja i upoređena su sa rezultatima simulacija.

### AK1.2

#### ANALIZA UGAONE RASPODELE INCIDENTNE ENERGIJE SPOLJAŠNJE BUKE U URBANIM USLOVIMA

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*Miodrag Stanojević, 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*

Zbog zavisnosti vrednosti izolacione moći fasade od ugla pod kojim zvučni talas pogađa fasadu od interesa je ispitati raspodelu uglova incidencije buke na fasadu u realnosti. U opštem slučaju oblik ove raspodele nije poznat. U ovom radu prikazana je metodologija za eksperimentalno određivanja ugaone raspodele incidentne energije spoljašnje buke na fasadi u urbanim uslovima. Metod se zasniva na lokalizaciji zvučnih izvora u prostoru upotrebi mikrofonskog niza sa 24 mikrofona i algoritma za prostorno-vremensku obradu signala. Metodologija je primenjena u nekoliko karakterističnih konfiguracija terena u urbanim uslovima kako bi se pokazale razlike u oblicima ugaonih raspodela. Korišćenjem poznatih građevinskih konstanti i



eksperimentalno utvrđenih oblika ugaonih raspodela incidentne energije spoljašnje buke izvršena je predikcija ostvarene vrednosti izolacione moći najčešće korišćenih pregrada u urbanim uslovima za analizirane merne lokacije. Na taj način moguće je sagledati razlike u ostvarenim vrednostima izolacione moći iste fasadne pregrade ugrađene u urbanim uslovima sa različitim konfiguracijama terena. Statističkom analizom većeg broja ovakvih merenja mogla bi se izvršiti kategorizacija lokacija u urbanim sredinama prema ostvarenim vrednostima izolacione moći.

#### AK1.3

### MERENJE IZOLACIONIH KARAKTERISTIKA ZVUČNIH BARIJERA PRIMENOM EN 1793-6 IN-SITU METODE

*Stefan Dimitrijević, Structor Akustik AB, Stockholm, Sweden*

*Miomir Mijić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

*In-situ* metoda definisana EN 1793-6 je postala uobičajen način za kvalifikovanje izolacionih karakteristika zvučnih barijera. Vrednosti zvučne izolacije za normalnu incidenciju se određuju merenjem impulsnih odziva korišćenjem mikrofonske rešetke koja se sastoji od devet mernih mikrofona. Upoređivanjem energije impulsnog odziva iz merenja u slobodnom polju i u prisustvu zvučne barijere moguće je izračunati njen indeks zvučne izolacije. Primenom odgovarajućeg vremenskog prozora odstranjuje se uticaj refleksije od tla kao i difrakcije iznad vrha barijere. Merenja je moguće primeniti bez oštećenja samih barijera i u prisustvu postojeće buke saobraćaja. U radu je prikazan namenski merni sistem koji zadovoljava kriterijume definisane EN 1793-6. Takođe, opisani su postupci primene *in-situ* metode na primeru zvučne barijere koja se nalazi u blizini železničke stanice u Knivsti u Švedskoj. Rezultati *in-situ* merenja su upoređeni sa rezultatima laboratorijskog merenja.

#### AK1.4

### SISTEM ZA MERENJE BUKE NA UDALJENIM LOKACIJAMA BAZIRAN NA ARDUINO PLATFORMI

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Buka u svetu predstavlja jedan od najvećih zagađivača čovekove okoline, bilo da se radi o čovekovom radnom ili životnom prostoru. Merenje buke predstavlja početni korak u sagledavanju i rešavanju tog problema. Merenje buke opisano je u velikom broju ISO standarda i takva merenja široko se koriste u inženjerskoj praksi. U ovom radu prikazan je sistem za merenje nivoa buke na udaljenim lokacijama čiju osnovu čini Arduino platforma. Motivacija za izradu ovog sistema je potreba za smanjenjem ukupne cene merenja, gde se pod cenom merenja ne podrazumeva samo finansijski deo već i vreme koje čovek utroši da bi se željeno merenje buke realizovalo i obradili rezultati. Sistem opisan u ovom radu omogućava automatizovano merenje nivoa buke, prikupljanje i slanje podataka sa udaljene lokacije i prikaz rezultata korisniku. Realizovani sistem ima autonomno napajanje i ne zahteva postojanje pristupa Internetu na udaljenoj lokaciji. Omogućeno je da korisnik, ili više korisnika, pristupa rezultatima merenja sa bilo koje lokacije na svetu. Realizovani sistem koristi *Open Source* platforme koje se jednostavno mogu nadograđivati, čime se povećava funkcionalnost sistema.

#### AK1.5

### MERENJE I ANALIZA POKRIVENOSTI DIREKTNIM ZVUKOM U SALAMA SA OZVUČENJEM

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*Miloš Bjelić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

*Miomir Mijić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

*Tatjana Miljković, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

U ovom radu biće prikazani rezultati merenja pokrivanja direktnim zvukom u salama sa zvučničkim sistemima. Glavni cilj projekta sistema za ozvučavanje je uniformno pokrivanje direktnim zvukom. Alati za merenje pokrivanja dostupni na tržištu pogodni su samo za testiranje ozvučenja na otvorenom. Dosadašnje verifikacije zvučničkih sistema obavljane su merenjem ukupnog zvuka. Ovakav metod nije prihvatljiv u merenju u zatvorenim prostorijama gde osim direktnog postoji i reflektovan zvuk. U radu je korišćen softver sa metodologijom za merenje nivoa direktnog zvuka po površini auditorijuma, realizovan u Laboratoriji za Akustiku Elektrotehničkog fakulteta u Beogradu. Ovim softverom dobija se realna slika o pokrivenosti direktnim, reflektovanim i ukupnim zvukom po površini sale. Posebno se posmatra uticaj prostorne rezolucije merenja koju korisnik može da izabere. Konstatovana je povezanost između veličine prostorije u kojoj se vrši testiranje sistema za ozvučavanje i broja tačaka u kojima se vrši merenje impulsnog odziva. Velikim auditorijumima odgovara gušći raspored ekvidistantnih tačaka merenja radi dobijanja preciznijih rezultata nivoa pokrivanja direktnim zvukom.

AK1.6

#### AKUSTIČKI DIZAJN VELIKE SALE U ZGRADI MAKEDONSKE FILHARMONIJE U SKOPLJU

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*Dragana Šumarac Pavlović, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

*Miloš Bjelić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

Stručni tim Laboratorije za akustiku Elektrotehničkog fakulteta pozvan je da realizuje akustički dizajn velike i male sale u objektu Makedonske filharmonije u Skoplju. Taj zadatak je urađen u saradnji sa makedonskom filijalom austrijske firme STRABAG. U rešavanju tog zadatka postojala su neka početna ograničenja, jer je u trenutku početka rada na dizajnu konstrukcija zgrade bila u celini izgrađena. Zbog toga nisu bile moguće intervencije na obliku i veličini sala, već je oblast delovanja bila ograničena samo na enterijer. U radu su opisane specifičnosti akustičkog dizajna velike sale i metodologija koja je pri tome korišćena. Postignuti rezultati ilustrovani su rezultatima merenja.

## Sesija AK2: Muzička akustika

Sreda, 13. Jun, 11:00 – 12:00, Sala 2

**Predsedavajući: Dragana Šumarac Pavlović, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija**

**Sonja Krstić, Visoka škola elektrotehnike i računarstva, Beograd, Srbija**

AK2.1

#### MERENJE KARAKTERISTIKA KLASIČNE GITARE

*Filip Pantelić, Visoka škola elektrotehnike i računarstva, Beograd, Srbija*

*Predrag Mladenović, Visoka škola elektrotehnike i računarstva, Beograd, Srbija*

*Danica Dudeš, Visoka škola elektrotehnike i računarstva, Beograd, Srbija*

*Dragana Šumarac Pavlović, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

*Miomir Mijić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

U ovom radu opisana je metoda merenja i izračunavanja karakteristika klasične gitare. Za generisanje pobude korišćena je metoda pucanja žice. Odziv instrumenta meren je u veoma bliskom polju iznad kobilice gitare. Na osnovu ovih merenja identifikovana su tri najniža karakteristična moda instrumenta i izračunat im je koeficijent atenuacije upotrebom Šrederove krive.

AK2.2

#### UTICAJ OBLIKA CEVI NA BOJU ZVUKA RENESANSNIH DUVAČKIH MUZIČKIH INSTRUMENATA

*Sonja Krstić, Visoka škola elektrotehnike i računarstva, Beograd, Srbija*

*Marko Milošević, Visoka škola elektrotehnike i računarstva, Beograd, Srbija*

*Nemanja Janković, Visoka škola elektrotehnike i računarstva, Beograd, Srbija*

U ovom radu opisano je istraživanje renesansnih duvačkih muzičkih instrumenata. Istraživanje je sprovedeno na instrumentima: krumhorna, kornamuza, kortholt, raušfajf, šalmaj, pomer i dulcijan. Ovi muzički instrumenti svi imaju dvostruki trščani jezičak i prema toj karakteristici spadaju u istu grupu drvenih duvačkih instrumenata. Uočeno je da neki od tih instrumenata imaju cilindričnu cev, neki konusnu, dok krumhorna ima savijenu cilindričnu, a dulcijan savijenu konusnu unutrašnju cev. U ovom radu je analiziran način na koji te različite karakteristike utiču na međusobni odnos harmonika tonova ovih instrumenata, a samim tim na boju tona. U audio studiju VIŠER snimljeni su tonovi celog opsega svih navedenih muzičkih instrumenata i analizirani su spektri snimljenih tonova. Tonovi su odsvirani ujednačenim nivoom I trajanjem od 2 s za svaki ton.

AK2.3

#### HRMATOGRAM TONOVA DUVAČKIH INSTRUMENATA

*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*

*Jovana Protić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

U procesima automatskog prepoznavanja sadržaja audio signala koriste se različita obeležja zasnovana na analizi spektralnog sadržaja koja svode kompletan spektar signala na opseg jedne oktave. U radu su posmatrane razlike u spektralnim karakteristikama tonova odviranih na tri različita drvena duvačka instrumenta, oboi, flauti i klarinetu sa ciljem da se analizira mogućnost primene hromatograma kao obeležja u prepoznavanju vrste instrumenta. Analizom su obuhvaćeni tonovi unutar celog opsega svakog pojedinačnog instrumenta, a detaljno su analizirani tonovi u rasponu od C4 do H4, gde je redni broj oktave predstavljen anglosaksonskom notacijom. Rezultati dobijeni analizom prikazanom u radu predstavljaju polaznu osnovu za definisanje šablona hroma profila (*Chroma class*) karakterističnih za pojedine instrumente.

AK2.4

#### SNIMANJE MODOVA OSCILOVANJA POVRŠINE U VEOMA BLISKOM POLJU TEHNIKOM IMPULSNE POBUDE

*Filip Pantelić, Visoka škola elektrotehnike i računarstva, Beograd, Srbija*

*Marko Milivojević, Visoka škola elektrotehnike i računarstva, Beograd, Srbija*

*David Petrović, Visoka škola elektrotehnike i računarstva, Beograd, Srbija*

U ovom radu opisana je procedura snimanja modova oscilovanja tanke drvene ploče ukrućene na svojim krajevima. Ploča je pobuđivana impulsom dok joj je odziv sniman u veoma bliskom polju u konačnom broju tačaka iznad vibrirajuće površine. Merna pozicija mikrofona određivana je pomoću ultrazvučnog sistema za detekciju položaja. Predložena metoda ima za cilj skraćivanje vremena potrebnog za snimanje modova oscilovanja površina u veoma bliskom polju.

### **Sesija AK3: Akustičke merne tehnike, Audio tehnika, Audio analitika**

Sreda, 13. Jun, 12:00 – 13:00, Sala 2

**Predsedavajući: Dragana Šumarac Pavlović, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija**

**Sonja Krstić, Visoka škola elektrotehnike i računarstva, Beograd, Srbija**

### AK3.1

#### SNIMANJE MEHANIČKIH KARAKTERISTIKA DRVETA

*Filip Pantelić, Visoka škola elektrotehnike i računarstva, Beograd, Srbija*

*Danica Dudeš, Visoka škola elektrotehnike i računarstva, Beograd, Srbija*

*Predrag Mladenović, Visoka škola elektrotehnike i računarstva, Beograd, Srbija*

*Dragana Šumarac Pavlović, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

*Miomir Mijić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

U ovom radu predstavljena je metoda merenja modula elastičnosti i faktora gubitaka drvenog uzorka. Sva merenja vršena su u veoma bliskom polju, što pruža dodatnu mogućnost vizualizacije modova oscilovanja drveta, čime se može ostvariti sigurnija identifikacija modova. Ovaj pristup je pogodan za ovakvu vrste merenja jer ne zahteva komplikovanu aparaturu, a osnovni rezultati se poklapaju sa standardizovanom procedurom i sa teorijskim očekivanjima.

### AK3.2

#### NEKI SPECIFIČNI ASPEKTI AUDIO SMETNJI IZ EE MREŽE

*Bogdan Brković, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

*Miloš Bjelić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

*Miomir Mijić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

Elektroenergetska mreža kao sistem napajanja audio uređaja čini da su svi audio uređaji, ali i svi drugi električni uređaji koje čovek koristi, međusobno povezani električno jedinstvenim sistemom. Šta više, između utičnica koje se nalaze u nekom fizičkom okruženju neumitno postoji mogućnost galvanske veze. S druge strane, audio praksa sa konverzijom frekvencijama do 192 kHz, s dinamičkim opsegom koji je omogućila 24-bitna konverzija, i uz ocenu kvaliteta audio signala visokom rezolucijom koju su doneli savremeni monitorski zvučnici povećali su osetljivost na smetnje i degradaciju signala. To je stvorilo uslove da se u praksi detektuju uticaji jedinstvenog EE sistema napajanja i posledično povise zahtevi prema ispravljačima za napajanje audio uređaja. U ovom radu su kroz rezultate praktičnih merenja prikazani neki specifični aspekti uticaja EE mreže. Dobijeni rezultati u izvesnom smislu bacaju novo svetlo na značaj koji danas može imati povezivanje audio komponenti posredstvom „globalne“ EE mreže na kvalitet audio signala.

### AK3.3

#### O POTREBI ZA OBELEŽJIMA ZVUKA NEZAVISNIM OD ZVUČNOG UZORKA

*Ivan Jokić, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Srbija*

*Stevan Jokić, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Srbija*

*Vlado Delić, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Srbija*

*Zoran Perić, Elektronski fakultet, Univerzitet u Nišu, Srbija*

Mel-frekvencijski kepralni koeficijenti, uobičajeno korišćena obeležja zvuka, zavise od rama odnosno uzorka zvučnog signala za koji se izračunavaju. Takođe, sam postupak njihovog izračunavanja ne uzima u obzir stvarnu meru energije u pojedinim spektralnim opsezima. Obzirom na ove činjenice a u cilju realizovanja što efikasnijeg prepoznavaća zvuka potrebno je netačnosti preslikane u obeležjima na neki način poništiti što efikasnijim modelima i kriterijumima donošenja odluke. U ovom radu su izneta određena razmišljanja i razmatranja koja ukazuju da su uobičajeni sistemi za prepoznavanje različitih zvukova na ovaj način dodatno usložnjeni što se odražava na njihovu brzinu donošenja odluke a samim tim i na efikasnost. Na osnovu toga stiče se utisak da tačno određivanje obeležja koje odgovara stvarnim energetske komponentama u signal može pojednostaviti postupak prepoznavanja i svesti ga samo na izdvajanje obeležja koje bi sada bilo uvek isto za odgovarajući zvučni izvor.

AK3.4

## ANALIZA MOGUĆNOSTI UPOTREBE BEŽIČNIH AKUSTIČKIH SENZORSKIH MREŽA

*Marko Milivojčević, Visoka škola elektrotehnike i računarstva, Beograd, Srbija*

*Zoran Perić, Elektronski fakultet, Univerzitet u Nišu, Srbija*

Bežične senzorske mreže (Wireless Sensor networks-WSN) su mreže sastavljene od malih uređaja opremljenih sensorom, mikroprocesorom, interfejsom za bežičnu komunikaciju i baterijskim, a ponekad i eksternim napajanjem. Pad cene ovakvih uređaja omogućio je sve širu primenu bežičnih senzorskih mreža. Izborom jednog ili više odgovarajućih senzora i tehnike međusobne komunikacije dobija se mreža određene namene. WSN mreže opremljene mikrofonom i primenjene u akustici su dobile poseban naziv bežične akustičke senzorske mreže (Wireless Acoustic Sensor Networks-WASN). U ovom radu se razmatra mogućnost unapređenja klasičnih kablovskih (žičanih) mikrofonskih sistema koji se koriste za akustička merenja (uključujući snimanje akustičkih karakteristika prostorija) u bežične mikrofonске sisteme bazirane na bežičnim senzorskim mrežama.

# AP Antennas and Propagation / Antene i prostiranje

## Session API1: Antennas and Propagation

Thursday, June, 14<sup>th</sup>, 08:00 – 10:30, Hall 4

**Chair: Branko Kolundzija, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia**

### API1.1

#### COMPACT NUMERICAL MODELS FOR EFFICIENT REPRESENTATION OF EM FIELD PROPAGATION THROUGH DISPERSIVE AND ANISOTROPIC MEDIA (Invited paper)

*Nebojša Dončov, Faculty of Electronic Engineering, University of Niš, Niš, Serbia*

*Miloš Kostić, Innovation Centre of Advanced Technologies Ltd., Niš, Serbia*

*Zoran Stanković, Faculty of Electronic Engineering, University of Niš, Niš, Serbia*

In the paper, compact numerical models for efficient representation of electromagnetic field propagation through dispersive and anisotropic media will be presented. These models incorporated into the TLM method with Z transformation allows to directly map the EM properties of considered media in the time-domain in order to efficiently study their harmonic and transient response. As a result, a powerful numerical tool is obtained for an efficient design of any EM structure.

### API1.2

#### FULL-DUPLEX ANTENNA SUBSYSTEM FOR MICROWAVE RADIO LINKS

*Prathap Valale Prasannakumar, Department of Electrical, Computer, and Energy Engineering, University of Colorado at Boulder, Boulder, USA*

*Mohamed A. Elmansouri, Department of Electrical, Computer, and Energy Engineering, University of Colorado at Boulder, Boulder, USA*

*Ljubodrag Boskovic, Department of Electrical, Computer, and Energy Engineering, University of Colorado at Boulder, Boulder, USA*

*Dejan S. Filipovic, Department of Electrical, Computer, and Energy Engineering, University of Colorado at Boulder, Boulder, USA*

The design of an in-band full-duplex antenna subsystem for a point-to-point microwave link is outlined. High isolation between the transmitter and receiver is achieved through the balanced-circulator approach. In the proposed approach, reflected signals from the antenna and the coupled/leaked signals from the circulators are canceled at the RX port of the beamforming network (BFN) leading to high system isolation. The utilized BFN consists of two 90° hybrids and two circulators. The realized full-duplex antenna is a circularly-polarized parabolic reflector antenna having gain > 20 dB, and return loss > 10 dB. System isolation > 30 dB is achieved. The impact of cross-polarization and the physical asymmetries on the system isolation is also discussed. Moreover, analog signal cancellation technique is applied to compensate imbalances and further improve the system isolation.

### API1.3

#### CAPACITANCE OF THE TWO-WIRE LINE SYMMETRICALLY SPACED INSIDE A RECTANGULAR SHIELD

*Dragan Filipović, Faculty of Electrical Engineering, University of Montenegro, Podgorica, Montenegro*

*Vladan Durković, Faculty of Electrical Engineering, University of Montenegro, Podgorica, Montenegro*

This paper presents two exact formulas for the capacitance per unit length of the two-wire line with a rectangular shield. The method of derivation uses symmetry and separation of variables in Laplace's

equation. Two simple, approximate formulas are extracted from the exact ones, and their accuracy is checked against the two exact formulas and another exact formula found in handbook literature.

API1.4

#### COMPARISON OF SEVERAL APPROACHES FOR CALCULATING 2D MOM INTEGRALS

*Veljko Crnadak, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia / IMTEL-Komunikacije Joint-Stock Company Belgrade, Belgrade, Serbia*

*Dragan Olčan, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

We present results for several different methods of calculating the singular integral of the Hankel function, that arises when analyzing scattering from an infinitely long conducting strip using method of moments. Particularly we focus on calculation of the diagonal elements in method of moments matrix. We use several different approaches for numerical calculation of the integral: trapezoidal rule, potential integrals evaluation method, double-exponential (DE) method, and finally, Gauss-Legendre (GL) method, with an adequate variable substitution.

API1.5

#### COMPARISON OF SLOTTED AND TRUNCATED CIRCULARLY POLARIZED PATCH ANTENNA ARRAYS AT 24 GHZ

*Jelena Mistic, Faculty of Electronic Engineering, University of Nis, Nis, Serbia / Academy of Criminalistic and Police Studies, Belgrade, Serbia*

*Branka Jokanovic, Institute of Physics, University of Belgrade, Belgrade, Serbia*

*Ivana Radnovic, Institute IMTEL Communications A.D., Belgrade, Serbia*

In this paper two designs of circularly polarized printed antenna arrays with the truncated and slotted patches are presented. Both designs are compared regarding the radiation patterns and axial ratio. It is shown that slotted patch antenna array exhibits wider operating range regarding 3 dB-axial ratio compared to the truncated one, but has a lower gain. According to the obtained results of linear antenna arrays with 6, 12 and 24 radiating elements both antenna designs can be used for the realization of antenna arrays intended for automotive radar applications.

API1.6

#### INFLUENCE OF CONDUCTOR SHAPE AND SIZE ON PROPERTIES OF HELICAL ANTENNAS

*Jelena Dinkić, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Miodrag Tasic, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Antonije Djordjevic, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

In this paper we investigate the influence of the conductor shape and size on the characteristics of helical antennas. We analyze three different sets of models – thin-wire models, wire-cage models and plate models. These models correspond to various technologies for manufacturing of helical antennas.

API1.7

#### SOIL SURGE CHARACTERISTICS DURING LIGHTNING DISCHARGE

*Jovan Cvetic, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Milan Ignjatovic, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Fridolin Heidler, Faculty of Electrical Engineering, EIT 7, University of the Federal Armed Forces, Munich, Germany*

*Dragan Pavlovic, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

An electro-dynamic model of soil has been developed that takes into account the frequency dependent and nonlinear soil parameters. Its primary aim is to examine and validate different engineering return stroke models during discharge, but it can successfully be used for examining and calculation of the grounding. The

model accounts for surge behaviour in soils with a wide range of conductivities. The use of the new model for studies at high lightning currents reveals that a great change in the grounding concept can be expected compared to what was previously established in many studies. It is shown that the concept of soil impedance is not applicable in cases of nonlinear resistance and capacitance of the grounding. The same holds for the current reflection coefficient. The new model can be applied when the wavelength of each component in the channel-base current frequency spectrum is much greater than its skin depth in the soil. For most soils the new model is applicable up to 10 MHz. It shows that the channel-base current and the grounding characteristics are related and cannot be treated independently. In other words, the current pulse in any particular return stroke, even in the same flash, „sees“ its own grounding impedance depending on its frequency content and current magnitude.

## **Sesija AP1: Antene i prostiranje**

Četvrtak, 14. Jun, 11:00 – 12:00, Sala 4

**Predsjedavajući: Nebojša Dončov, Elektronski fakultet, Univerzitet u Nišu, Niš, Srbija**

### AP1.1

#### **PREDLOG ANALITIČKOG MODELA KOJI APROKSIMIRA PRVOBITNU KRIVU MAGNEĆENJA FEROMAGNETNIH MATERIJALA**

*Ana Jovanović, Elektrotehnički fakultet, Univerzitet Crne Gore, Podgorica, Crna Gora*

*Vladan Vujičić, Elektrotehnički fakultet, Univerzitet Crne Gore, Podgorica, Crna Gora*

*Luka Lazović, Elektrotehnički fakultet, Univerzitet Crne Gore, Podgorica, Crna Gora*

*Vesna Rubežić, Elektrotehnički fakultet, Univerzitet Crne Gore, Podgorica, Crna Gora*

U ovom radu predložen je analitički model koji aproksimira prvobitnu krivu magnećenja feromagnetnih materijala. Nepoznati parametri predloženog modela određeni su u postupku haotične optimizacije. U cilju određivanja ovih parametara formirana je fitness funkcija, koja predstavlja razliku između mjerene i simulirane prvobitne krive magnećenja. Optimalne vrijednosti parametara su vrijednosti koje minimizuju fitness funkciju. Validacija modela sa optimalnim parametrima izvršena je upoređivanjem sa mjenom krivom i postojećim analitičkim modelima.

### AP1.2

#### **ODREĐIVANJE PRIMARNIH PARAMETARA VODA BEZ GUBITAKA SA TEM TALASOM KORIŠĆENJEM WIPL-D SOFTVERA**

*Miloš Jovičić, WIPL-D d.o.o., Novi Beograd, Srbija*

*Branko Kolundžija, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*

U ovom radu pokazaćemo efikasnu metodu za određivanje primarnih parametara voda bez gubitaka sa TEM talasom korišćenjem WIPL-D softvera. Zahvaljujući ovom metodi u mogućnosti smo da odredimo i pojedine fizičke karakteristike voda ako su poznati primarni ili sekundarni parametri.

### AP1.3

#### **SIMULACIJA RADARSKJE POVRŠINE BRODOVA U KRATKOTALASNOM FREKVENTNOM OPSEGU**

*Nemanja Grbić, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*

*Pavle Petrović, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*

*Nikola Stevanović, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*

*Bojan Džolić, Institut VLATACOM, Novi Beograd, Srbija*

*Dejan Nikolić, Institut VLATACOM, Novi Beograd, Srbija*



*Nikola Lekić, Institut VLATACOM, Novi Beograd, Srbija*

Radari u kratkotalasnom frekventnom opsegu koji koriste površinski talas, primenjuju se kao senzori u sistemima za nadgledanje morske površine do 200 nautičkih milja. Poznavanje radarske površine brodova je veoma važno u procesu projektovanja i eksploatacije kratkotalasnih radara. U radu je prikazana analiza radarske površine u kratkotalasnom frekventnom opsegu više brodova, na osnovu elektromagnetskog modelovanja u programskom paketu WIPL-D.

AP1.4

#### ELEKTROMAGNETSKO MODELOVANJE POSTAVKE ZA MERENJE KOEFICIJENTA REFLEKSIJE UWB ŠTAMPANIH MONOPOL ANTENA

*Dragan Nikolić, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija / Vojnotehnički institut, Beograd, Srbija*

*Miodrag Tasić, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*

Mernu postavku za merenje koeficijenta refleksije (ili dijagrama zračenja) antena uobičajeno čine, pored same ispitivane antene, merni uređaji (npr. analizator mreža) i koaksijalni (merni) vodovi koji povezuju delove postavke. U pojedinim slučajevima, npr. kada je reč o električki malim antenama, merna postavka može da značajno utiče na tačnost merenja. UWB (Ultra-Wideband) frekvencijski opseg proteže se od 3,1 GHz do 10,6 GHz, pa se u nižem delu ovog opsega UWB štampane monopol antene mogu smatrati električki malim. Standardne tehnike za smanjenje štetnog uticaja mernih vodova prilikom merenja antene, poput korišćenja "prigušnica", nisu dovoljno širokopojasne da pokriju čitav UWB frekvencijski opseg. U ovom radu ispitujemo da li se detaljnim elektromagnetskim modelovanjem postavke za merenje koeficijenta refleksije antene može postići zadovoljavajuće poklapanje rezultata merenja i simulacije.

# AU Automatic Control / Automatika

## Sesija AU1: Automatsko upravljanje

Sreda, 13. Jun, 8:00 – 9:30, Sala 3

**Predstavljajući: Željko Đurović, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija**

AU1.1

PODEŠAVANJE POLOVA SISTEMA SA ZATVORENOM POVRATNOM SPREGOM “TURN OVER” METODOM

*Radmila Gerov, Elektronski fakultet, Niš*

*Zoran Jovanović, Elektronski fakultet, Niš*

U radu je razmatrana sinteza regulatora po stanju linearnog sistema podešavanjem polova sistema sa zatvorenim povratnom spregom modifikovanom “Turn over” metodom. Svi polovi sistema sa zatvorenim povratnom spregom nalaze se u željenom području kompleksne s-ravni i optimalno su podešeni. Metoda je ilustrovana na primerima sinteze regulatora kod stabilnih i nestabilnih linearnih, stacionarnih, kontrolabilnih, multivarijabilnih sistema sa otvorenom povratnom spregom. Dobijeni rezultati upoređeni su sa rezultatima dobijenim metodama sinteze optimalnih linearno kvadratnih regulatora.

AU1.2

ADAPTIVNI REZONANTNI PROŠIRENI OPSERVER STANJA U KONCEPTU UPRAVLJANJA SA AKTIVNIM POTISKIVANJEM POREMEĆAJA

*Momir Stanković, Military Academy in Belgrade, Serbia*

*Stojadin Manojlović, Military Academy in Belgrade, Serbia*

*Srdan Mitrović, Military Academy in Belgrade, Serbia*

*Davorin Mikluc, Military Academy in Belgrade, Serbia*

*Milica Naumović, Military Academy in Belgrade, Serbia*

U radu je predložena nova struktura regulatora na bazi rezonantnog proširenog opservera stanja (Resonant Extended State Observer -RESO) sa ugrađenim adaptivnim estimatorom rezonante učestanosti. Na ovaj način omogućeno je adaptivno podešavanje parametara RESO-a, odnosno procena totalnog poremećaja nepoznate frekvencije. Performanse praćenja prostoperiodičnih i složenoperiodičnih referenci, primenom predloženog rešenja u konceptu upravljanja sa aktivnim potiskivanjem poremećaja (Active Disturbance Rejection Control-ADRC) sa jednim stepenom slobode, su pokazale efikasnost ovakve strukture u slučajevima kada je frekvencija referentnog signala nepoznata ili promenljiva.

AU1.3

KLASIFIKACIJA SIGNALA IZVIĐAČKIH RADARA PRIMENOM METODE NOSEĆIH VEKTORA

*Dimitrije Bujaković, Military Academy in Belgrade, Serbia*

*Milenko Andrić, Military Academy in Belgrade, Serbia*

*Boban Bondžulić, Military Academy in Belgrade, Serbia*

*Slobodan Simić, Military Academy in Belgrade, Serbia*

*Davorin Mikluc, Military Academy in Belgrade, Serbia*

U ovom istraživanju je projektovan hijerarhijski linearni klasifikator zasnovan na metodi nosećih vektora za klasifikaciju signala sa audio izlaza izviđačkih radara. Kao obeležja korišćena su centralna Doplerova frekvencija i širina spektra oko nje. Ova obeležja su izdvojena na osnovu spektrograma primenom metoda digitalne obrade slike. U radu je predložen optimalni izbor parametara linearnog klasifikatora zasnovanog na metodi nosećih vektora korišćenjem ukupne verovatnoće ispravne klasifikacije. Dobijeni rezultati pokazuju

da je projektovanjem ovog hijerarhijskog klasifikatora ostvarena verovatnoća ispravne klasifikacije od 93.32% u odnosu na celokupni skup vektora obeležja.

AU1.4

JEDAN PRIMER DIGITALNOG UPRAVLJANJA DC MOTOROM PRIMENOM TIRISTORA I LABVIEW-A  
(Education Section)

*Davorin Mikluc, Military Academy in Belgrade, Serbia*

*Milenko Srećković, Military Academy in Belgrade, Serbia*

*Momir Stanković, Military Academy in Belgrade, Serbia*

U ovom radu su prezentovani rezultati upravljanja motorom jednosmerne struje primenom softverskog alata LABVIEW. Motor je upravljani strujom u rotoru koja je formirana tiristorskim kolom za punotalasno ispravljanje. Digitalno upravljanje se sastoji iz softverskog generisanja ugla paljenja tiristora, analogno-digitalnih konvertora i kartice za prikupljanje i generisanje podataka kao komunikacija između računara i tiristorskog kola. Akvizicijskom karticom se mere napon tahogeneratora i struja rotora. Na osnovu izmerenih vrednosti izvršena je identifikacija parametara funkcije prenosa motora, a zatim je analiziran uticaj softverskog PID regulatora na rad sistema.

AU1.5

UPRAVLJANJE SISTEMOM OSVETLJENJA U PAMETNIM ZGRADAMA (Young researcher)

*Miloš Milošević, Institut RT-TK, Novi Sad, Srbija*

*Nenad Četić, Institut RT-TK, Novi Sad, Srbija*

*Jelena Kovačević, Institut RT-TK, Novi Sad, Srbija*

*Tihomir Anđelić, Institut RT-TK, Novi Sad, Srbija*

Ovaj rad predlaže jedno rešenje za regulaciju i upravljanje rasvetom u pametnoj kući. Rad se oslanja na OBLO Living sistem, idejno rešenje naučno-istraživačkog instituta „RT-RK“ u oblasti kućne automatizacije. Rad uključuje i primenu Raspberry Pi računara u ulozi centralne jedinice za računanje upravljanja. Srž rada odnosi se na metode automatskog upravljanja primenjene u okviru sistema za regulaciju osvetljenosti.

## **Session AUI1: Distributed Control and Tracking**

Wednesday, June, 13<sup>th</sup>, 9:30 – 10:30, Hall 3

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

AUI1.1

ON THE ROBUST DISTRIBUTED CONTROL OF INVERTER-BASED MICROGRIDS (Invited paper)

*Alessandro Pisano, DIEE - Università degli Studi di Cagliari*

*Milan Gholami, DIEE - Università degli Studi di Cagliari*

*Alessandro Pilloni, DIEE - Università degli Studi di Cagliari*

*Elio Usai, DIEE - Università degli Studi di Cagliari*

In this paper, we present a novel control strategy to perform the exact finite-time restoration among voltages and frequencies of an islanded inverter-based microgrid. The problem is attacked from a cooperative-based control perspective inspired to the tracking consensus paradigm. Ad-hoc chattering-free sliding-mode based distributed algorithms are designed to enhance the underlying robustness and convergence properties of the system with respect to the existing solutions. Particularly, the restoration is achieved while dispensing with the knowledge of the distributed generators' models and parameters. Performance of the control system is analyzed by Lyapunov tools, and a simple set of tuning rules are derived. The effectiveness of the proposed scheme is verified by simulations on a realistic inverter-based microgrid modelization.

AUI1.2

## ON STABILITY OF MULTI-STEP CONSENSUS SCHEME FOR DISTRIBUTED TARGET TRACKING IN SENSOR NETWORKS

*Nemanja Ilić, Technical College of Applied Studies*

*Khaled Obaid Al Ali, Etimad Abu Dabi and Vlatacom Institute, Belgrade*

*Miloš Stanković, Innovation Center, Faculty of Electrical Engineering, University of Belgrade and Vlatacom Institute, Belgrade*

*Srđan Stanković, Innovation Center, Faculty of Electrical Engineering, University of Belgrade and Vlatacom Institute, Belgrade*

In this paper we discuss an adaptive multi-step consensus scheme for distributed target tracking by sensor networks with nodes having limited sensing range. The considered distributed adaptation strategy provides asymptotic consensus gains (giving the desired importance to the nodes observing the target), together with the fast convergence rate of the consensus scheme. Consequently, the obtained tracking algorithm exhibits interesting characteristics regarding stability from the theoretical point of view. Namely, it is shown how the consensus scheme can ensure stability even in the case of locally unstable trackers. An analysis of the beneficial reduction of noise influence due to the applied consensus scheme is also included. Numerical examples are given as an illustration of the considered properties of the applied algorithm.

AUI1.3

## OBJECT TRACKING IN THERMAL IMAGES BASED ON SURF AND KLT FEATURES

*Nataša Vlahović, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

*Željko Đurović, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

Object tracking represents an important and challenging problem of the Computer and Machine Vision field, in visual domain as well as in thermal imaging. Thermal imagery has become popular in modern era, since thermal cameras decreased price, increased image quality, enabled night and severe fog visibility and represent less intrusion on privacy in modern cities. That is why thermal image tracking algorithms are in the development phase nowadays. In this paper, the focus is on pedestrian objects tracking in saturated images, where there is no visible texture in objects. The main goal is to avoid tracking errors in cases of two or more objects overlapping the tracked object (severe occlusions). This problem is solved by using SURF (Speeded-up Robust Features) and KLT (Kanade Lucas Tomasi) feature tracker and Kalman filter.

## **Session AUI2: Automatic Control**

Thursday, June, 14<sup>th</sup>, 8:00 – 9:00, Hall 3

**Chair: Boban Veselić, Elektronski Fakultet Niš**

AUI2.1

## ON THE ROBUSTNESS OF TARGET TRACKING WITH RESPECT TO ERRORS IN PARAMETER VALUES

*Asem Al-Hasaeri, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*

*Predrag Tadić, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*

*Aleksandra Marjanović, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*

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

One of the core components of all target tracking systems is the assignment of measurements to tracks—the so called data association task. Regardless of the particular method used, certain parameters which describe the environment and the measurement process must be known. The most important among these are the false alarm density and the probability of detecting the target. The goal of this paper is to assess the sensitivity of one of the standard assignment methods, namely the probabilistic data association algorithm, to errors in the values of these parameters. Through computer simulations, we show that the performance of the tracking

algorithm can suffer significantly if such errors occur. This motivates further work towards finding reliable methods for on-line estimation of relevant parameters.

#### AUI2.2

##### TEMPERATURE DISTRIBUTION REGULATION BASED ON MODEL PREDICTIVE CONTROL

*Predrag Vasilić, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*

*Aleksandra Marjanović, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*

*Sanja Vujnović, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*

*Nikola Popović, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*

The paper presents one approach to temperature distribution control in tangentially fired thermal power plant boilers. It has been shown that the information on flame asymmetry can be detected directly from the temperatures of the flue gasses on the left and on the right side of the boiler. These measurements together with the number of active mills define the structure of control algorithm whose outputs reflect the participation of each mill in the firing process. The paper proposes a Dynamic matrix control (DMC)-based regulator with periodical parameter tuning. The model for parameter tuning algorithm and closed-loop simulations was derived using the weighted recursive least squares (WRLS) technique on real measurements obtained at Nikola Tesla B1 thermal power plant (TENT B1) in Serbia.

#### AUI2.3

##### ON DIMENSION REDUCTION TECHNIQUES (Young researcher)

*Nikola Popović, Faculty of technical sciences, University of Novi Sad, Novi Sad, Serbia*

*Sanja Vujnović, Global Electronic, Beočin, Serbia*

*Predrag Tadić, Faculty of technical sciences, University of Novi Sad, Novi Sad, Serbia*

*Predrag Vasilić, Faculty of technical sciences, University of Novi Sad, Novi Sad, Serbia*

In recent years the amount of data available for analysis is exponentially increasing. In many cases, the datasets have a high number of dimensions when compared to the number of observations, which poses a problem for statistical data analysis methods. In those situations, often the first step is to apply some dimension reduction technique. Classification is an important group of problems, so this paper analyzes the effect of some reduction techniques on class separability. The techniques that are analyzed are: Principal Component Analysis, Kernel PCA, Linear Discriminant Analysis and Support Vector Decomposition Machine. They are analyzed on a dataset obtained by preprocessing raw acoustic signals of an impact between a wooden stick and different types of objects.

#### AUI2.4

##### MODEL-DRIVEN-ENGINEERING IN EDUCATION: POSITION CONTROL OF AN ELECTRONIC THROTTLE VALVE (Education Section)

*Laszlo Juhasz, Deggendorf Institute of Technology, Germany*

*Judu Sahu, Deggendorf Institute of Technology, Germany*

*Amir Samiee, Deggendorf Institute of Technology, Germany*

*Nicolas Tiefnig, Deggendorf Institute of Technology, Germany*

*Michael Wagner, Deggendorf Institute of Technology, Germany*

Digitally controlled electronic throttle valves are typical mechatronic systems containing mechanical, electrical, and electronic as well as computer hardware/software elements. The typical multi-domain nature of mechatronic systems is represented by the electronic throttle valve (ETV) through the mutual interaction between its mechanical and the electrical subsystem. The use of ETV in academic education of Model-Driven-Engineering (MDE) methods is advantageous because of several aspects. On one hand, even a very simple controller with manually tuned parameters can result in stable - although poor - positioning behavior.

On the other hand, physical modelling, parameter identification and enhanced control methods based on the parametrized model can result in significant increase in the dynamic positioning quality. But high-quality control represents a complex task because of the nonlinearities (spring, dry friction and backlash) and the electro-mechanical architecture (throttle, gearbox, electrical drive, PWM-modulation). On this way, the students can enhance their knowledge in the field of system modelling, parameter identification and control theory. Practical experience with the application of theoretical knowledge onto a real and moving plant is also important. Through the comparison of the control quality of a simple ad-hoc controller and an enhanced control law - derived using the identified plant model and parameter - students can easily recognize the advantages of the model-based control approach and MDE methods.

## **Session AUI3: Automatic Control**

Thursday, June, 13<sup>th</sup>, 9:15 – 10:30, Hall 3

**Chair: Željko Đurović, Elektrotehnički fakultet, Beograd**

AUI3.1

### **SOLVABILITY OF LINEAR SINGULAR IMPULSIVE SYSTEMS**

*Nataša Kablar, LOLA Institute*

In this paper for the class of linear singular impulsive dynamical systems we present solvability results. We define consistent initial conditions, tractability and regularity, we discuss existence and uniqueness of solutions, and we define equivalent statements for solvability definition of singular impulsive system. A linear singular impulsive system represents mixture of singular differential and singular difference and algebraic equations. In special case, for singular matrices being regular, results are standard as in case of linear impulsive systems. In case of continual or discrete dynamics being absent, results specialize to classical singular discrete, or singular continual systems, respectively. This class of system is here defined for the first time. This paper also considers wider class of general systems that includes both singular and standard impulsive systems.

AUI3.2

### **APPLICATION OF REAL DIFFERENTIATORS FOR SPEED ESTIMATION IN HIGH PERFORMANCE ELECTRIC DRIVES**

*Milutin Petronijević, Faculty of Electronic Engineering, Niš*

*Čedomir Milosavljević, Faculty of Electrical Engineering, University of East Sarajevo*

*Boban Veselić, Faculty of Electronic Engineering, Niš*

This paper compares several speed estimation algorithms in digitally controlled adjustable speed drives (ASDs). A high performance induction motor ASD usually uses incremental encoder for angular position measurement, from which angular speed need to be estimated. One approach to speed estimation is implementation of real differentiators. A new digital differentiator is proposed that eliminates some shortcomings of the well-known Levant's sliding mode differentiator. The presented comparative experimental analysis shows that the proposed differentiator is suitable in high performance drives, in a wide speed range.

AUI3.3

### **AN EXAMPLE OF FAULT DETECTION SYSTEM FOR INDUCTION MOTORS BASED ON INTERNET OF THINGS (Young researcher)**

*Stefana Jocić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Milan R. Rapaić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Željko Kanović, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Vukan Turkulov, Faculty of Technical Sciences, University of Novi Sad, Serbia*

Recently, condition monitoring and early fault detection of induction motors gained a considerable interest. This paper presents an example of fault detection system for induction motors based on modern cloud platform, Microsoft Azure. The developed system uses classic vibration analysis technique to detect a broken rotor bar fault type and Radial Basis Function (RBF) neural network to classify the state of induction motors. Power BI is used to display obtained results in real-time.

AUI3.4

PARALLEILZATION OF GENERALIZED PARTICLE SWARM OPTIMIZATION ALGHORITM (Young researcher)

*Vesna Pavković, Faculty of technical sciences, University of Novi Sad, Serbia*

*Milan R. Rapaić, Faculty of technical sciences, University of Novi Sad, Serbia*

*Zoran D. Jeličić, 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*

Parallelization of generalized particle swarm optimization algorithm (a variant of PSO algorithm based on principles of control theory) is presented in this paper. Two different variants of parallelization are proposed and compared to GPSO on a set of benchmark functions. Two proposed variations obtain finer results and thus confirm the effectiveness of the newly proposed algorithm.

AUI3.5

ESTIMACIJA PARAMETARA LINEARNIH SISTEMA PRIMENOM GRADIJENTNOG ALGORITMA SA KONTROLISANOM DUŽINOM KORAKA

*Mirna N. Kapetina, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

*Milan R. Rapaić, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

*Alessandro Pisano, Dipartimento di Ingegneria Elettrica ed Elettronica Università degli Studi di Cagliari Cagliari, Italia*

*Boris B. Jakovljević, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

U radu je predstavljen jedan postupak za adaptivnu estimaciju parametara široke klase linearnih sistema. Predloženi pristup može biti primenjen na sisteme sa transportnim kašnjenjem, distribuiranim parametrima, frakcione sistema kao i druge sisteme opisane funkcijama prenosa proizvoljne forme, racionalnim ili iracionalnim. Predost predloženog algoritma je što način na koji parametri figurišu u funkciji prenosa može biti i linearan i nelinearan. Zakon adaptacije realizovan je primenom gradijentnog algoritma sa kontrolisanom dužinom koraka (unit vector) i sa adaptivnim pojačanjem. Efikasnost algoritma je ilustrovana kroz reprezentativne primere.

# **BT Biomedical Technique / Biomedicinska tehnika**

## **Session BTI1: Biomedical Engineering**

Wednesday, June, 13<sup>th</sup>, 11:30 – 13:00, Hall 1

**Chair: Dejan Popović, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia**

### BTI1.1

#### CHALLENGES OF CLOSING THE LOOP IN UPPER-LIMB PROSTHETICS (Invited paper)

*Marko Marković, Department of Trauma Surgery, Orthopedics and Plastic Surgery, University Medical Center Göttingen, Göttingen, Germany*

*Meike A. Schweisfurth, Faculty of Life Sciences, University of Applied Sciences, Hamburg, Germany and Department of Trauma Surgery, Orthopedics and Plastic Surgery, University Medical Center Göttingen, Göttingen, Germany*

*Arndt F. Schilling, Department of Trauma Surgery, Orthopedics and Plastic Surgery, University Medical Center Göttingen, Göttingen, Germany*

*Dario Farina, Department of Bioengineering, Imperial College London, London, UK*

*Strahinja Došen, Faculty of Medicine, Department of Health Science and Technology Center for Sensory-Motor Interaction, Aalborg University, Aalborg Denmark and Department of Trauma Surgery, Orthopedics and Plastic Surgery, University Medical Center Göttingen, Göttingen, Germany*

Sensory feedback is critical for grasping in able-bodied subjects. Consequently, closing the loop in upper-limb prosthetics by providing sensory feedback to the amputee is expected to improve prosthesis utility. Nevertheless, even though amputees rate the prospect of sensory feedback highly, its benefits in daily life are still very much debated. We address this issue by building a concise knowledge base about a variety of different factors that influence closed-loop control. We demonstrate that the complex, multifaceted nature of feedback is likely responsible for inconsistent literature results. More specifically, we identify that the factors such as the quality of the control interface, the availability of intermediate feedback sources, task complexity and user experience have decisive influence on performance of implemented feedback solutions. We use these insights to implement and evaluate a novel vibrotactile feedback interface for multi-functional, dexterous prostheses in a clinically relevant setting and demonstrate that it improves not only prosthesis control efficiency but also the overall subjective experience.

### BTI1.2

#### CLASSIFICATION OF PARKINSONISM BASED ON FOOT TAPPING TEST

*Vladislava Bobić, University of Belgrade - School of Electrical Engineering, and Innovation Center, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Milica Djurić-Jovičić, Innovation Center, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Milica Ječmenica-Lukić, Neurology clinic, Clinical Center of Serbia, Medical faculty, University of Belgrade, Serbia*

*Igor Petrović, Neurology clinic, Clinical Center of Serbia, Medical faculty, University of Belgrade, Serbia*

*Nataša Dragašević, Neurology clinic, Clinical Center of Serbia, Medical faculty, University of Belgrade, Serbia*

*Vladimir Kostić, Neurology clinic, Clinical Center of Serbia, Medical faculty, University of Belgrade, Serbia*

*Mirjana Popović, Institute of Medical Research – University of Belgrade, Belgrade, Serbia*

Foot tapping represents a standard clinical test used for the assessment of motor abilities of patients with Parkinson's disease (PD). In this paper, we analyzed the data recorded by gyroscope mounted on a foot bridge during the foot tapping test (FTT). The data was collected from 17 healthy controls, 17 patients with PD and 17 patients with Multiple System Atrophy (MSA). By using the several signal processing techniques, we



extracted the features, and organized these into three datasets based on their type and clinical usability. One dataset comprised basic spatio-temporal features: tapping angle, duration and speed, whereas the second feature set included two more spatio-temporal features: maximum lifting and maximum foot drop velocities. Frequency-based parameters describing tap-to-tap variability and rhythm regularity were further added forming the third feature set. The feature sets were fed to the Support Vector Machine, and the accuracy was assessed with 10-fold cross validation. Obtained results showed that frequency-based parameters contribute to better differentiation between the evaluated groups with accuracy of  $83.94 \pm 1.17\%$ .

### BTI1.3

#### INFLUENCE OF TWO WEEKS BALANCE PRACTICE WITH FEEDBACK ON THE GAIT IN HEMIPLEGIC PATIENTS

*Jasmina Milovanović, Practice for physical rehabilitation, Belgrade, Serbia*

*Marija Gavrilović, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*

*Ivan Topalović, Institute of Technical Sciences of SASA, Belgrade, Serbia*

*Dejan B. Popović, Serbian Academy of Sciences and Arts, Belgrade, Serbia, and Aalborg University, Aalborg, Denmark*

We hypothesized that practicing balance with feedback will improve the gait in hemiplegic patients. The practice consisted of two weeks 30-minute long Wii-Fit balance board gaming. The gait analysis was based on ground reaction pressures (GRP) recorded with the custom designed insoles. The data were collected at 100 samples per second from two insoles, each comprising five pressure (force) sensors. The sensors communicated with the host computer by a WiFi link. Custom software was developed in Matlab for automatic segmentation of the GRP data into segments belonging to swing and stance phases of each step. The examiner could correct the automatic segmentation if necessary. The outputs from the program were: pressure vs. time from all sensors and standard gait data (cadence, symmetry index, etc.). The results show that the exercise of the function with feedback has positive effects on the gait performance. The exercise period was only two weeks, and the group was small and heterogeneous; hence, a more extensive study is required for proving the significance.

### BTI1.4

#### GYROSCOPE-BASED METHOD FOR EVALUATION OF GAIT SYMMETRY

*Marija Gavrilović, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*

The hypothesis of the research was that MEMS based gyroscopes mounted on the lateral side of the thigh can be used for the assessment of the symmetry of the gait. To test the hypothesis we recorded gait characteristics with insoles in both shoes which measured the ground reaction force (GRF) distribution (five sensors per insole) and inertial measurement units (IMU) mounted on the lateral side of legs. We introduced the interval f1 when the angular rate in the sagittal plane is positive and f2 when the angular rate is negative. The symmetry of gait defined by the intervals f1 and f2 was compared with the symmetry calculated from the durations of the stance and swing phases. The analysis was performed by using the data collected in a short clinical study with twelve stroke patients. The IMU and GRF based estimated symmetries showed strong correlation ( $r=0.87$ ,  $p<0.001$ ). The differences between the IMU and GRF based estimated symmetries were within 4%. The results suggest that the IMU can be used instead of the GRF instrumented insoles for the assessment of the symmetry in the clinical environment.

### BTI1.5

#### EFFECTS OF WII-FIT BALANCE BOARD EXERCISE ON THE POSTURE OF STROKE PATIENTS

*Slobodanka Kundaica University of Novi Sad, Novi Sad, Serbia*

*Marija Gavrilović, University of Belgrade - School of Electrical Engineering, Belgrade, Serbia*

*Ivan Topalović, Institute of Technical Sciences of SASA, Belgrade, Serbia*

*Dejan B. Popović, Serbian Academy of Sciences and Arts, Belgrade, Serbia, and Aalborg University, Aalborg, Denmark*

We studied the effects of the balancing exercise with visual feedback to the correction of posture in stroke patients. We included eight stroke patients into a 30-minute daily, two-week long clinical study where Wii-Fit balance board was the instrument to provide visual feedback. We assessed the posture before and after the treatment by four clinical tests: Berg balance test, Barthel index, Timed up & go and Functional reach test. We also analyzed the ground reaction pressures (GRP). We measured the GRP by using insoles comprising five MEMS sensors each. We developed a program that created maps showing ground pressure distribution. The program uses cubic spline interpolation of data. The maps of left and right sole were compared to assess the symmetry, and the maps before and after the treatment were used to examine the effects of the exercise. The clinical test scores suggest improved standing after the treatment compared with before the treatment. The maps of ground reaction pressure also show improvement, but more critical provide information for correcting the posture.

#### BT11.6

##### NEUROMUSCULAR STIMULATION AND ELECTRONIC STIMULATOR OUTPUT STAGE FOR GENERATING VARIOUS CURRENT WAVEFORMS

*Filip Gašparić, Faculty of technical sciences, University of Novi Sad, Novi Sad, Serbia*

*Predrag Vukov, Global Electronic, Beočin, Serbia*

*Nera Vlasisavljević, Faculty of technical sciences, University of Novi Sad, Novi Sad, Serbia*

*Nikola Jorgovanović, Faculty of technical sciences, University of Novi Sad, Novi Sad, Serbia*

The artificial stimulation of neuromuscular structures has found many applications in modern medicine. There are many devices, which are intended for the stimulation of neuromuscular structures, developed for commercial and scientific research purposes. The majority is based on generating rectangular current or voltage impulses. This form of stimulation has long been found in clinical practice. However, from scientific point of view, having an electronic stimulator which is able to generate arbitrary waveforms seems to be necessary in order to examine physiological response to various waveforms of the stimulus. In this work the design of PC-based electronic stimulator that is able to generate different current waveforms is presented.

#### BT11.7

##### PHYSIOLOGICAL DATA ACQUISITION SYSTEM FOR A BIOMEDICAL ENGINEERING EDUCATION

*Olivera Tomašević, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

*Luka Mejić, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

*Darko Stanišić, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

*Vojin Ilić, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

This paper describes the physiological data acquisition system designed for the student laboratory exercises. The system has the functionality of electrocardiography and electromyography monitoring and also can be used as a photoplethysmograph. The system is portable and can be completely functional without the cable connections to other devices. It has an open architecture, which enables various types of expandings and modifications, which is suitable for student project realizations.

#### BT11.8

##### GLOBAL CONTRAST REDUCTION FOR BETTER LOCAL STRUCTURE VISUALIZATION IN DIGITAL RADIOGRAPHY

*Vladimir Ostojić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Đordje Starčević, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Vladimir Petrović, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Tijana Delić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Siniša Suzić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

Radiography images can be processed with multiscale algorithms to produce better detail visibility and to improve local contrasts. In this paper we propose a method that can be used to decrease the global contrast that represents the intensity differences between the thickest and the thinnest anatomical structures. Global contrast was reduced by manipulating the values of the low-pass approximation of the image in the multiscale representation. Proposed approach was embedded into a multiscale radiography image enhancement algorithm and it was shown that it leads to increase of the visibility of the finer structures in the image. Proposed approach is easy to implement and simple to use as it is controlled by only one parameter.

BT11.9

#### MODIFIED LOGARITHMIC VALUE MAPPING FOR BETTER DENSE STRUCTURE VISIBILITY IN DIGITAL RADIOGRAPHY

*Vladimir Ostojić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Dordje Starčević, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Vladimir Petrović, Faculty of Technical Sciences, University of Novi Sad, Serbia*

In this paper we analyze the possibility of nonlinear value mapping for digital radiographic images prior to detail and contrast enhancement. This preprocessing step is designed to increase differentiation between dense anatomical structures that are typically indistinguishable in unprocessed images. We analyzed the effects of using the logarithm operator for nonlinear preprocessing and the possible modifications that result in reduced noise amplification and artifact creation. A modification that reduces the slope of the logarithmic curve near the coordinate origin is proposed. It was shown that the visibility of dense structures increases if the proposed mapping is used, while the noise prominence is reduced compared to the unmodified logarithmic mapping.

BT11.10

#### INFLUENCE OF SPECIMEN PREPARATION AND NANOINDENTATION PROTOCOL ON THE MECHANICAL PROPERTIES OF BOVINE BONE

*Staša Vučinić, Faculty of Technical Sciences, University of 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, Serbia*

*Milica Šipovac, Faculty of Medicine, University of Novi Sad, Novi Sad, Serbia*

*Sofija Stefanović, BioSense Institute, University of Novi Sad, Novi Sad, Serbia*

*Goran Stojanović, Faculty of Technical Sciences, University of Novi Sad, Serbia*

The physical properties of bone tissue have been investigated at different levels, macro, micro and nano scale. The aim of this study was to assess the influence of two specimen preparation techniques and six nanoindentation protocols on modulus and hardness of bovine bone specimens. Embedding in resin do not affect the mechanical properties of bone samples. More precise and repeatable results are obtained using higher indentation forces. Larger number of measurements are required for bone indentation analysis using lower forces.

BT1.1

#### UPOREDNA ANALIZA METODA ZA KLASIFIKACIJU UZORAKA PRIMENJENIH KOD TROKLASNE KLASIFIKACIJE MAMOGRAFSKIH SNIMAKA

*Marina Milošević, Fakultet tehničkih nauka Univerziteta u Kragujevcu, Čačak, Srbija*

*Željko Jovanović, Fakultet tehničkih nauka Univerziteta u Kragujevcu, Čačak, Srbija*

*Dragan Janković, Elektronski fakultet Univerziteta u Nišu, Niš, Srbija*

*Djordje Damjanović, Fakultet tehničkih nauka Univerziteta u Kragujevcu, Čačak, Srbija*

U ovom radu predstavljen je sistem za prepoznavanje tumora dojke na mamografskom snimku (mamogramu) baziran na klasifikaciji uzoraka i analizi tekstone slike. Predloženi sistem obuhvata: predobradu mamograma, izdvajanje obeležja tekstone slike i klasifikaciju mamograma u tri klase. Obeležja izračunata pomoću statističke metode združenog pojavljivanja nivoa sivog (eng. Gray Level Cooccurrence - GLC) korišćena su za procenu tekstone tumorskih regija. Nakon predobrade mamografskih snimaka, za svaki je izdvojeno ukupno 20 obeležja tekstone slike. Sposobnost prepoznavanja normalnog, benignog i malignog tkiva ispitana je korišćenjem klasifikatora zasnovanog na podržavajućim vektorima (eng. Support Vector Machine - SVM), klasifikatora koji koristi metodu k-najbližih suseda (eng. k-nearest neighbor - k-NN) i naivnog Bajesovog klasifikatora. Efikasno korišćenje podataka prilikom klasifikacije, omogućeno je primenom metode kros-validacije. Klasifikator zasnovan na podržavajućim vektorima u osnovi je razvijen za binarnu klasifikaciju. U ovom radu opisan je troklasni SVM klasifikator nastao kombinovanjem dva binarna SVM klasifikatora, a zatim su upoređene njegove performanse sa performansama druga dva klasifikatora koji su inicijalno dizajnirani za višeklasnu klasifikaciju. Procena efikasnosti primenjenih klasifikacionih metoda izvršena je pomoću matrice konfuzije i ROC krive (eng. Receiver Operating Characteristic curve). Dobijeni eksperimentalni rezultati pokazali su da je predloženi SVM klasifikator efikasniji u razvrstavanju uzoraka u tri klase od druga dva klasifikatora.

## BT1.2

### VEŠTAČKE NEURALNE MREŽE U PREKLINIČKIM STUDIJAMA ZA DETEKCIJU EPILEPTIČNIH NAPADA

*Andrijana Pušica, Univerzitet u Beogradu – Elektrotehnički fakultet, Beograd, Srbija*

*Marko Vorkapić, Institut za medicinsku fiziologiju “Rihard Burian”, Medicinski fakultet Univerziteta u Beogradu, Beograd, Srbija*

*Andrej Savić, Univerzitet u Beogradu – Elektrotehnički fakultet, Beograd, Srbija i Tecnia Srbija, Beograd, Srbija*

*Nemanja Useinović, Institut za medicinsku fiziologiju “Rihard Burian”, Medicinski fakultet Univerziteta u Beogradu, Beograd, Srbija*

*Olivera Stanojlović, Institut za medicinsku fiziologiju “Rihard Burian”, Medicinski fakultet Univerziteta u Beogradu, Beograd, Srbija*

*Dragan Hrnčić, Institut za medicinsku fiziologiju “Rihard Burian”, Medicinski fakultet Univerziteta u Beogradu, Beograd, Srbija*

*Milica Janković, Univerzitet u Beogradu – Elektrotehnički fakultet, Beograd, Srbija*

Veštačke neuralne mreže (VNM) su softverska simulacija prirodnih sinapsi moždanih ćelija koje omogućavaju učenje na osnovu velikog broja ulaznih podataka, prepoznavanja obeležja signala i donošenja odluka. VNM imaju značajnu primenu u automatskoj detekciji epileptičnih napada u moždanim električnim signalima. Jedna od odlika moždanih električnih signala je da poseduje nelinearne karakteristike. U ovom radu su biotične nelinearne karakteristike elektrokortikografskog (ECoG) signala iskorišćene kao obeležja za obučavanje veštačke neuralne mreže u cilju automatske detekcije epileptičnih napada. Mreža je primenjena na ECoG signalima snimljenim na tri pacova kojima su medikamentom izazivani epileptični napadi tokom prekliničke studije. Ukupan performans primenjene neuralne mreže na snimljenim ECoG signalima je 92.90%.

# EE Power Engineering / Elektroenergetika

## Session EEI1: Power Engineering

Tuesday, June, 12<sup>th</sup>, 14:30 – 16:00, Hall 3

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

### EEI1.1

BENCHMARKING OF GRID SYNCHRONIZATION ALGORITHMS UNDER LOW-VOLTAGE GRID DISTURBANCES (Young researcher)

*Filip Filipović, Faculty of Electronic Engineering, University of Niš, Serbia*

*Milutin Petronijević, Faculty of Electronic Engineering, University of Niš, Serbia*

*Nebojša Mitrović, Faculty of Electronic Engineering, University of Niš, Serbia*

*Bojan Banković, Faculty of Electronic Engineering, University of Niš, Serbia*

Distributed generation is composed of various types of renewable energy sources with different voltage-current characteristics. In order to transfer the power to the power grid, various types of converter configurations and control algorithms are used. A synchronization of the distributed energy sources with the power grid is a complex task which requires the estimation of the grid voltage phase position and frequency. The difference in voltages, phases, and frequency between the grid quantities and the converter output may lead to its irregular operation. The purpose of this paper is to compare some of the most popular three-phase grid synchronization algorithms under anomalies that can occur in a low-voltage grid. Anomalies include voltage sags, harmonics and DC offset. Algorithms are created in MATLAB/Simulink and tests are performed on a dSPACE development platform DS1103.

### EEI1.2

PHOTOVOLTAIC CONVERTER COMPATIBLE WITH REAL-TIME EXPLICIT POWER FLOW CONTROL FRAMEWORK FOR MICRO-GRIDS

*Evgenije Adžić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Marko Vekić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Vlado Porobić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Steva Grabić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Milan Rapajić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Zoran Ivanović, Faculty of Technical Sciences, University of Novi Sad, Serbia*

This paper describes implementation of specific photovoltaic (PV) converter which is compatible with agent-based real-time explicit power flow control framework, called COMMELEC, proposed for future micro-grids in [1,2]. Developed converter is capable not only to track maximum power point, as conventional PV converters, but to realize specific active and reactive power, or power factor set-points which might be referenced very fast through communication network at 100 ms time-base or less. Main goal for using proposed PV converter interface within the COMMELEC organized micro-grid is to provide mechanism which supports maintaining power balance at all times (observed and influenced at 100 ms). Paper presents converter details about hardware, firmware and applied control algorithms, and at the end it gives test results obtained within working micro-grid demonstrator at DESL Laboratory, EPFL, Lausanne.

### EEI1.3

PHOTOVOLTAIC POWER PLANTS AS PART OF FACULTY MICROGRID (Young researcher)

*Nemanja Savić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Vladimir Katić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Boris Dumnić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Dragan Milićević, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Zoltan Čorba, Faculty of Technical Sciences, University of Novi Sad, Serbia*

In this paper, photovoltaic power plants are presented in detail as an initial part of the research and conceptual design of a microgrid based on renewable distributed energy sources. In addition to the classification of topologies, modes of operation and microgrid control, the conceptual concept of the microgrid of the Faculty of Technical Sciences Novi Sad are presented in detail, with a special focus on the processing, analysis and description of the technical, economic and ecological aspects of the photovoltaic power plants as an integral part of the conceptual design of the microgrid system of the Faculty of Technical Science Novi Sad based on renewable distributed energy sources. In order to prove the justification of the current and future exploitation of solar energy and electricity generation at the microlocation of photovoltaic power plants installed on the roofs of the Faculty of Technical Sciences and the Mechanical Institute, this very paper presents the potentials of solar energy in the territory of the Autonomous Province of Vojvodina with a special focus on the intensity of solar radiation, technical data of the total electricity generation from photovoltaic power plants, economically feasible data, as well as ecological data related to the reduction of greenhouse gas emissions, specifically carbon dioxide (CO<sub>2</sub>).

EEI1.4

TESTING OF MAGNETOMECHANICAL TORQUE SENSOR USING ELECTROMAGNETIC LOAD EMULATOR - TEMPERATURE CORRECTION (Young researcher)

*Marko Šućurović, Faculty of Technical Sciences Čačak, University of Kragujevac, Serbia*

*Vojislav Vujičić, Faculty of Technical Sciences Čačak, University of Kragujevac, Serbia*

*Miloš Božić, Faculty of Technical Sciences Čačak, University of Kragujevac, Serbia*

*Marko Rosić, Faculty of Technical Sciences Čačak, University of Kragujevac, Serbia*

*Branko Koprivica, Faculty of Technical Sciences Čačak, University of Kragujevac, Serbia*

The aim of this paper is to present the results of testing of a simple magnetomechanical torque sensor using the electromagnetic load emulator. A focus has been given to the variation of these results with the temperature inside the sensor. A simple method for the temperature correction of the results has been proposed. The paper presents a description of the experimental setup, construction of the developed torque sensor, the results of the experiments, as well as a proper discussion.

EEI1.5

EFFECTS OF STATOR RESISTANCE VARIATION ON SVM-DTC INDUCTION MOTOR DRIVE

*Goran Vuković, Faculty of Electrical Engineering, University of East Sarajevo, BiH*

*Milutin Petronijević, Faculty of Electronic Engineering, University of Niš, Serbia*

*Marko Gecić, Torqeedo GmbH, Gilching, Germany*

In this paper, the effects of the stator resistance variation on direct torque control (DTC) of induction motor drive are analyzed. To evaluate the stator flux of induction motor, the voltage type estimator is used. The stator resistance, used as a parameter in estimator, is a function of the motor temperature. Use of incorrect resistance value for the stator flux estimation can lead to the drive unstable operation and performance degradation. Based on computer simulations, the influence of stator resistance variation for two flux estimators is analyzed and obtained results are compared.

## Sesija EE1: Elektroenergetika

Sreda, 13. Jun, 11:00 – 13:00, Sala 3

**Predsedavajući: Prof. dr Vladimir Katić, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija**

**Prof. dr Miroslav Bjekić, Fakultet tehničkih nauka, Univerzitet u Kragujevcu, Čačak, Srbija**

### EE1.1

#### MODELIRANJE STRUJE UKLJUČENJA NEOPTEREĆENOG TRANSFORMATORA BAZIRANO NA MODIFIKOVANOJ FROEHLICH-OVOJ KRIVOJ

*Goran Joksimović, Elektrotehnički fakultet, Univerzitet Crne Gore, Crna Gora*

*Branko Durković, Elektrotehnički fakultet, Univerzitet Crne Gore, Crna Gora*

U radu je razvijen model pogodan za analizu struje uključanja neopterećenog monofaznog transformatora na mrežu. Karakteristika magnećenja jezgra transformatora opisana je približnim analitičkim izrazom koji je u literaturi poznat kao Frojlihova (Froehlich) kriva. On je modifikovan na način da je njim moguće uzeti u obzir i postojanje zaostale magnetske indukcije u jezgru. Detaljno je opisan način izvođenja diferencijalne jednačine koja opisuje proces kao i način njenog numeričkog rešavanja. Prevažodni cilj modela jeste njegova primena u edukativnom procesu.

### EE1.2

#### ENERGETSKI EFIKASNA KLIMATIZACIJA POMOĆU FOTONAPONSKOG PRETVARANJA ENERGIJE

*Zoltan Čorba, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Srbija*

*Vladimir Katić, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Srbija*

*Dragan Milićević, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Srbija*

*Boris Dumnić, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Srbija*

*Bane Popadić, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Srbija*

U letnjim mesecima se masovno koriste klima uređaji za snižavanje temperature u prostorijama. U tim mesecima je na našim prostorima najveće sunčevo zračenje. Ovo znači da je potrošnja klima uređaja u letnjim mesecima u korelaciji sa proizvodnjom električne energije fotonaponske elektrane (FNE). Radi ispitivanja mogućnosti korišćenja FNE za napajanje klima uređaja na Fakultetu tehničkih nauka (FTN) u Novom Sadu izvršena su jednomesečna merenja potrošnje klima uređaja. Na osnovu dobijene potrošnje električne energije, definisana je potrebna snaga elektrane koja bi pokrila potrošnju klima uređaja na dnevnom nivou. Tehnoekonomskom analizom je utvrđena isplativost ovakvog načina povećanja energetske efikasnosti, ali i zaštite životne sredine.

### EE1.3

#### MODIFIKACIJA INŽENJERSKOG MODELA POVRATNOG UDARA ATMOSFERSKOG PRAŽNENJA

*Vesna Javor, Elektronski fakultet, Univerzitet u Nišu, Srbija*

U ovom radu je prikazana modifikacija modela povratnog udara atmosferskog pražnjenja koji spada u grupu inženjerskih modela. Modifikacija se bazira na pretpostavci da funkcija kojom se modeluje struja duž kanala atmosferskog pražnjenja najmanje opada po intenzitetu na sredini kanala, a znatno izraženije na krajevima kanala, tako da je funkcija slabljenja struje kombinacija linearne i sinusoidalne funkcije, a model je označen skraćenicom MTL<sub>SIN</sub>. Struja u bazi kanala je aproksimirana analitički produženom funkcijom sa više ekstremuma (MP-AEF), ranije predloženom od strane autora. Dati su rezultati za električno polje atmosferskog pražnjenja koji se dobro slažu sa eksperimentalnim rezultatima, kao i rezultati drugih inženjerskih modela kao što su TL model, modifikovani model sa eksponencijalnim opadanjem (MTLE) i sa linearnim opadanjem struje duž kanala atmosferskog pražnjenja (MTLL).

EE1.4

#### ZAŠTITNA ZONA ODVODNIKA PRENAPONA U ELEKTRIČNIM INSTALACIJAMA NISKOG NAPONA

*Vladan Radulović, Elektrotehnički fakultet, Univerzitet Crne Gore, Crna Gora*

*Martin Čalasan, Elektrotehnički fakultet, Univerzitet Crne Gore, Crna Gora*

Zaštita uređaja u električnim instalacijama niskog napona od prenapona se ostvaruje primjenom uređaja za zaštitu od prenapona, od kojih se u najširoj primjeni koriste odvodnici prenapona. Uobičajena praksa u električnim instalacijama niskog napona je primjena samo jedne grupe odvodnika prenapona na razvodnoj tabli (tzv. jednostepena zaštita od prenapona). U radu su date analize performansi jednostepene zaštite od prenapona za različite vrste i vrijednosti opterećenja štice uređaja, kao i za različite dužine provodnika između odvodnika prenapona i štice uređaja. Analize su izvedene primjenom kombinovanog talasa kojim se reprezentuje scenario prodora prenaponskih i strujnih talasa putem električnog priključka pri nastanku atmosferskog pražnjenja. Pokazuje se da refleksije i prelamanje talasa na opterećenju štice uređaja značajno utiču na talasni oblik i vrijednosti prenapona na štice uređaju. Na osnovu dobijenih rezultata izvedeni su odgovarajući zaključci u pogledu vrijednosti zaštitne zone odvodnika prenapona.

EE1.5

#### SIMULACIJA KARAKTERISTIČNIH CIKLUSA VOŽNJE ELEKTRIČNOG AUTOMOBILA (Mladi istraživač)

*Anđela Starčević, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Srbija*

*Vladimir Katić, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Srbija*

Технологија електричних возила се данас налази у свом најдинамичнијем добу развоја и може се очекивати интензиван раст броја ових возила на путевима Србије. Електрична возила имају кључне предности, нулту емисију и знатну већу ефикасност коришћења. Међутим, за тестирање њихових карактеристика не постоје одговарајући циклуси вожње прилагођени стању на путевима у Србији. У раду су предложена три типа циклуса вожње: градска траса, вожња аутопутем и ванградска вожња. Извршено је њихово тестирање коришћењем адаптираног MATLAB/Simulink модела електричног аутомобила на три трасе у АП Војводини и изведени су одговарајући закључци. На крају је на бази резултата тестирања дат предлог оптималног распореда пунионица на територији АП Војводине.

EE1.6

#### ПРОЦЕС ТЕСТИРАЊА И КВАЛИТАТИВНОГ ИСПИТИВАЊА АВИОНСКИХ СРЕБРАНО ЦИНЧНИХ АКУМУЛАТОРА

*Milan Petrović, Ратно ваздухопловство и противваздухопловна одбрана, Војска Србије*

*Dragoljub Spasić, Ратно ваздухопловство и противваздухопловна одбрана, Војска Србије*

Циљ овог рада је представљање процеса тестирања и квалитативног потврђивања сребрно цинчних авионских акумулаторских ћелија. Овај тип ћелија се користи у вишенаменским борбеним авионима и као такав мора бити подвргнут различитим тестовима. Сходно употреби ових ћелија, оне морају испуњавати одређени ниво квалитета. У оквиру испитивања електричних карактеристика ћелије морају бити подвргнуте специфичним тестовима. Пражњењем ћелија номиналном струјом проверили смо капацитивност. Струја је контролисана помоћу лабораторијског извора једносмерне струје, а струја у електричном колу је мерена и контролисана на шенту. Стартност ћелија смо проверили пражњењем акумулатора помоћу шента, а струја пражњења је мерена преко напона на шенту. Довођење ћелија у радно стање, испитивање ћелија на ниским температурама, испитивање способности стартовања неки су од тестова које смо спровели и који ће бити презентовани у овом раду. После ових лабораторијских експеримената, ћелије су праћене у њиховом процесу експлоатације на авиону Миг- 29, као и у току контролних циклуса кондиционирања. На крају ћемо представити резултате истраживања, као и завршну потврду испитивања.

EE1.7

#### MODELOVANJE ŽIČANO-CILINDRIČNOG ELEKTROSTATIČKOG FILTRA HEKSAGONALNOG PRESEKA (Mladi istraživač)



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

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

Heksagonalni poprečni presek kolektorskih elektroda kod cilindričnih elektrostatičkih filtara sa žičanim emitorskim elektrodama pogodan je zbog kompaktnosti sekcija, kao i zbog raspodele potencijala i električnog polja, što doprinosi većoj efikasnosti filtra. Na osnovu Maksvelovih jednačina za elektrostatički slučaj, Peek-Kaptz-ove jednačine za žičano-cilindričnu konfiguraciju filtra i prihvatljivih uprošćenja, modelovano je električno polje u unutrašnjosti filtra. Zbog heksagonalnog poprečnog preseka neophodna je primena numeričkih metoda za rešavanje problema. U radu je prikazan i proračun električnog polja i potencijala i rezultati programa FEMM (Finite Elements Method Magnetics) primenom metoda konačnih elemenata.

EE1.8

МОДЕЛ РАСПОДЕЛЕ НАПОНА НА КОНДЕНЗАТОРСКИМ СТРУКТУРАМА ЗА ЕЛЕКТРОМЕХАНИЧКУ КОНВЕРЗИЈУ ЕНЕРГИЈЕ (Mladi istraživač)

*Stevan Cvijetićanin, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Srbija*

*Dušan Zorica, Matematički insituti Srpske akademije nauka i umentnosti, Srbija*

У раду ће бити разматран модел електромеханичке конверзије енергије засноване на промени електростатичке енергије плочастог кондензатора услед његове деформације, односно промене његове капацитивности. За процену количине конвертоване енергије, енергије губитака и оптималног трајања циклуса конверзије формулисан је математички модел расподеле напона између електрода, како у устаљеном стању, тако и током прелазних процеса. Модел је формулисан узимајући у обзир индуктивне, капацитивне и ефекте несавршености електрода и диелектрика разматране структуре. У устаљеном стању на расподелу напона утицај имају само несавршености електрода и диелектрика, док је за прелазне процесе узет у обзир и ефекат капацитивности, а индуктивни феномени су занемарени из физички оправданих разлога.

# **EK Electric Circuits and Systems and Signal Processing / Električna kola, električni sistemi i obrada signala**

## **Session EKI1: Electric Circuits and systems and signal processing**

Monday, June 11<sup>th</sup>, 2018, 14:30-16:30, Hall 4

**Chair: Dragana Perić, Vlatacom Institute of High Technologies, Belgrade, Serbia**

EKI1.1

### **PERFORMANCE COMPARISON OF SWIR VISION SYSTEMS USING MTF ANALYSIS**

*Dragana Perić, Vlatacom Institute of High Technologies, Belgrade, Serbia*

*Branko Livada, Vlatacom Institute of High Technologies, Belgrade, Serbia*

*Miloš Radisavljević, Vlatacom Institute of High Technologies, Belgrade, Serbia*

*Saša Vujić, Vlatacom Institute of High Technologies, Belgrade, Serbia*

In this paper we present results of performance analysis of vision systems that are built using two different SWIR cameras and two different SWIR lenses. Performance evaluation is done in electro-optical laboratory by measuring modulation transfer function (MTF) and also in field where real imagery is taken for daylight and lowlight scenarios.

EKI1.2

### **THERMAL-TO-VISIBLE FACE RECOGNITION FOR ILLUMINATION INVARIANT SYSTEMS**

*Ranko Petrović, Vlatacom Institute of High Technologies, Belgrade, Serbia*

*Branka Stojanović, Vlatacom Institute of High Technologies, Belgrade, Serbia*

*Miloš Pavlović, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Srđan Stanković, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia and Vlatacom Institute of High Technologies, Belgrade, Serbia*

The main goal of the research described in this paper is to develop a robust face recognition system, which would be less sensitive to illumination conditions, compared to traditional systems. Utilization of an additional sensor for low illumination conditions - a thermal band imaging sensor - can provide a solution to this problem. Such a system, in order to be operational with the existing visible light recognition databases, should include thermal-to-visible face recognition which is in the focus of this paper. This paper provides a comparative analysis of the available approaches to thermal-to-visible face recognition, and the most important signal processing technologies behind them, as a preparation for the development and implementation of an illumination invariant face recognition system competitive at the world market.

EKI1.3

### **COMPARATIVE ANALYSIS OF FEATURE DESCRIPTOR ALGORITHMS IN MULTISENSORS SYSTEMS**

*Rade Pavlović, Military Technical Institute, Ministry of defence, Belgrade, Serbia,*

*Nataša Vlahović, Vlatacom Institute of High Technologies, Belgrade, Serbia,*

*Vladimir Petrović, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

Multisensor systems are commonly used for target tracking and have better performance if more useful information about the scene from different sensors is available. This way more reliable and more complete information is obtained than in the case of only one sensor. In this paper, we test and compare feature matching on thermal, visual range video data and fused streams obtained from them using dynamic image fusion algorithm. For feature matching, a comparison of three different descriptors from three different families of feature descriptors is analysed (SURF- Speeded-up Robust Features Method, FREAK- Fast Retina Keypoint, MSER- Maximally Stable Extremal Regions). All the descriptors are tested for matching accuracy and complexity on all three video streams of different contents.

EKI1.4

#### FACIAL EXPRESSION AND LIGHTING CONDITIONS INFLUENCE ON FACE RECOGNITION PERFORMANCE

*Miloš Pavlović, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia,*

*Ranko Petrović, Vlatacom Institute of High Technologies, Belgrade, Serbia,*

*Branka Stojanović, Vlatacom Institute of High Technologies, Belgrade, Serbia,*

*Srđan Stanković, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia and Vlatacom Institute of High Technologies, Belgrade, Serbia*

Face recognition is one of the biometric methods which have found practical uses for different purposes. Visible light face recognition systems have been well developed and achieve very good performance in controlled conditions. This paper compares the effect of different facial expressions and different illumination on face recognition performance with the face recognition code based on Histogram of Oriented Gradient (HOG) features extract method. The results presented in this paper points to the fact that different illumination conditions have significant impact on facial recognition systems performance, and that a new sensor based on infrared imaging should be included..

EKI1.5

#### ADAPTIVE VIDEO STABILIZATION USING KALMAN FILTERING

*Nataša Vlahović, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia and Vlatacom Institute of High Technologies, Belgrade, Serbia*

*Milan Stojanović, Vlatacom Institute of High Technologies, Belgrade, Serbia,*

*Miloš Stanković, Vlatacom Institute of High Technologies, Belgrade, Serbia,*

*Srđan Stanković, Vlatacom Institute of High Technologies, Belgrade, Serbia*

The main goal of digital video stabilization algorithms is to remove unwanted motion from video sequence. Usually, undesired motion is created when holding camera in hand, or when camera is mounted on some moving platform (vehicle, boat, Unmanned Aerial Vehicle) or in the case of the severe wind conditions. In this paper, motion estimation is based on Harris corners and optical flow pyramid Lucas Kanade algorithm. When homography transformation is obtained, Kalman filter is used to estimate the intentional from global motion in image, and calculate undesired motion parameters for the compensation step. The noise statistics vary, depending on the scene change, thus different noise values were calculated for several regions, depending on trajectory of points in image. The trajectory of points in image shows the level of shaking in frames, and altered noise values are used for selected regions.

EKI1.6

#### EVOLUTION OF GABOR FILTER IN APPLICATION OF LICENSE PLATE DETECTION

*Vladimir Tadić, University of Dunaujvaros, Dunaujvaros, Hungary,*

*Zoltan Kiraly, University of Dunaujvaros, Dunaujvaros, Hungary,*

*Željens Trpovski, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija,*

*Tatjana Lončar Turukalo, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija,*

*Peter Odry, University of Dunaujvaros, Dunaujvaros, Hungary*

This work presents the evaluation of Gabor filter in application of license plate detection. The initial algorithm is based on vertically oriented Gabor filter, from later was developed a Gabor filter bank with crisp-distinctly specified parameters. As the ultimate step of development, the fuzzified Gabor filter was presented. All three filters give satisfactory results, but in experiments it was proved that the fuzzified Gabor filter gives the best results in preprocessing of the initial image of vehicle, because the fuzzified filter has the best response in the region of license plate. After this the license plate was extracted with least damages. The components of interest were efficiently extracted, and the procedure was found to be very noise-resistant..

EKI1.7

#### PHASE CORRECTION OF THE QMF NEARLY PERFECT RECONSTRUCTION IIR FILTER BANKS

*Jelena D. Čertić, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia,*

*Miroslav Lutovac, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia,*

*Ljiljana Milić, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia and Mihajlo Pupin Institute, Belgrade, Serbia*

This paper presents options for the phase corrections of the overall frequency response of the two-channel QMF filter bank based on the IIR filter pair with approximately linear phase. The correction is important if the two channel bank is used as a building block for the design of the multichannel octave filter bank. The three proposed correctors are of similar structure. Each of them consists of the single stage all-pass filter. The possible options are discussed regarding overall additional delay and complexity..

EKI1.8

#### MULTIPLE PROCEDURES FOR FAST COMPUTATION OF AN ITERATION-BASED SIMULATION METHOD

*Vladimir Mladenović, Faculty of Technical Sciences in Čačak, University of Kragujevac, Čačak, Serbia,*

*Danijela Milosević, Faculty of Technical Sciences in Čačak, University of Kragujevac, Čačak, Serbia,*

*Marian Greconici, Facultate de Electrotehnica si Electroenergetica, Universitatea Politehnica Timisoara, jud. Timis, Romania,*

*Miroslav Lutovac, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia,*

In this paper, we provide an improvement of algorithms for the fast computation of complex mathematical operations. These algorithms are related to systems and processes that are largely the wearers of today's high technologies. The method provides to obtain closed form solutions using computer algebra systems such as Wolfram language and provides a better insight into the complex computations. This method relies on a previously developed the iterative-based simulation method and for a fast computation uses the Kummer's transformation..

## **Session EKI2: Signal processing applications and educational systems**

Tuesday, June 12<sup>th</sup>, 2018, 08:00-09:30, Hall 4

**Chair: Miroslav Lutovac, The Academy of Engineering Sciences of Serbia (AINS) and The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia**

EKI2.1

### **ENVIRONMENT AND GRAPHICAL USER INTERFACE FOR DESIGN OF CONTINUOUS-TIME SYSTEMS**

*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,*

*Vladimir Mladenović, University of Kragujevac, Faculty of Technical Sciences, Čačak, Serbia*

Environment and graphical user interface (GUI) is presented that is intended for the fast design, discovering properties of systems, advanced continuous-time system synthesis, exact simulation and verification, and it helps to skip the gap between theory and practice in electrical engineering. The software is written using computer algebra system (CAS) as add-ons of CAS for extending the usefulness of the software environment. From the schematic description the mathematical representation of the system can be automatically obtained. The further automated symbolic manipulations are possible according to user preferences in such a way that all representations (mathematical, graphical, as net-list, software code, and time-domain and frequency domain responses) are obtained from the same system description. The paper is devoted to researchers and scientist using basic electrical engineering tasks, so that time-consuming tasks can be automated in software and properties of the systems can be discovered, and finally describing how conditions and discovered properties can be used for synthesis, verifications, simulations, and optimization with real parameters. All derived properties are available as closedform relations, which can help the faster design of robust systems.

EKI2.2

### **SOFTWARE SIGNAL GENERATOR AS A TESTING TOOL FOR AUTOMOTIVE APPLICATIONS**

*Staća Sekulić, RT-RK Computer Based Systems, Novi Sad, Serbia,*

*Duško Davidović, RT-RK Computer Based Systems, Novi Sad, Serbia,*

*Mališa Marijan, RT-RK Computer Based Systems, Novi Sad, Serbia,*

*Velibor Ilić RT-RK Computer Based Systems, Novi Sad, Serbia*

In this paper, we suggest a method for implementing a simple software signal generator for testing automotive applications. The goal is to replace expensive hardware signal generator with the software tool. This software solution reduces dependencies in using specialized hardware signal generators or real time system during the development and testing. Hardware solution requires additional software for the configuration, wiring and setting up simulation with software tools to be fulfilled. Bypassing the hardware solution, there is much more simplified environment, where the data is exchanged in loop-back.

EKI2.3

### INTRODUCING DBBT EQUIPMENT IN PRACTICAL INSTRUCTION WITHIN COMMUNICATION COURSES AT THE VISER SCHOOL (BELGRADE)

*Slavica Marinković, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

*Milutin Nešić, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

*Ivan Pavlović, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

*Amela Zeković, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

*Vera Petrović, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

This paper gives an overview of the equipment that has been obtained through Erasmus+ project Digital Broadcasting and Broadband Technologies (DBBT) master studies with an aim to facilitate learning of digital communications using modern instruments and real world signals. The goal is to help students gain better understanding of theoretical concepts behind communication systems as well as to motivate them to learn complex telecommunications topics. We first present and discuss hardware and software that has been used within telecommunication courses at Electronics and Telecommunications Department and then show how the new equipment will fit in the curriculum.

EKI2.4

### PRACTICAL TEACHING IN THE FIELD OF DIGITAL BROADCASTING AND BROADBAND TECHNOLOGIES AT THE VISER SCHOOL IN BELGRADE

*Milutin Nešić, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

*Slavica Marinković, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

*Ivan Pavlović, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

*Amela Zeković, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

*Vera Petrović, The School of Electrical and Computer Engineering of Applied Studies, Belgrade, Serbia*

Digital broadcasting and broadband technologies require integration of knowledge from various courses in electronics, telecommunications, audio and video technologies and software engineering. The applied studies strive to facilitate learning of these subjects by paying special attention to practical instruction. This paper presents an example of practical instruction that aims to help students to understand digital communications problems and solutions by studying DVB-T2 parameters. This is done by first recording the real world digital video stream with measurement receiver, playing programs and examining the stream with media player, remodulating it with DVB-T modulator and observing it with another measurement receiver. Some parameters that are studied are: RF parameters: signal level, SNR, MER, BER, constellation and service information: PSI/SI, PID.

EKI2.5

### WEB VISUAL SEARCH USING RE-RANKING METHOD AND NEURAL NETWORK MACHINE LEARNING

*Milena Vesić, ICT College of Vocational Studies in Belgrade, Belgrade, Serbia,*

*Goran Zajić, ICT College of Vocational Studies in Belgrade, Belgrade, Serbia,*

*Nenad Kojić, ICT College of Vocational Studies in Belgrade, Belgrade, Serbia,*

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

There is a continuing growth of online visual data. The latest development of web technologies enabled the efficient access to image and video databases using online services. The visual search is demanding from the efficiency standpoint. In this paper we proposed re-ranking for content based information retrieval improvement. The machine learning based system with relevance feedback uses Euclidean distance based initial search with re-ranking in order to provide a user with relevant images. The relevant images are selected according to feature standard deviation, feature participation importance and feature correlation. Re-ranked images enable more efficient search in the initial phase. User conducts the search using the relevance feedback in the desired direction.

EKI2.6

#### AN EXAMPLE OF VITAL SIGNAL FRACTAL ANALYSIS FOR E-HEALTH APPLICATIONS

*Milan Milivojević, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia,*

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

*Milorad Paskaš, Innovation Center of School of Electrical Engineering, University of Belgrade,*

*Irina Reljin, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia,*

E-health (telemedicine) applications consider processing of different vital signals in various domains. The objective is efficient and rapid indication of patients pathological conditions. Mechanisms upholding functioning of cardiovascular system are inherently nonlinear. Hence the implementation of nonlinear techniques for vital signal processing is consequent. In this paper we analyzed referent vital signals from PhysioNet dataset. Two groups of signals are processed: signals with and without pathologies. In this paper an example of vital signal fractal analysis is realized through calculation of Higuchi's fractal dimension and using detrended fluctuation method on electrocardiograms.

### **Sesija EK1: Električna kola, električni sistemi i obrada signala**

Utorak, 12. Jun, 2018, 09:30-10:30, Sala 4

**Predsedavajući: Branimir Reljin, Akademija inženjerskih nauka Srbije i Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija**

EK1.1

#### ANALIZA VIŠESTRUKKE PERIODE PONAVLJANJA IMPULSA IMPULSNIH RADARA

*Aleksandar Ristić, Vojna akademija, Univerzitet odbrane u Beogradu, Srbija,*

*Slobodan Simić, Vojna akademija, Univerzitet odbrane u Beogradu, Srbija, i*

*Boris Timotijević Vojna akademija, Univerzitet odbrane u Beogradu, Srbija*

U radu je analiziran višestruki period ponavljanja impulsa (Pulse Repetition Interval – PRI), navedene su kategorije višestrukog PRI-a koje se najčešće upotrebljavaju, i objašnjenja je njihova praktična primena u radarskim sistemima. Prikazan je princip analize PRI-a radarskog signala i prikazani su rezultati praktične realizacije. Oblici radarskih signala i rezultati analize PRI-a su simulirane u programskom paketu Matlab, i implementirane na FPGA ploču, a rezultati su verifikovani na osciloskopu

EK1.2

## PROCENA KVALITETA ZAMRLJANIH I JPEG KOMPRIMOVANIH SLIKA

*Nenad Stojanović, Vojska Srbije, Srbija*

*Boban Bondžulić, Vojna akademija, Univerzitet odbrane u Beogradu, Beograd, Srbija*

*Ivana Stojanović, Telekom Srbija a.d., Beograd, Srbija*

*Vladimir Petrović, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

U radu je razmatrana procena kvaliteta zamrljanih slika i slika koje su nakon zamrljanja komprimovane JPEG kodovanjem. Analiza je izvršena na delu slika od interesa iz četiri javno dostupne baze slika pomoću znatnog broja objektivnih mera za procenu kvaliteta slike. Akcenat je dat na proceni kvaliteta slika sa dve distorzije. Karakteristike objektivnih mera za procenu kvaliteta slike su predstavljene kroz stepen slaganja sa subjektivnim skorovima. Razmatran je i uticaj JPEG kompresije na kvalitet zamrljanih slika.

EK1.3

## ANALIZA PERFORMANSI OBJEKTIVNIH MERA PROCENE KVALITETA NA SEKVENCAMA SA PAKETSKIM GUBICIMA

*Marko Novčić, Vojna akademija, Univerzitet odbrane u Beogradu, Beograd, Srbija*

*Boban Bondžulić, Vojna akademija, Univerzitet odbrane u Beogradu, Beograd, Srbija*

*Boban Pavlović, Vojna akademija, Univerzitet odbrane u Beogradu, Beograd, Srbija*

*Jovan Bajčetić, Vojna akademija, Univerzitet odbrane u Beogradu, Beograd, Srbija*

*Nenad Stojanović, Vojna akademija, Univerzitet odbrane u Beogradu, Beograd, Srbija*

U radu su analizirane performanse objektivnih mera procene kvaliteta na sekvencama sa paketskim gubicima. Analiza je sprovedena na sedam javno dostupnih baza video sekvenci sa subjektivnim impresijama kvaliteta. Performanse objektivnih mera su predstavljene kroz stepen slaganja sa subjektivnim skorovima kvaliteta i to kroz koeficijent linearne korelacije i kroz korelaciju rangova. Pokazano je da objektivne mere imaju visok stepen slaganja sa subjektivnim skorovima kvaliteta na podskupovima sekvenci koje potiču od iste izvorne sekvence. Međutim, stepen slaganja na nivou kompletnih baza značajno zavisi od izbora objektivne mere i izbora baze. Najbolje slaganje sa subjektivnim skorovima kvaliteta ostvarila je objektivna mera koja razmatra varijaciju lokalnog kvaliteta unutar kadrova test sekvenci.

EK1.4

## ARDUINO MIKROKONTROLER SA PRIMERIMA

*Nataša A. Kablar, Lola Institut, 11000 Beograd, Srbija*

U ovom radu izlažemo osnove Arduino mikrokontrolera koji je jednostavan za učenje ali i za projektovanje jednostavnijih i kretavnih projekata za upotrebom senzora i aktuatora različite vrste, i za programiranje u Arduino okruženju. Arduino softver rogramira PIN-ove Arduino ploče kao ulazno/izlazne na koje se mogu vezati uređjaji – senzori i aktuatori, displeji, zvučni uređjaji, spikeri, moduli, šeldovi, ethernet ili WiFi proširenja, bluetooth proširenja, itd. kojima se upravlja preko programa i mikrokontrolera. Daje se osnovna definicija mikrokontrolera, na primeru Arduina, sa prikazom osnovnih elemenata na Arduino UNO mikrokontroleru. Zatim se daju osnovni primeri različite upotrebe Arduino ploče sa mikrokontrolerom, na primeru treperenja/naizmjeničnog treperenja/zatamljenja LED lampica, na primeru upravljanja detektorom kretanja, i na primeru upravljanja step motorom. Opisane su i druge vrste Arduino mikrokontrolera koje služe različitim svrhama i aplikacijama. Dati su predlozi za dalji rad.



## **Session EKI3: Machine Learning for Complex Networks**

Thursday, June 14<sup>th</sup>, 2018, 09:30-10:30, Hall 2

**Chair: Ljiljana Trajković, School of Engineering Science at Simon Fraser University, Burnaby, British Columbia, Canada**

EKI3.1

MACHINE LEARNING FOR COMPLEX NETWORKS (Invited paper)

*Ljiljana Trajković, School of Engineering Science at Simon Fraser University, Burnaby, British Columbia, Canada*

Collection and analysis of data from deployed networks is essential for understanding modern networks. Traffic traces collected from various deployed communication networks and the Internet have been used to characterize and model network traffic, analyze Internet topologies, and classify network anomalies. Data mining and statistical analysis of network data are often employed to determine traffic loads, analyze patterns of users' behavior, and predict future network traffic. Spectral graph theory has been applied to analyze various topologies of complex networks and capture historical trends in their development. Recent machine learning techniques have proved valuable for predicting anomalous traffic behavior and for classifying anomalies in complex networks. Further applications of these tools will help improve our understanding of the underlying mechanisms that govern the behavior of complex networks such as the Internet, social networks (Facebook, LinkedIn, Twitter, Internet blogs, forums, and websites), power grids, gene regulatory networks, neuronal systems, food webs, social systems, and networks emanating from augmented and virtual reality platforms. They will also help improve performance of these networks and enhance their security.

# EL Electronics / Elektronika

## Session ELI1: Electronic Systems and Applications

Tuesday, June, 12<sup>th</sup>, 16:00 – 18:00, Hall 4

Chair: **Tom Kazmierski, Faculty of Physical Sciences and Engineering, University of Southampton**  
**Dušan Grujić, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia**

### ELI1.1

#### DISTRIBUTED EVENT-BASED MASSIVELY PARALLEL COMPUTING (Invited paper)

*Tom Kazmierski, Faculty of Physical Sciences and Engineering, University of Southampton*

Event-driven computing is an established approach to solving many practical problems in science and engineering. Such problems include real-time industrial control, mathematical modelling of discrete systems in design automation applications, operations on data-bases and many others. Traditionally, event-driven software tools have been realised typically on standard, single processor computers or processors with relatively few cores. CPU time requirements for event-driven processing in typical application domains were not excessive. This, however, has changed over the last few decades as the complexity of modern computing tasks has grown significantly. Recent technological advances have brought about new computing platforms, based on massively parallel interconnected networks of small cores. Processors have become negligibly cheap and practical systems of up to a million computing cores have already been built. Examples of such massively parallel systems are SpiNNaker, a neural network modelling platform, and BIMPA (Biologically Inspired Massively Parallel Architecture). Like SpiNNaker, BIMPA is also a system that implements models of very large networks of spiking neurons to model human brain behaviour.

This talk will present the aims of the POETS system, which extends the architectures of SpiNNaker and BIMPA and proposes an alternative approach to very large systems composed of cheap, small cores such that general-purpose computing problems can be tackled. This is achieved through the mapping of small, simple behavioural definitions onto a self-organising and reconfigurable platform of thousands of cores. A variety of traditionally compute intensive engineering and research problems can be solved in this way and results can be produced orders of magnitude faster than conventional machines at a fraction of the cost. In other words, POETS generalises the concept of processing a large number of interconnected simple homogeneous modules and extends it to a reconfigurable network of heterogeneous processes of variable complexity. Thus, a far greater range of application domains can be addressed.

### ELI1.2

#### ON THE SELECTION OF LDO FOR RF APPLICATIONS

*Dušan Grujić, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia and Lime Microsystems*

*Mihajlo Božović, Lime Microsystems*

*Pavle Jovanović, Lime Microsystems*

*Milan Savić, Lime Microsystems*

*Miloš Božić, Lime Microsystems*

In this paper we address the problem of selecting the appropriate LDO for RF applications. Using an inadequate LDO in RF system will most likely result in performance degradation, such as increased phase noise, and will undo the efforts to achieve target performance. We present output noise measurement results of five commercially available LDOs and compare their performance, which will hopefully be useful to RF designers.

### ELI1.3

#### ORGANIZATION OF REMOTE MONITORING AND CONTROL

*Dragana Petrovic, Iritel a.d. Beograd, Serbia*

*Bojana Jovanovic, Iritel a.d. Beograd, Serbia*

*Miroslav Lazić, Iritel a.d. Beograd, Serbia*

Remote monitoring and control have become a mandatory element of every power, telecommunication and information system. There are different approaches to organize remote monitoring and control. The paper analyzes the four most commonly used concepts. Sequential monitoring is the easiest to implement, but it is not applicable to all users. Parallel monitoring is a better solution, but particular monitor is required for each monitored system. Centralized monitoring seems like the best solution – different systems can be supervised on one monitor, but this is not a suitable solution for preventive maintenance. The best solution is the indirect monitoring system. In this system, part of the data is forwarded to the local maintenance sectors. On the basis of the collected data about system elements functioning, potential problems that can lead to system failure are estimated. In this way, preventive maintenance can also be organized. Preventive maintenance is the ultimate goal of any remote monitoring and control system.

#### ELI1.4

##### DERIVED ALARMS - UPGRADE OF THE REMOTE MONITORING SYSTEM

*Dragana Petrović, Iritel a.d. Beograd, Serbia*

*Miroslav Lazić, Iritel a.d. Beograd, Serbia*

*Bojana Jovanović, Iritel a.d. Beograd, Serbia*

The possibility of remote monitoring has become a mandatory initial requirement for each electronic system assembly and an increasingly demanding requirement for each individual device in an electronic system. Large companies, using remote monitoring, have an insight into system activity and alarm situations. Advanced monitoring systems also have a controlling role, so they allow remote adjustment of the monitored system parameters. It is common that each electronic device has a built-in circuit that can send data about the device operation. A better solution is when there is a special device that would analyze the operation of each individual element in the electronic system, and send the alarms to the competent sectors, based on the overall system state. SDNU is a remote monitoring and control system for power electronics devices. The generation of derived alarms is the main characteristic of SDNU, which separates it from similar monitoring systems. The derived alarms were created by a long-term analysis of the monitoring system and operation of the power electronics devices. They are generated at the moment of irregular operation of the monitored system, and before the alarm situation arises.

#### ELI1.5

##### ADAPTIVE LOAD CURRENT FEEDFORWARD CONTROL OF PULSED OUTPUT CURRENT CONVERTERS

*Filip Savic, Texas Instruments Deutschland GmbH*

*Giacomo Calabrese, Texas Instruments Deutschland GmbH*

*Giovanni Frattini, Texas Instruments Italia S.r.l.*

Certain DC-DC converter topologies (e.g. boost) are characterized by pulsed output current which translates into a Right-Half-Plane-Zero (RHPZ) in their transfer function. This behavior constrains the achievable closed-loop bandwidth, posing severe limitations to the converter's dynamic performance. In this work, load current feedforward control technique is investigated in order to minimize the RHPZ impact. The proposed solution employs differentiation of the boost converter's output voltage for the estimation of the load current. The level of the estimated feedforward signal is set to the near-optimal theoretical value by employment of an auto-tuning circuitry. The feedforward signal is then combined with the peak current mode control loop. The auto-tuning circuitry makes the approach less dependent on converter's parameters like output capacitance and duty cycle.

#### ELI1.6

##### USING ASSEMBLY LANGUAGE FOR CREATING GAMES

*Haris Turkmanovic, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*David Vukoje, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Aleksandra Lekic, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Milan Prokin, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

The aim of this paper is to demonstrate some interesting and useful approaches for writing a program in the assembly language. In order to demonstrate the possibilities of the assembly language, a project called “Arkanoid” was created. This project is written in assembly language and it presents few interesting algorithms. Assembly language, which is used for designing the game is x86 Assembly language, which produces object code for the x86 class of processors. As a working environment is chosen Visual Studio 2015, because it gives the useful tools for debugging and testing of the created software (game). Execution of the program results in a “Arkanoid” game, placed in Windows OS Console.

ELI1.7

A REPORT ON RECENT DEVELOPMENT IN APPLICATION OF FREE CAD SOFTWARE TO IC CURRICULA

*Aleksandar Pajkanovic, Faculty of Electrical Engineering, University of Banja Luka*

*Zeljko Ivanovic, Faculty of Electrical Engineering, University of Banja Luka*

This report presents recent developments in the application of free CAD software tools to the integrated circuits curricula at the Faculty of Electrical Engineering, University of Banja Luka. Due to recent introduction of highly specialized courses on one side and lack of funding on the other side, there exists a need for utilizing a comprehensive toolchain covering all steps of integrated circuits design at lowest cost – i.e. at no cost, if possible at all. A plan for such a trade-off was conceived two years ago and in this paper, actual implementations utilized over these two iterations of courses are presented. Modifications needed are described, student achievements and hands-on experiences are shown and important conclusions are given in order to further improve knowledge outcomes.

## **Session ELI2: Electronic Circuits and Applications**

Wednesday, June, 13<sup>th</sup>, 08:00 – 10:30, Hall 4

**Chair: Predrag Petković, University of Niš, Faculty of Electronic Engineering, Niš, Serbia**

**Lazar Saranovac, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia**

ELI2.1

THE DESIGN OF FULLY DIFFERENTIAL COMPARATOR FOR SAR ADCS

*Djordje Glavonjic, School of Electrical Engineering, University of Belgrade, Serbia and NovellIC Microsystems*

*Ivan Milosavljević, School of Electrical Engineering, University of Belgrade, Serbia and NovellIC Microsystems*

*Dusan Krcum, School of Electrical Engineering, University of Belgrade, Serbia and NovellIC Microsystems*

*Jelena Popovic-Bozovic, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Lazar Saranovac, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

The design of fully differential comparator intended to be used in successive approximation register (SAR) analog to digital converters (ADC) is presented in this paper. Comparator employs four preamplifier stages with the input offset cancellation, while rail-to-rail operation is enabled by using strongARM latch at the output. Implementation has been performed in 130nm CMOS, while the performances are validated through the post-layout simulations. Obtained standard deviation values from the Monte Carlo simulations for input referred noise and offset are 1.37 mV and 7.62 mV, respectively. Proposed circuitry draws only 0.85 mA from 1.2 V, while occupies area of 150  $\mu\text{m}$  x 36  $\mu\text{m}$ .

## ELI2.2

### CLOCK SYNTHESIZER FOR DATA CONVERTERS IN DIGITAL AUDIO BROADCASTING SYSTEMS

*Dusan Krcum, School of Electrical Engineering, University of Belgrade, Serbia and NovelIC Microsystems*

*Ivan Milosavljević, School of Electrical Engineering, University of Belgrade, Serbia and NovelIC Microsystems*

*Djordje Glavonjic, School of Electrical Engineering, University of Belgrade, Serbia and NovelIC Microsystems*

*Marko Ninic, NovelIC Microsystems*

*Darko Tasovac, School of Electrical Engineering, University of Belgrade, Serbia and NovelIC Microsystems*

*Jelena Popovic-Bozovic, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Lazar Saranovc, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

The design of clock synthesizer for data converters used in the new-generation of digital audio broadcasting (DAB) systems is presented in this paper. The programmable synthesizer based on integer-N phased-locked loop (PLL) provides two different output frequencies 332.8 MHz and 345.6 MHz. Modified source-coupled multivibrator is used as a current-controlled oscillator (CCO), which is area-compact and less sensitive to supply perturbations in comparison to the classical ring oscillator. The simulations of the proposed PLL demonstrate a locking process in the both operating modes, while consuming only 6 mW from 1.2 V supply. The closed-loop phase noise at 10 kHz offset from the carrier is less than -95 dBc/Hz in both bands. The total core area is 0.152 mm<sup>2</sup>.

## ELI2.3

### NEW MULTI-LOOP ARCHITECTURE FOR BAND PASS SIGMA-DELTA MODULATOR

*Miloš Petković, Serbia and Montenegro Air Traffic Services SMATSA llc*

*Goran S. Đorđević, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

*Srdjan Đorđević, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

*Predrag Petković, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

This paper presents a new architecture suitable for band pass Sigma-Delta modulator design. It is derived by combining two classical architectures. Main advantages are seen in simplified noise shaping filter design, simplified implementation and facilitated stability control. Simulated examples verify the aforementioned features.

## ELI2.4

### EFFICACY ANALYSIS OF NEW CLASS E AMPLIFIER SOLUTION

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

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

*Predrag Petković, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

In this paper a new RF power amplifier configuration operating at 40.68MHz is described. Amplifier is used as welding actuator in a blood separator device. A new configuration of class E amplifier with inductive coupling of resonant circuit is proposed. The basic idea for amplifier design was achieving the efficiency of over 80% using real components and minimizing component count that lead to simplifying the setup procedure and manufacturing cost. Special attention is paid to the impedance matching method using mutual inductance setting of coupled oscillator circuitry. A number of simulation analyses have been made to find optimal parameter values for best compromise of power efficiency and component value sensitivity.

## ELI2.5

### INVESTIGATION OF CHAOTIC BEHAVIOR IN CLAPP OSCILLATOR

*Ivana Vasiljević, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Nikola Petrović, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Aleksandra Lekić, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

In this paper we investigate the chaotic behavior of the class of oscillators denoted as Clapp oscillator. Clapp oscillator is simple oscillator containing one transistor and a few reactive elements: inductors and capacitors. It is chosen for its design simplicity and a good performance. Oscillator with chaotic behavior can be used to construct chaotic radar. For that matter, in this paper are investigated two approaches for construction of the chaotic Clapp oscillator which can be further verified experimentally using microstrip technology.

## ELI2.6

### AUTOMATED TEST FIXTURE FOR IN-PRODUCTION FUNCTIONAL TESTING OF ELECTRONIC DEVICES

*Milan Vukajlovic, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Srdjan Tadic, Bitgear Wireless Design Services, Belgrade, Serbia*

We present one practical solution for automated test fixture for electronic devices. Testing is done during production, and the emphasis is not only on electrical tests but on verifying end-to-end device functionality. The proposed solution is fully automated, it provides reliable failure detection and it is affordable and suitable even for small production runs (such as 100-1000 pieces per month). The solution is shown in form of a case-study based on the real production of the consumer device, which has been proven on the market. We present the complete system, including details of the device under test, designed test fixture, a C++ application and web application.

## ELI2.7

### PRACTICAL REALIZATION OF THE OPERATIONAL CONVEYOR IN DISCRETE TECHNOLOGY

*Milan Veskovic, Faculty of Technical Sciences, University of Kragujevac, Kragujevac, Serbia*

*Slobodan Djukic, Faculty of Technical Sciences, University of Kragujevac, Kragujevac, Serbia*

*Predrag Petkovic, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

Practical realization of the operational conveyor in discrete technology is presented in this paper. Operational conveyor circuit topology based on current-steering output stage are also described and analyzed. Operational conveyor is realized with bipolar transistor with discrete elements on the raster board as voltage to current converter. PSPICE program was used to verify the proposed design of the operational conveyor. The results of the simulation are presented and compared with the results of the measurement of the realization that was published.

## ELI2.8

### DESIGN AND REALIZATION OF A SWITCH-MODE POWER AMPLIFIER WITH GAN FET

*Zoran Zivanovic, IMTEL KOMUNIKACIJE AD, Belgrade, Serbia*

*Vladimir Smiljakovic, IMTEL KOMUNIKACIJE AD, Belgrade, Serbia*

This paper presents the design of a high efficiency class E power amplifier, operating in switch-mode, which is optimized for 50  $\Omega$  load at 13.56 MHz. The operating principles are briefly explained, including the functional block diagram. The prototype has been built and experimental results are presented to support the theoretical analysis and to demonstrate the converter performance. The idea was to demonstrate the performance of GaN transistors in order to show their significant advantages over silicon MOSFETs.

## ELI2.9

### CLASS AB HIGH POWER AUDIO AMPLIFIER

*Jovana Milošević, Prointer ITSS, Banja Luka, Republic of Srpska*

*Tatjana Pešić-Brdanin, Faculty of Electrical Engineering, University of Banja Luka, Republic of Srpska*

*Jovan Galić, Faculty of Electrical Engineering, University of Banja Luka, Republic of Srpska*

In this paper designing, analysis and practical implementation of a single-channel class AB high power audio amplifier are presented. The audio amplifier is designed for home use, although it has a power of 130 W at 4  $\Omega$  load resistance. For testing purposes, a parallel push-pull class AB high power audio amplifier with bipolar transistors and symmetric power supply are used. The quality of the amplifier regarding frequency response, Total Harmonic Distortion (THD) and Intermodulation Distortion (IMD) are examined in particular.

ELI2.10

#### DESIGN OF AN ACCESS CONTROL SYSTEM THROUGH A KEYBOARD IN THE HANDLING OF AN ELEVATOR

*Fabrizio Torres, National University of Callao-Peru*

*Asesor M. Chauca, National University of Callao-Peru*

This work addresses the problem of security in buildings that have an elevator in which each stop is at the entrance of each department or precinct. It describes the analysis, design and evaluation of a control system in order to solve this problem since if it does not place some access restriction for its use, anyone can maneuver it and go to another department when no one is at that moment. The driver used in this project is an arduino UNO, in which a matrix keyboard is added for each client to enter a password when the elevator is going to operate.

### **Session ELI3: Modeling and Design of Electronic Systems**

Wednesday, June, 13<sup>th</sup>, 11:00 – 12:00, Hall 4

**Chair: Miljana Milić, University of Niš, Faculty of Electronic Engineering, Niš, Serbia**

ELI3.1

#### DYNAMIC TASK SCHEDULING USING A TIMED ACTIONS METHOD IMPLEMENTED ON ARDUINO PLATFORM

*Miloš Ljubenović, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

*Sandra Došić, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

*Miljana Milić, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

In this paper we will describe the development and implementation of enhanced library of modules, dedicated to small controller systems with the requirement for simultaneous usage of peripherals, sensors, or less demanding real-time systems. The aim is to analyze the abilities of library for time sharing with the emphasize on the simplicity and low memory occupation in Atmel controllers from the AT series.

ELI3.2

#### AGING AWARE HDL MODELLING OF DELAYS IN LOGIC GATES

*Miljana Milić, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

*Miloš Ljubenović, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

*Sandra Došić, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

*Duško Lukač, member of the IEEE Germany Section*

Digital circuits delay behavior has a random nature. If we consider aging process of digital circuits, one can notice some patterns in this randomness. To estimate the circuit's behavior during aging, statistical analysis and simulations must be used, such as Monte-Carlo analysis. On the other hand, it requires large number of circuit simulations with different element parameters. When we apply an aging aware modeling of logic circuit delay, it's possible to speed up Monte-Carlo simulations by using a logic simulator for timing behavior analysis instead of an electrical simulator. This paper suggests some advanced techniques of digital circuits

delay modeling that enables these accelerations. These models describe different delay parameters of logic gates, while, in order to use them for statistical analysis of the timing behavior, special random delay generation is enabled.

### ELI3.3

#### MODELING OF MECHANICAL DISPLACEMENTS COMPONENTS FOR COMPOSITE ULTRASONIC TRANSDUCER

*Igor Jovanović, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

*Uglješa Jovanović, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

*Dragan Mančić, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

In this paper components of the mechanical displacements points of the composite ultrasonic transducer in the radial and thickness direction of oscillation are determined. Composite transducer is composed of a back metal mass, a front metal mass and two sets of piezoceramic elements which are separated by central metal mass. Components of mechanical displacements are determined as the function of axial and radial dimensions using an electromechanical equivalent circuit of the complete composite transducer. To obtain numerical results previously developed Matlab/Simulink three-dimensional models of piezoceramic rings and metal cylindrical endings were used. The obtained theoretical results can be used to have a better insight in the composite transducers behavior, especially for transducers in which non-axial oscillation modes can be excited. The proposed method is illustrated based on the practical design of a composite power transducer.

## Sesija EL1: Elektronska kola i sistemi

Sreda, 13. Jun, 12:00 – 13:00, Sala 4

**Predsedavajući: Željko Ivanović, Elektrotehnički fakultet, Univerzitet u Banjoj Luci, BiH**

### EL1.1

#### ANALIZA BLOKOVSKOG ŠIFROVANJA ZA MODULARNU HARDVERSKU AES ARHITEKTURU

*Velibor Škobić, Institut RT-RK, Banja Luka, BiH*

*Željko Ivanović, Elektrotehnički fakultet, Univerzitet u Banjoj Luci, BiH*

*Ivan Velikić, Institut RT-RK, Republika Srbija*

U ovom radu analizirane su hardverske implementacije metoda blokovskog šifrovanja ECB, CFB, OFB i CTR. Analizirane implementacije koriste AES algoritam za šifrovanje i dešifrovanje. Hardverska arhitektura AES algoritma koja se koristi je modularna i omogućava implementaciju sa 8, 16 ili 32 bitnom putanjom. Prezentovani su rezultati implementacije metoda blokovskog šifrovanja za sve tri implementacije AES modula.

### EL1.2

#### EFIKASAN PRISTUP AUTOMATIZACIJI ZASNOVAN NA IOT

*Bejtović Muhamed, Fakultet Tehničkih Nauka, Kosovska Mitrovica*

Sa razvojem koncepta Internet stvari (IOT eng. Internet of Things) stvorena je mogućnost da se obezbedi efikasnije upravljanje i razmena podataka povezivanjem fizičkih uređaja sa senzorima, aktuatorima i Internetom. Broj IoT uređaja u 2017 godini povećan je za oko 31% u odnosu na 2016 godinu, sa apsolutnim iznosom od oko 8,4 milijardi objekata. Eksperti procenjuju da će se IoT sastojati od oko 30 milijardi objekata do 2020 godine, kao i da će globalna tržišna vrednost IoT do 2020 godine dostići 7,1 triliona dolara. U ovom radu je predstavljena ideja automatizacije, odnosno upravljanja uređajima u tzv. "Pametnoj kući", sa ciljem smanjenja vremena odziva uređaja na zadate komande. Osnovni hardverski deo projekta čini ATmega 2560 mikrokontroler, dok je softverski deo zasnovan na JavaScript i Node.js tehnologiji.



### EL1.3

#### CMOS DELITELJ UČESTANOSTI SA 4 SA INJEKCIONOM SINHRONIZACIJOM ZA 22GHZ OPSEG UČESTANOSTI

*Dragana Jevtic, Elektrotehnicki fakultet, Univerzitet u Beogradu, Beograd, Srbija*

*Milos Marinkovic, Elektrotehnicki fakultet, Univerzitet u Beogradu, Beograd, Srbija*

*Nikola Petrovic, Elektrotehnicki fakultet, Univerzitet u Beogradu, Beograd, Srbija*

*Radivoje Djuric, Elektrotehnicki fakultet, Univerzitet u Beogradu, Beograd, Srbija*

Rad se bazira na projektovanju CMOS delitelja učestanosti sa 4 sa injekcionom sinhronizacijom (engl. Injection Locked Frequency Divider - ILFD), kod koga se učestanost ulaznog signala menja u opsegu od 21.6GHz do 23.2GHz. ILFD kolo je realizovano pomoću spregnutnog para NMOS tranzistora i LC oscilatornog kola, uz dodavanje još jednog tranzistora direktno u oscilatorno kolo, kako bi se povećao nivo injektovane struje. Da bi se postigao željeni opseg delitelja učestanosti, potrebno je primeniti odgovarajuću tehniku kojom se postiže povećanje opsega učestanosti. U ovom radu je prikazana tehnika isticanja trećeg harmonika, i prikazano je na koji način pojedini faktori (ulazna snaga i Q faktor oscilatornog kola) utiču na opseg učestanosti za koje je moguće uspostavljanje oscilacija. Za projektovan ILFD pomoću CAD alata Cadence napravljen je lejaut i urađene su postlelaut simulacije. Rezultati simulacija pokazuju pouzdan rad delitelja u opsegu učestanosti koji je nešto veći od nominalnog opsega.

### EL1.4

#### PROJEKTOVANJE MREŽE ZA PRILAGOĐENJE ŠIROKOPOJASNOG POJAČAVAČA SNAGE SA MINIMALNOM TALASNOŠĆU P1DB U PROPUSNOM OPSEGU

*Nikola Petrović, Elektrotehnicki fakultet, Univerzitet u Beogradu, Beograd, Srbija*

*Radivoje Đurić, Elektrotehnicki fakultet, Univerzitet u Beogradu, Beograd, Srbija*

*Jelena Popović Božović, Elektrotehnicki fakultet, Univerzitet u Beogradu, Beograd, Srbija*

Ovaj rad sadrži analitičko izvođenje mreže za prilagođenje širokopojasnog pojačavača snage u klasi A nastale modifikovanjem Čebiševljevog filtra trećeg reda. Na osnovu parametara pojačavača snage, kao što su optimalna otpornost, parazitne kapacitivnosti koje se vide na njegovom izlazu, kapacitivnosti ostrva za lemljenje, kao i zdatog propusnog opsega, određeni su parametri mreže za prilagođenje sa minimalnom talasnošću u zdatom propusnom opsegu za dve različite modifikacije Čebiševljevog filtra. Izlazna filtarska mreža za prilagođenje je projektovana tako da izvrši prilagođenje optimalne otpornosti pojačavača snage Ropt koja rezultuje maksimalnom linearnošću pojačavača na 50 oma. Dobijeni rezultati za propusni opseg od 3.1GHz do 10.6GHz su potvrđeni u Cadence-ovom CAD alatu Virtuoso u 65nm tehnologiji.

# ML Metrology / Metrologija

## Session MLI1: Metrology

Monday, June, 11<sup>th</sup>, 14:30 – 16:30, Hall 1

**Chair:** Marjan Urekar, Faculty of Technical Sciences, University of Novi Sad, Serbia

### MLI1.1

#### SIGNAL-PATH COMPENSATION OF MEASUREMENT SYSTEMS (Invited paper)

*Tamás Dabóczy, Department of Measurement and Information Systems, Budapest University of Technology and Economics, Budapest, Hungary*

Measuring instruments and many gadgets in the world of Internet of Things (IoT) gather information from physical processes. The quality of the system, the reliability of a decision of an autonomous system depends strongly on the accuracy of the measurement. The measurement chain (called signal-path) suffers from distortions (known deterministic alterations) and disturbances (stochastic or unknown alterations). This paper surveys possible digital compensations of these unwanted effects in complicated cases like ill-posed problems, estimation of quantities that cannot be directly measured by a sensor etc. Industrial application opportunities are also discussed.

### MLI1.2

#### RESEARCH OF THE INTEGRATION-DIFFERENTIATION METHOD FOR MEASURING THE FUNDAMENTAL COMPONENT OF REACTIVE POWER

*Andrey N. Serov, Measurement Technique Department, National Research University "Moscow Power Engineering Institute", Moscow, Russia*

*Nikolay A. Serov, Measurement Technique Department, National Research University "Moscow Power Engineering Institute", Moscow, Russia*

*Alexey A. Lupachev, Measurement Technique Department, National Research University "Moscow Power Engineering Institute", Moscow, Russia*

Currently, the following concepts of reactive power are distinguished: reactive power of the fundamental frequency, reactive power of harmonics and reactive power of a given frequency band. The most important parameter is the reactive power of the fundamental spectral component. In this article the method of measuring the reactive power of sinusoidal signal, based on the integration and differentiation of one of the signals is studied. The implementation of this measurement method based on the first-order digital integrator and the first-order digital differentiator. The digital differentiator based on the algorithm of approximation by two samples is considered. Comparison of the considered method with popular methods of integration, time delay from the point of view of measurement error is carried out. The analytical dependence for calculation of additional error of measurement of reactive power caused by deviation of frequency of the input signal is obtained. An expression to determine the gain factors of the integrator and the differentiator, which allows minimizing the error of reactive power measuring near the nominal value of the frequency of input signal is obtained. Simulation mathematical modeling in software package Matlab 7.0 and Simulink 8.0 is performed.

### MLI1.3

#### USAGE OF CONCURRENT PROGRAMMING IN STOCHASTIC ACTIVE ELECTRIC ENERGY MEASUREMENT

*Velibor Pjevalica, JP Srbijagas, Technical Provision Section, Novi Sad, Serbia*

*Platon Sovilj, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

*Nebojša Pjevalica, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

*Nenad Petrović, School of Electrical Engineering, Belgrade, Serbia*

This paper presents the application of concurrent programming on the server side of the emulated dispatching center for measuring electrical energy. The assumption made in this paper is that the measurement results from the measuring points are obtained by a stochastic method and are kept in the RAM memory of the central dispatching server. This assumption makes possible to increase overall result accuracy in long term measurement. However, this is not mandatory for concurrent approach in processing of given data. Technical requirement that has to be solved is speed in data processing. Since it is necessary to have a result in real time, it is necessary to process the results as quickly as possible. Concurrent programming solves this problem. The aim of this paper is to adapt the measurement data obtained from a large number of measuring points to the high accuracy and flexibility of the stochastic method, and that, in conjunction with the continuity of measurements, a higher accuracy is achieved. There are several concurrent approaches in present programming and here are presented three based on Microsoft© technologies: PLINQ, regular threads and thread pool.

MLI1.4

#### LABVIEW-ARDUINO UNO TEMPERATURE MEASURING SYSTEM

*Josif Tomic, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

*Miodrag Kušljević, Termoelektro Enel AD, Beograd, Serbia*

*Platon Sovilj, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

*Vladimir Rajs, Faculty of Technical Sciences, University of Novi Sad, 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 functions.

MLI1.5

#### NATURALLY WEIGHTED MEASUREMENT DATA IN POWER GRID - MEASUREMENT DATA IN FOURIER DOMAIN

*Vladimir Vujicic, Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Belgrade, Serbia*

*Aleksandar Radonjic, Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Belgrade, Serbia*

*Platon Sovilj, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

The latest development of stochastic digital measurement method allows extremely simple measurement of Fourier coefficients and, thus, the harmonic amplitudes: the natural weights of the measurement data in Fourier domain. The significance of each measurement data is defined by its weight, which allows the optimization of data recording, data analysis and artificial neural network training in a power grid.

MLI1.6

#### STOCHASTIC EMBEDDED SYSTEMS

*Vladimir Vujicic, Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Belgrade, Serbia*

*Aleksandar Radonjic, Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Belgrade, Serbia*

*Dragan Pejic, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia*

Computing, analog-to-digital conversion and digital-to-analog conversion are the three most important functions in embedded systems. The last two may include stochasticity regardless of whether the computing

is stochastic or not. The purpose of this paper is to specify and clarify the role of stochasticity in embedded systems.

## **Sesija ML1: Metrologija**

Ponedjeljak, 11. Jun, 11:00 – 13:00, Sala 1

**Predstavljajući: Dragan Denić, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija**

### ML1.1

#### MEĐULABORATORIJSKO POREĐENJE MERENJA SNAGE SMETNJI NA MREŽNOM VODU

*Aleksandar M. Kovačević, Tehnički opitni centar, Generalštab Vojske Srbije, Beograd, Srbija*

*Nenad Munić, Tehnički opitni centar, Generalštab Vojske Srbije, Beograd, Srbija*

*Veljko Nikolić, Tehnički opitni centar, Generalštab Vojske Srbije, Beograd, Srbija*

*Ljubiša Tomić, Vojnotehnički Institut, Beograd, Srbija*

*Ivana Kostić, Tehnički opitni centar, Generalštab Vojske Srbije, Beograd, Srbija*

Međulaboratorijsko poređenje merenja snage smetnji na mrežnom vodu prikazano je u ovom radu. Pri tome, međulaboratorijsko poređenje su pokrenule, organizovale i realizovale dve akreditovane laboratorije s ciljem da potvrde svoju tehničku kompetentnost za merenje navedene veličine.

### ML1.2

#### MERENJE NISKIH NIVOVA RF SIGNALA I PRORAČUN MERNE NESIGURNOSTI MERENJA

*Miša Markuš, Tehnički opitni centar, Generalštab Vojske Srbije, Beograd, Srbija*

*Ivica Milanović, Tehnički opitni centar, Generalštab Vojske Srbije, Beograd, Srbija*

*Neda Spasojević, Tehnički opitni centar, Generalštab Vojske Srbije, Beograd, Srbija*

U radu je predstavljen postupak merenja niskih vrednosti nivoa RF signala korišćenjem mernog prijemnika 8902A, proizvođača Hewlett Packard. Opisana metoda koristi se prilikom etaloniranja signal generatora i oslabljivača, a karakterišu je široki dinamički opseg i visoka tačnost. Posebno poglavlje u radu posvećeno je proračunu merne nesigurnosti merenja.

### ML1.3

#### UNAPREĐENJE METODE SOFTVERSKI PODRŽANOG GENERISANJA TEST SIGNALA ZA VERIFIKACIJU MERILA KVALITETA ELEKTRIČNE ENERGIJE

*Milan Simić, Univerzitet u Nišu, Elektronski fakultet u Nišu, Niš, Srbija*

*Dragan Živanović, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

*Dragan Denić, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

*Živko Kokolanski, Fakultet za elektrotehniku i informacione tehnologije - FEIT, Skoplje, Makedonija*

*Goran Miljković, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

U radu je prikazano unapređenje metode softverski podržanog generisanja referentnih test signala, primenljivih pri verifikaciji instrumenata za detekciju i merenje standardnih poremećaja kvaliteta električne energije. Rešenje generatora test signala bazirano na primeni računara, koje uključuje softver virtuelne instrumentacije, akvizicionu karticu za generisanje signala i pojačavač snage za pojačanje izlaznog signala, već je predstavljeno i opisano u ranije objavljenim radovima [1, 2]. Definisane osnovnih parametara signala za generisanje pomoću LabVIEW softvera podržano je Script fajlovima, što omogućava jednostavno ponavljanje specifičnih test signala i kombinovanje različitih sekvenci u dugotrajne kompleksne kompozitne

signale. Osnovna prednost ove metode u poređenju sa sličnim rešenjima je mogućnost generisanja dugotrajnih sekvenci signala u skladu sa unapred definisanim algoritmima za testiranje, što uključuje različite kombinacije poremećaja signala u skladu sa Evropskim standardom EN 50160. Eksperimentalna verifikacija prikazanog rešenja obavljena je testiranjem analizatora kvaliteta električne energije Fluke 435. U radu su prikazani neki od karakterističnih naponskih test signala generisanih sa različitim poremećajima i dobijeni rezultati memorisani testiranim instrumentom.

ML1.4

#### JEDNO REŠENJE PROBLEMA NELINEARNOSTI NTC TERMISTORA

*Jelena Jovanović, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

*Dragan Denić, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

*Milan Simić, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

U ovom radu predstavljena je nova metoda linearizacije NTC termistora. Novina ove metode ogleda se u primeni dva različita linearizaciona kola: serijsko-paralelnog otpornog razdelnika napona i dvostepenog deo-po-deo linearnog A/D konvertora. Na izlazu razdelnika napona, koji sadrži NTC termistor, dobija se pseudo-linearni napon. Pseudo-linearni napon se dalje linearizuje, i istovremeno prevodi u digitalni format, primenom dvostepenog deo-po-deo linearnog A/D konvertora. Prvi stepen konverzije vrši deo-po-deo linearni fleš A/D konvertor, dok drugi stepen konverzije obavlja linearni fleš A/D konvertor, koji povećava rezoluciju merenja, ali ne vrši linearizaciju. Nakon primene predložene metode linearizacije na Muratin termistor NTSD0KSV103FE1B0, za temperaturni opseg od -40 do 120°C, nelinearnost je smanjena na 0.024%, dok je za najuži od razmatranih opsega, tj. za opseg od 20 do 60°C, nelinearnost smanjena na 0.002%.

ML1.5

#### VISOKONAPONSKA SIMETRIČNA KOMPOZITNA ZENER DIODA KAO ZAMENA ZA ELEKTRONSKU CEV U KOLU NAPAJANJA NIŠANSKOG RADARA 3MK7

*Marjan Urekar, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

U radu je opisan detaljan postupak utvrđivanja, traženja i otklanjanja kvara u kolu napajanja generatora vremenske baze nišanskog radara 3Mk7. Neispravne gasom ispunjene elektronske cevi za stabilizaciju napona su zamenjene novim elektronskim sklopom sačinjenim od standardnih komponenti – visokonaponskom simetričnom kompozitnom zener diodom, koja je ovde opisana i analizirana. Dati su rezultati merenja pre i posle primene ovog rešenja.

ML1.6

#### EKSPERIMENTALNA PROVERA UNAPREĐENE METODE ZA ODREĐIVANJE EFEKTIVNE VREDNOSTI

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*Marina Bulat, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

*Nemanja Gazivoda, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

*Stefan Mirković, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

*Dorđe Novaković, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

*Aleksandar Radonjić, Institut tehničkih nauka SANU, Univerzitet u Beogradu, Beograd*

Ovaj rad predstavlja nastavak istraživanja metode za određivanje efektivne vrednosti metodom odabiranja i primenom unapređene definicije. Simulacionim putem je pokazano da se javlja problem prilikom određivanja efektivne vrednosti, kada količnik učestanosti odabiranja i učestanosti ulaznog signala nije celobrojan. Dat je predlog unapređenja definicije za određivanje efektivne vrednosti. Pokazano je da se primenom unapređene definicije dobijaju rezultati bolje preciznosti nego primenom standardne definicije. Simulacije su rađene nad prostoperiodičnim signalom poznate amplitude, pa je bila poznata tačna vrednost merene veličine - efektivna vrednost. Ovaj rad se bavi eksperimentalnom proverom predložene definicije. Za razliku

od simulacija, ovde nismo u stanju da na lak način kontrolišemo sve bitne parametre eksperimenta. Dodatni problem je što sada ne znamo tačnu vrednost merene veličine.

#### ML1.7

##### EVALUACIJA FUNKCIJE GUSTINE RASPODELE GENERATORA PSEUDOSLUČAJNOG NAPONA

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*Marjan Urekar, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

*Marina Bulat, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

U ovom radu prikazan je sistem za evaluaciju generatora pseudoslučajnog napona, kako bi se poboljšala SAADK 2G metoda merenja pomoću dva generatora šuma. Poboljšanje se ogleda u određivanju funkcija gustine verovatnoće i funkcije raspodele verovatnoće. U radu će biti opisan način izvedbe, kao i princip funkcionisanja uređaja za evaluaciju funkcije gustine verovatnoće. Na kraju rada dato je poređenje razvijenih generatora sa pseudoslučajnim generatorom brojeva na računaru.

#### ML1.8

##### RAZVOJ SISTEMA ZA UDALJENA MERENJA I AKVIZICIJU PRIMENOM VIRTUALNIH MERNIH INSTRUMENTATA

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*Dorđe Novaković, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

*Platon Sovilj, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

*Dragan Pejić, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

*Marjan Urekar, Fakultet tehničkih nauka, Univerzitet u Novom Sadu, Novi Sad, Srbija*

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U cilju razvoja sistema za merenje i akviziciju parametara kvaliteta životne sredine i uslova radne sredine, razvijen je koncept merno-avizionog sistema kao i prateći softver za daljinski nadzor i upravljanje, snimanje podataka i analizu rezultata. Sistem je baziran na mikrokontroleru iz PIC32 familije i senzorskih modula koji služe za merenje parametara okoline. Sistem je zamišljen tako da se lako može proširiti broj senzora koji komuniciraju sa centralnom jedinicom. Za kontrolu i prikupljanje informacija sa udaljene lokacije razvijena je LabVIEW PC aplikacija (virtualni instrument). Odabir komunikacionih protokola za povezivanje mikrokontrolera i senzorskih blokova je izvršen tako da se uz minimalne korekcije programskog koda mogu lako priključiti dodatni senzorski blokovi, što daje veliku fleksibilnost celom sistemu. Pored toga, grafičko programiranje PC aplikacije takođe olakšava izmenu njenog izvršnog koda u slučaju dodavanja ili uklanjanja pojedinih komponenti.

#### ML1.9

##### СТОХАСТИЧКИ ДИГИТАЛНИ ОН-ЛИНЕ КРИТЕРИЈУМ ПОТПУНОСТИ СПЕКТРА СИГНАЛА

*Бојан Вујчић, Факултет техничких наука, Универзитет у Новом Саду, Нови Сад, Србија*

*Љубица Жупунски, Факултет техничких наука, Универзитет у Новом Саду, Нови Сад, Србија*

*Платон Совиљ, Факултет техничких наука, Универзитет у Новом Саду, Нови Сад, Србија*

Проблем у било ком дигиталном мерењу је – да ли је оно изнад Никвистове границе !? За већину мерења тај проблем не постоји ако се користе флеш АД конвертори. У стохастичкој дигиталној мерној методи (СДММ) се најчешће користе двобитни флеш АД конвертори, па се чини да ту тај проблем не постоји. Међутим, познавање спектра мереног сигнала омогућује оптимизацију обраде сигнала, тако

да је тај проблем увек актуелан и овај рад је прилог његовом решавању. У раду је дефинисан критеријум потпуности спектра мереног сигнала заснован на два независна и истовремена мерења укупне снаге сигнала. Он је истраживан и потврђен у два практична случаја.

# **MO Microelectronics and Optoelectronics, Nanosciences and Nanotechnologies / Mikroelektronika i optoelektronika, nanonauke i nanotehnologije**

## **Session MOI1: Microelectronics and Microsystems 1**

Thursday, June, 14<sup>th</sup>, 08:00 – 10:30, Hall 1

**Chairs: Ninoslav Stojadinović, Serbian Academy of Sciences and Arts - branch in Niš and Faculty of Electronic Engineering, University of Niš, Serbia;**

**Dana Vasiljević Radović, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia**

### MOI1.1

**DESIGN AND CHARACTERIZATION OF THERMOELECTRIC ENERGY HARVESTING SYSTEMS FOR WIRELESS SENSOR NODES (Invited paper)**

*Zoran Prijjić, Faculty of Electronic Engineering, University of Niš, Serbia*

*Ljubomir Vračar, Faculty of Electronic Engineering, University of Niš, Serbia*

*Aneta Prijjić, Faculty of Electronic Engineering, University of Niš, Serbia*

As a process of obtaining electrical energy by conversion from the surrounding sources, energy harvesting is convenient for powering wireless sensor nodes. Operation of the nodes requires reliable systems for conversion, storage and management of the harvested energy. This paper reviews some of the most common design principles and characterization methods for the energy harvesting systems based on the small thermoelectric generators. Techniques for solving cold boot issues and achieving prolonged autonomy of the nodes are highlighted. Illustrative design examples of the nodes, based on the commercially available (off-the-shelf) devices, are presented.

### MOI1.2

**DEVICE SIMULATIONS OF OFF-STATE BREAKDOWN VOLTAGE IN THE RF SILICON-BASED LDMOS POWER TRANSISTORS**

*Vladimir Milovanović, Faculty of Engineering, University of Kragujevac, Serbia*

*Darko Tasovac, NovellC Microsystems, Serbia*

Past decades saw a tremendous incline in the performance of laterally diffused metal oxide semiconductor (LDMOS) field-effect transistors (FETs), putting them as the leading radio-frequency (RF) power technology in several application areas, like for example cellular infrastructure. One of the key parameters of LDMOS devices is certainly the breakdown voltage. Careful engineering of the transistor is necessary to optimize various parameters and achieve good compromise between number of key quantities. Device designers use technology computer-aided design simulation tools to reduce development time and to make their designs competitive. This paper deals with simulations of off-state avalanche breakdown in LDMOS transistors. Two ways of estimating the breakdown voltage are identified and applied in simulations of a typical LDMOS device. Analysis of simulation results confirms that the two methods are practically equivalent.

### MOI1.3

**STEADY-STATE ANALYSIS OF STOCHASTIC TIME RESPONSE OF CHEMICAL AND BIOLOGICAL MICROFLUIDIC SENSORS**

*Ivana Jokić, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

*Zoran Djurić, Serbian Academy of Sciences and Arts, Institute of Technical Sciences of SASA, Serbia*



*Katarina Radulović, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

*Miloš Frantlović, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

*Predrag Krstajić, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

*Katarina Cvetanović Zobenica, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

In this paper we first give a short review of two stochastic models describing both the expected value and variance of the random number of adsorbed particles in microfluidic adsorption-based chemical and biological sensors. One model takes into account the influence of coupling of stochastic adsorption-desorption processes and mass transfer on the change of the number of adsorbed particles, while the other neglects the influence of mass transfer. Subsequently, by using the two models, we perform the analysis of the expected value and variance, as well as the sensor's signal-to-noise ratio, after reaching the steady state of all transient processes. We compare the results obtained by using the different models, and determine conditions for their application. We estimate the influences of the sensing surface area and the concentration of target particles on statistical parameters of sensor response and signal-to-noise ratio, considering the cases where mass transfer is significant, and those where it is not. We particularly analyze the mass transfer influence on the expected value, variance and signal-to-noise ratio. Such analysis does not exist in the available literature. The presented analysis yields new knowledge about the stochastic response of adsorption-based sensors, and it is significant for their optimization in order to achieve reliable analyte detection and improved sensing performance.

MO11.4

#### DIRECT LASER WRITING OF MICRO-STRUCTURES IN VECTOR MODE FOR CHEMICAL SENSORS

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*Milče Smiljanić, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

*Žarko Lazić, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

*Katarina Cvetanović Zobenica, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

*Dana Vasiljević Radović, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

*Danijela Randjelović, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

Chemical sensors are the key part of the sensing platforms. They have different operating principles, but most of them are based on microstructures formed on the surface of the chip. In this paper we present technique for obtaining micro sized structures for the use in two different types of the chemical sensors. One type of the sensor is based on the electrical conductivity alteration in Au thin-film while the other is based on the optical properties of periodic metallic structures utilizing plasmonic effects. Technique presented here is based on the laser writing on the photosensitive material in “vector mode” where only continuous lines could be directly written. Width of the written lines is modified by alternating technique parameters. Narrowest obtained lines have width of about 1  $\mu\text{m}$  with clearance of about 3  $\mu\text{m}$

MO11.5

#### TWO TYPES OF INTEGRATED HEATERS FOR SYNTHESIS OF $\text{TiO}_2$ NANOPARTICLES IN MICROREACTORS

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*Milče M. Smiljanić, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

*Žarko Lazić, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

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*Dana Vasiljević Radović, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

In this paper we fabricated two types of heaters for microreactors which are used in synthesis of TiO<sub>2</sub> nanoparticles. We used standard photolithographic processes to design gold and p-type heaters diffused in n-type silicon substrate. Heaters are designed to be integrated part of microreactors. The temperature necessary for synthesis of TiO<sub>2</sub> nanoparticles is achieved with both types of heaters. P-type diffused heaters are shown better in terms of power consumption.

#### MOI1.6

#### CUSTOMIZATION OF EVANESCENT NEAR FIELDS ON FREESTANDING PLASMONIC NANOMEMBRANES

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*Zoran Jakšić, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

*Ivana Mladenović, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

*Dragan Tanasković, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

*Dana Vasiljević Radović, Institute of Chemistry, Technology and Metallurgy – Center of Microelectronic Technologies, University of Belgrade, Serbia*

For a very long time optical evanescent near fields have been considered useless for practical applications and remained a theoretical curiosity. However, with advances in micro and nanotechnologies and the decreasing sizes of the photonic devices there came a need to overcome diffractive limit which sparked a practical interest in these previously overlooked field components. With the discovery of Surface Plasmon Polaritons (SPP), bound surface modes propagating along interfaces between materials with different signs of relative dielectric permittivity and being evanescent in the direction perpendicular to the interface a path was open to actively design spectral and spatial properties of near fields. Now plasmonic metamaterials and evanescent near fields are used not just for imaging beyond diffractive limit but also in transformation optics, biochemical sensing, cloaking devices, photonic integrated circuits, etc. Freestanding plasmonic nanomembranes are fairly simple and yet highly versatile structures which can be utilized in practically any of the fields of application of plasmonics, making them an ideal platform to build upon. In this paper we present a novel structural design as a means for customizing and tailoring the near field response of multilayer freestanding nanomembranes. To this purpose ellipsoidal diffractive "bumps" are built into the nanomembrane as the coupling elements between freely propagating and evanescent modes.

#### MOI1.7

#### APPLICATION OF NANOTECHNOLOGY IN AGRICULTURE AND FOOD PRODUCTION – NANOFOOD AND NANOAGRICULTURE

*Enisa Omanović-Miklićanin, Faculty of Agriculture and Food Sciences, University of Sarajevo, Bosnia and Herzegovina*

*Mirjana Maksimović, Faculty of Electrical Engineering, University of East Sarajevo, Bosnia and Herzegovina*

Nanotechnology presents one of the exciting new fields of research that holds potential to address many of the pressing needs in all areas of the food and agriculture. Numerous and diverse characters and combinations of nanotechnologies may be applied from plant cropping and animal feeding to food production, manufacturing and packaging, therefore contributing to safe and quality food products. Methods based on nanotechnology present very powerful alternative to the existing methods for identification and quantification of contaminants and other ingredients in food, improving production and enhancing food safety through the development of nano-based detection systems. Additionally, in the evaluation of food quality and safety (nano) spectroscopic methods are very important due to rapid and non-destructive analytical performances. This work highlights the importance of nanotechnology and nanospectroscopy and summarizes their main applications in agriculture and food sciences

MO1.8

#### RUGGEDIZED AMLCD DISPLAY COLOR GAMUT CORRECTIONS POSSIBILITIES

*Branko Livada, Vlatacom Institute of High Technologies, Belgrade, Serbia*

Wide gamut active matrix liquid crystal displays – AMLCD, nowadays play an important role in the HDTV development. Due to LCD color filter spectral limitation the wide gamut is achievable only by proper backlight design. In some particular application as ruggedized avionic displays the presentation of the selected colors are important. The AMLCD display color gamut model used for display backlight design is presented. This model application results are used for selection of the backlight R, G, B LEDs providing proper color gamut and required color presentation. According to model results display backlight is built and measured. Display gamut measurement results comply with model results.

## **Sesija MO1: Mikroelektronika, mikrosistemi i optoelektronika**

Četvrtak, 14. Jun, 11:00 – 12:30, Sala 1

**Predsedavajući: Zoran Prijić, Elektronski fakultet, Univerzitet u Nišu, Srbija**

MO1.1

#### ELEKTROHEMIJSKI PROCESI KOD P-KANALNIH VDMOS TRANZISTORA SNAGE PRI SUKCESIVNOM NBT NAPREZANJU I OZRAČIVANJU

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*Danijel Danković, Elektronski fakultet, Univerzitet u Nišu, Srbija*

*Snežana Golubović, Elektronski fakultet, Univerzitet u Nišu, Srbija*

*Snežana Đorić-Veljković, Građevinsko-arhitektonski fakultet, Univerzitet u Nišu, Srbija*

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*Ninoslav Stojadinović, Elektronski fakultet, Univerzitet u Nišu; Srpska akademija nauka i umetnosti (SANU) - ogranak u Nišu, Srbija*

U ovom radu analizirani su elektrohemijjski procesi tokom sukcesivnog NBT (negative bias temperature) naprežanja i ozračivanja komercijalnih p-kanalnih VDMOS (Vertical Double-Diffused Metal Oxide Semiconductor) tranzistora snage, kao i tokom njihovog spontanog oporavka. Određene su promene gustina naelektrisanja u oksidu gejta i površinskih stanja do kojih dolazi usled elektrohemijjskih procesa, a prikazano

je i odgovarajuće ponašanje napona praga tokom posmatranog naprežanja i oporavka. Pokazano je da prethodno ozračivanje bitno utiče na promene gustina naelektrisanja u oksidu gejta i površinskih stanja tokom NBT naprežanja, dok prethodno NBT naprežanje gotovo da nema uticaja na njihov dalji značajni porast tokom ozračivanja. Uočeno je da tokom spontanog oporavka, kod prethodno ozračenih komponenata dolazi do promena gustina naelektrisanja u oksidu gejta i površinskih stanja, dok kod prethodno NBT naprežanih komponenata nisu uočene njihove promene, iako napon praga kod svih komponenata ostaje praktično stabilan.

#### MO1.2

##### KARAKTERIZACIJA ELEKTRIČNO PROGRAMABILNOG MOS TRANZISTORA SA PLIVAJUĆIM GEJTMOM

*Aleksandar Jevtić, Elektronski fakultet, Univerzitet u Nišu, Srbija*

*Stefan Ilić, Elektronski fakultet, Univerzitet u Nišu, Srbija*

*Vojkan Davidović, Elektronski fakultet, Univerzitet u Nišu, Srbija*

*Aneta Prijić, Elektronski fakultet, Univerzitet u Nišu, Srbija*

*Zoran Prijić, Elektronski fakultet, Univerzitet u Nišu, Srbija*

U ovom radu je vršena karakterizacija integrisanog kola ALD1108E koje se sastoji iz četiri električno programabilna MOS tranzistora sa plivajućim gejtom, tzv. EPAD-a (Electrically Programmable Analog Device). Programiranje ovih tranzistora je zapravo precizno podešavanje napona praga na željenu vrednost od strane korisnika, a praktično se ostvaruje dovođenjem naelektrisanja na plivajući gejt. Svi EPAD-i imaju inicijalni napon praga od 1 V. Ispitivana je zavisnost pomeraja napona praga od parametara impulsa kojim se programiraju tranzistori. Takođe, realizovan je programator koji sa visokom preciznošću može da podesi napon praga tranzistora na željenu vrednost u opsegu od inicijalne vrednosti do 4 V.

#### MO1.3

##### OPTIMIZACIJA I MODELOVANJE DEBELOSLOJNOG SEGMENTIRANOG TERMISTORA ZA GRADIJENTNI SENZOR TEMPERATURE TLA

*Stanko Aleksić, Fakultet tehničkih nauka, Univerzitet u Kragujevcu, Čačak, Srbija*

*Nebojša Mitrović, Fakultet tehničkih nauka, Univerzitet u Kragujevcu, Čačak, Srbija*

*Miloljub Luković, Fakultet tehničkih nauka, Univerzitet u Kragujevcu, Čačak, Srbija*

*Slobodan Djukić, Institut za multidisciplinarna istraživanja -IMSI, Univerzitet u Beogradu, Srbija*

*Aleksandra Kalezić-Glišović, Fakultet tehničkih nauka, Univerzitet u Kragujevcu, Čačak, Srbija*

Konstrukcija i način dobijanja debeloslojnih NTC segmentiranih termistora opisani su ukratko. Merena je i analizirana zavisnost električne otpornosti u funkciji od slojne otpornosti, geometrijske veličine segmenta, temperature ambijenta i vremena. Korišćena je termistorska pasta na bazi praha čistog nikiel manganita  $\text{NiMn}_2\text{O}_4$  a mereni rezultati otpornosti su upoređeni sa rezultatima dobijenim preko matematičko-fizičkog modela. Optimizacija je vršena u cilju dobijanja pogodne vrednosti otpornosti segmentiranog termistora za novi gradijentni senzor temperature tla. Novi senzor je formiran u obliku redne veze 10 segmentiranih termistora, zatim je baždaren na sobnoj temperaturi i postavljen na travnjak u bušenu rupu dubine od 55 cm da meri promenu temperature sa dubinom u 40 tačaka. Vršena su prva dnevna i mesečna praćenja promene profila temperature tla. Rezultati su značajni za korelaciju temperature vazduha i tla i prenos energije kroz gornji sloj tla.

#### MO1.4

##### ANALIZA UTICAJA POČETNE TEMPERATURE TEST UZORKA PRI PRIMENI IMPULSNE TERMOGRAFIJE

*Ljubiša Tomić, Vojnotehnički institute, Beograd, Srbija*

*Vesna Damjanović, Rudarsko-geološki fakultet, Univerzitet u Beogradu, Srbija*

*Katarina Mišković, Vojnotehnički institute, Beograd, Srbija*

*Boban Bondžulić, Vojna akademija, Univerzitet odbrane u Beogradu, Srbija*

*Dragan Knežević, Vojnotehnički institute, Beograd, Srbija*

*Aleksandar Kovačević, Tehnički opitni centar, Beograd, Srbija*

Impulsna termografija kao atraktivna i pouzdana metoda za nedestruktivna testiranja se poslednjih godina primenjuje u ispitivanjima termoprovodnih materijala. U radu su prikazani rezultati primene ove metode za ispitivanje simuliranih defekata u aluminijumskoj test pločici. Izvršena je analiza snimljenih termograma poređenjem razlike temperature oblasti iznad defekta i oblasti van defekta. Posebno su analizirani temperaturni kontrasti najvećeg defekta - slučaj kada su početene temperature ispitivanog objekta različite u odnosu na ambijentalnu tj. kada se test pločica i pre spoljašnje pobude zagreva ili hladi.

MO1.5

#### RAZVOJ INFRACRVENE TERMOGRAFIJE

*Vesna Damnjanović, Rudarsko-geološki fakultet, Univerzitet u Beogradu, Srbija*

*Ljubiša Tomić, Vojnotehnički institute, Beograd, Srbija*

*Slobodan Petričević, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

*Danica Pavlović, Institut za fiziku, Univerzitet u Beogradu, Srbija*

*Darko Vasiljević, Institut za fiziku, Univerzitet u Beogradu, Srbija*

U radu je prikazan hronološki razvoj infracrvene termografije. Navedene su mogućnosti njene široke primene danas. Data je prognoza budućih pravaca razvoja ove bezkontaktne metode namenjene za nedestruktivno ispitivanje materijala, lociranje zagrejanih objekata i živih bića, detekciju gasova, kao i za praćenje različitih procesa.

# **MT Microwave Technique, Technologies and Systems / Mikrotalasna tehnika, tehnologije i sistemi**

## **Sesija MT1 Mikrotalasna tehnika, tehnologije i sistemi**

Utorak, 12. Jun, 08:00 – 09:00, Sala 1

**Predsedavajući: Zlatica Marinković, Elektronski fakultet, Univerzitet u Nišu, Srbija**

### MT1.1

#### MODELOVANJE HP MIKROTALASNIH ADAPTERA MODELI IZ SERIJE 281 I 292

*Nenad Munić, Tehnički opitni centar, Beograd, Srbija*

*Aleksandar Kovačević, Tehnički opitni centar, Beograd, Srbija*

*Veljko Nikolić, Tehnički opitni centar, Beograd, Srbija*

*Ljubiša Tomić, Vojnotehnički Institut, Beograd, Srbija*

*Milica Stojković, Tehnički opitni centar, Beograd, Srbija*

Adapteri su našli široku primenu u raznim mikrotalasnim kolima. Modelovanjem kola se na jeftin i brz način mogu optimizovati parametri sistema. Cilj ovog rada je modelovanje adaptera proizvođača Hewlett-Packard serija 281 (talasovod-koaksijalni vod) i 292 (talasovod-talasovod). U radu je pokazano kako promena raznih parametara modela adaptera utiče na vrednosti: „cut off“ frekvencije, položaja rezonantnih frekvencija, gubitaka itd. Predmet ovog rada je upravo prikaz simulacionih modela, kao i odgovarajućih rezultata simulacija i eksperimenata.

### MT1.2

#### PRIKUPLJANJE I KONVERZIJA RF ENERGIJE U ŠIROKOM FREKVENCIJSKOM OPSEGU

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

*Branka Jokanović, Institut za fiziku, Univerzitet u Beogradu, Beograd, Srbija.*

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

*Nikola Bošković, Institut za fiziku, Univerzitet u Beogradu, Beograd, Srbija*

U ovom radu je opisano projektovanje osnovnih elemenata sistema za prikupljanje i konverziju RF energije (RF energy harvesting) koji radi u opsegu frekvencija od 1 do 16 GHz. Sistem se sastoji od antene i ispravljačkog kola sa detektorskom diodom. Korišćenjem nelinearne analize (harmonic balance) određen je opseg optimalnih ulaznih impedansi detektorske diode na osnovu Spice modela proizvođača. Nakon toga, projektovan je niz koji se sastoji od dve širokopojasne pentagonalne dipol antene, koje su povezane koplanarnim vodom (CPS). Detektorska dioda se postavlja na CPS vod na sredini između dipola. Pri optimizaciji antenskog niza se vodilo računa da ulazna impedansa antene, na mestu gde se priključuje dioda, bude približno jednaka njenoj optimalnoj ulaznoj impedansi, bar u nekom delu željenog radnog opsega. Na taj način, izbegava se kolo za prilagođenje impedanse između antene i detektora, koje dodatno komplikuje sistem i unosi slabljenje.

### MT1.3

#### INVERZNO OČITAVANJE ITU-R P.1546 KRIVIH ZA NIVO EM POLJA RADIO-DIFUZNIH PREDAJNIKA

*Miloš Radojković, Energoprojekt Entel, Beograd, Srbija*

*Zlatica Marinković, Elektronski fakultet u Nišu, Univerzitet u Nišu, Niš, Srbija*

*Aleksandar Atanasković, Elektronski fakultet u Nišu, Univerzitet u Nišu, Niš, Srbija*

U ovom radu predložen je novi metod za inverzno očitavanje krivih iz preporuke ITU R-1546 za očekivani nivo elektromagnetnog polja koji potiče od radiodifuznih predajnika. Predloženi metod je baziran na primeni veštačkih neuronskih mreža i omogućava efikasno određivanje rastojanja za zadati nivo polja. Metod je ilustrovan na primeru krivih koje se odnose na frekvenciju 600 MHz. Prikazani su rezultati koji potvrđuju tačnost predloženog metoda.

MT1.4

#### KRUŽNI LINEIČNI OBRUČ U SFERNOJ VAZDUŠNOJ ŠUPLJINI UNUTAR BI-IZOTROPNOG MATERIJALA TELLEGEN-OVOG TIPA

*Žaklina Mančić, Elektronski fakultet u Nišu, Univerzitet u Nišu, Niš, Srbija*

*Zlata Cvetković, Elektronski fakultet u Nišu, Univerzitet u Nišu, Niš, Srbija*

U ovom radu izvršen je proračun električnog i magnetnog skalar potencijala kružnog lineičnog obruča naelektrisanog ukupnim naelektrisanjem  $q$ , smeštenog u sferičnoj šupljini koja postoji unutar bi-izotropnog materijala Tellegen-ovog tipa. Rešavane je Poisson-ova i Laplace-ova jednačina u sfernom koordinatnom sistemu uz zadovoljenje graničnih uslova na razdvojnoj površini vazduh-bi-izotropna sredina. Zatim su nacrtani odgovarajući grafici i izvedeni određeni zaključci.

## Session MTI1 Microwave technique, technologies and systems

Tuesday, June, 12<sup>th</sup>, 09:00 – 10:30, Hall 1

**Chair: Vera Marković, Faculty of Electronic Engineering Niš, University of Niš, Niš, Serbia**  
**Branka Jakanović, Institute of Physics, University of Belgrade, Pregrevica, Serbia**

MTI1.1

#### COMBINATIONS SCENARIOS OF OPTICAL AND RF-COMMUNICATION NETWORKS FOR DIFFERENT HIGH DATA RATE MULTIMEDIA APPLICATIONS AND INNOVATIONS IN AUTONOMOUS DRIVING (Invited Paper)

*Erich Leitgeb, Institute of Microwave and Photonic Engineering, Graz University of Technology, Graz, Austria*

In this contribution Combinations of Optical- and RF-Wave Propagation are illustrated for different scenarios. The considerations include Optical Wireless Communication (OWC, well known as Free Space Optics (FSO)) as hybrid transmission methods with telecommunication technologies (like WLAN, RF- and satellite communications) and also Sensing Technologies (like LiDAR and radar combinations). The contribution deals with possible fields of applications for optical wireless in conjunction with automated driving. The scope considers requirements (including infrastructure and regulations), differences of Optical and RF-Wave Propagation and promising combinations of optical techniques with conventional wireless technologies. This paper should also provide inputs to define new ideas and aspects for the future research focus within Europe.

MTI1.2

#### LINEARIZATION OF HARMONIC AUTOMOTIVE RADAR

*Aleksandar Atanasković, Faculty of Electronic Engineering Niš, University of Niš, Niš, Serbia*

*Nataša Maleš-Ilić, Faculty of Electronic Engineering Niš, University of Niš, Niš, Serbia*

*Aleksandra Đorić, Faculty of Electronic Engineering Niš, University of Niš, Niš, Serbia*

*Predrag Eferica, Faculty of Electronic Engineering Niš, University of Niš, Niš, Serbia*

In this paper, a new automotive radar concept for target detection and classification is suggested. The harmonic radar receivers detect the targets carrying the nonlinear tag that generates the nonlinear products of

the transmitter signals - the second harmonics and intermodulation products of the third-order. The vulnerable targets, such as pedestrians, children and similar, are identified by reflecting the third-order intermodulation products, whereas the cars are detected by reflection of the second harmonics of the radar transmitter signals - two LFM modulated carriers. Therefore, the power amplifier in the radar transmitter, that generates the intermodulation products due to its nonlinear transfer characteristic, is linearized by the linearization technique that uses the second harmonics of the useful signals.

### MT11.3

#### USING RAT RACE BALUN TRANSITION FOR CHARACTERIZATION OF 60 GHz FMCW TRANSMITTER MODULE

*Siniša Jovanović, IMTEL Komunikacije, Belgrade, Serbia*

*Ivan Milosavljević, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia; NovellC Microsystems, Belgrade, Serbia*

*Veselin Branković, NovellC Microsystems, Belgrade, Serbia*

This paper features the design and realization of a balun transition developed for signal monitoring at the  $32\times$  down scaled frequency output of a highly integrated FMCW transmitter module. The module operates in a millimeter-wave frequency range from 59.5 GHz to 70.5 GHz. The balun connects 100  $\Omega$  balanced scaled outputs of the FMCW transmitter chip to a 50  $\Omega$  unbalanced single-ended output of the RF board. The balun characteristics were optimized for achieving good matching at both the balanced and the unbalanced port as well as for a low insertion loss, less than 1 dB, within the entire scaled frequency range of interest, from 1.7 up to 2.3 GHz. It provides a frequency down-scaled sample of the main output signal which allows testing and monitoring of various features of the transmitter's output signal.

### MT11.4

#### K-BAND CPW-FED RECTANGULAR SLOT DIPOLES FOR 5G APPLICATIONS

*Marija Milijić, Faculty of Electronic Engineering Niš, University of Niš, Niš, Serbia*

*Branka Jokanović, Institute of Physics, University of Belgrade, Pregrevica, Serbia*

This paper presents the results of parametric analysis of the rectangular slot dipole fed by CPW line for application in 5G frequency range 24.25-27.5 GHz band. The influence of the dipole geometrical parameters on the dipole key performances like resonant and antiresonant frequencies, and antenna bandwidth is demonstrated. This research opens the door to the reconfigurability of slot dipole antennas by means of variable length of the extended CPW line, which can adjust the antiresonant frequency and impedance level at antiresonance.

### MT11.5

#### EXPERIMENTAL SHIELDING EFFECTIVENESS ANALYSIS OF A METAL ENCLOSURE WITH CIRCULAR AIR-VENTS

*Nataša Nešić, College of Applied Technical Sciences Niš, Niš, Serbia*

*Nebojša Dončov, Faculty of Electronic Engineering Niš, University of Niš, Niš, Serbia*

*Slavko Rupčić, Department of Communications, Faculty of Electrical Engineering, Osijek, Croatia*

*Vanja Mandrić-Radivojević, Department of Communications, Faculty of Electrical Engineering, Osijek, Croatia,*

*Bratislav Milovanović, University Singidunum, Belgrade, Serbia,*

This paper presents the experimental study of shielding effectiveness of a metallic enclosure with circular air-vents and a monopole-receiving antenna. The front panel of enclosure is removable so that three groups of  $4\times 3$  circular apertures with different frontal wall coverage with air-vents are taken into consideration. The experimental results are obtained in a semi-anechoic room and compared with numerical ones calculated by TLM method with incorporated compact wire and air-vent models.



# NM Novel Materials / Novi materijali

## Session NMI1: New Materials

Monday, June, 11<sup>th</sup>, 11:00 – 12:00, Hall 3

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

### NMI1.1

INFLUENCE OF RARE EARTH ADDITION ON THE STRUCTURAL AND MAGNETIC PROPERTIES OF COBALT FERRITE NANOSTRUCTURES (Invited paper)

*Georgiana Bulai, Integrated Center for Studies in Environmental Science for North-East Region (CERNESIM), Alexandru Ioan Cuza University of Iasi, Romania*

*Stefan Irimiciuc, Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Romania*

*Vasilica Gafton, Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Romania*

*Silviu Gurlui, Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Romania*

*Ovidiu Caltun, Faculty of Physics, Alexandru Ioan Cuza University of Iasi, Romania*

Cobalt ferrites are suitable materials for the development of sensors and magneto-optic devices and the substitution of iron with the rare earth (RE) ions can significantly modify the structural and consequently electric and magnetic properties of samples. The main aim of our series of studies was to analyze the influence of RE substitution, in terms of composition and type, on the properties of  $\text{CoFe}_{1-x}\text{RE}_x\text{O}_4$  (RE = Gd, Dy, Yb) bulk, nanoparticles and thin films. Bulk materials were obtained by different synthesis process (classical ceramic or combustion), nanoparticles were produced mainly by coprecipitation and thin film were grown by pulsed laser deposition technique. The talk will go in deep details for the last technique, case in which an in-situ plasma plume analysis was done during the deposition in order to study the correlation between plasma parameters and the structural and magnetic characteristics of the obtained samples. The plasma analysis was done for all depositions by fast ICCD imaging and space and time resolved optical emission spectroscopy. The nanopowders obtained by coprecipitation were used for target synthesis at 1250°C for 5 hours. The resulting disks were placed in a stainless steel vacuum chamber where a  $10^{-3}$  Torr base pressure was ensured. The monocrystalline (100) Si substrate was placed at a distance of 5 cm in front of the target during the 60 min deposition. To reduce and even avoid the deposition of micro-sized droplets on the surface of the deposited samples, the Nd-YAG laser (532 nm) fluence was kept at 2 J/cm<sup>2</sup>. The structural properties of nanoparticles, bulk materials and thin films were investigated by XRD, Raman spectroscopy and SEM/EDX technique which revealed the influence of the RE concentration on phase composition, lattice parameters and crystallinity. The magnetic character of the deposited samples confirmed by VSM and SQUID was strongly influenced by growth conditions.

### NMI1.2

RATE COEFFICIENTS FOR H<sup>+</sup> IN n-BUTANOL

*Željka Nikitović, Institute of Physics, University of Belgrade, Belgrade, Serbia*

In this work we select most probable reactions of H<sup>+</sup> ions with n-Butanol. Appropriate gas phase enthalpies of formation for the products were used to calculate scattering cross section as a function of kinetic energy with Denpoh-Nanbu theory. Calculated cross sections can be used to obtain transport parameters, specially rate coefficients as a function of E/N (E -electric field; N-gas density) for H<sup>+</sup> ions in n-Butanol gas.

### NMI1.3

SINTERING TEMPERATURE INFLUENCE ON ELECTRICAL RESISTIVITY OF Er DOPED BaTiO<sub>3</sub> CERAMICS

*Miloš Đorđević, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

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

*Vojislav Mitić, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

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

The electrical resistivity of Er doped BaTiO<sub>3</sub> ceramics in function of sintering temperature is investigated in this article. The concentrations of Er<sub>2</sub>O<sub>3</sub> in doped samples were ranged from 0.01 to 1.0 at% Er. The samples were prepared by a conventional solid state sintering procedure and sintered at 1320°C, 1350°C and 1380°C for 4 hours. For low dopants concentration (0.01 at% Er), SEM analysis shows abnormal grain growth with the average size range between 10 μm - 50 μm. The increase of dopants concentration and sintering temperature in samples causes decrease of average grain size, and for samples doped with 1.0 at% Er, grain size range between 2 μm - 30 μm. The specific electrical resistance were measured in temperature range from 25°C to 170°C at different frequencies, from 100Hz to 1MHz. To a temperature of 120°C, resistivity slightly increases with increasing of temperature, but above this temperature the resistivity increases rapidly. The value of the electrical resistivity decreases with increasing concentration of Er, to a concentration of 0.5 at% Er, and then resistivity increases. Also, with increasing sintering temperature the electrical resistivity decreases.

## **Sesija NM1: Novi Materiali**

Ponedjeljak, 11. Jun, 12:00 – 13:00, Sala 3

**Predsedavajući: Vesna Paunović, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija**

### NM1.1

#### **MIKROSTRUKTURNE I DIELEKTRIČNE KARAKTERISTIKE BaTiO<sub>3</sub> KERAMIKE DOPIRANE RAZLIČITIM ADITIVIMA**

*Stefan Ilić, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

*Miloš Đorđević, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

*Vesna Paunović, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

*Vojislav Mitić, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

U radu su ispitivane mikrostrukturne i dielektrične karakteristike uzoraka BaTiO<sub>3</sub> keramike dopirane MnCO<sub>3</sub> i CaZrO<sub>3</sub> u koncentraciji od 0.5 do 1.5 wt% aditiva. Uzorci modifikovane BaTiO<sub>3</sub> keramike dobijeni su konvencionalnom metodom polazeći od čistih prahova i sinterovani 2 sata na temperaturi od 1300°C. Kod MnCO<sub>3</sub> i CaZrO<sub>3</sub> dopirane keramike postignuta je uniformna mikrostruktura sa srednjom veličinom zrna od 1-2 μm i 3μm respektivno. Najveću vrednost dielektrične konstante na sobnoj temperaturi i najveću promenu dielektrične konstante sa promenom temperature pokazuje CaZrO<sub>3</sub> dopirana keramika. Kirijeva temperatura svih uzoraka pomena je ka nižim vrednostima u odnosu na nedopiranu keramiku. Svi uzorci imaju isti tok promene dielektrične konstante sa frekvencijom koja postiže konstantnu vrednost za frekvencije veće od 6 kHz. Tangens ugla gubitaka kreće se u opsegu od 0.018 za uzorke dopirane CaZrO<sub>3</sub> do 0.25 za uzorke dopirane MnCO<sub>3</sub> i postiže konstantnu vrednost za frekvencije veće od 10 kHz.

### NM1.2

#### **MAGNETNA SVOJSTVA FeCoV LEGURE DOBIJENE PIM/MIM TEHNOLOGIJOM BRIZGANJA KOMPOZITA PRAHA SA RASTOPLJENIM VEZIVOM**

*Borivoje Nedeljković, Univerzitet u Kragujevcu, Fakultet tehničkih nauka Čačak, Srbija*

*Nebojša Mitrović, Univerzitet u Kragujevcu, Fakultet tehničkih nauka Čačak, Srbija*

*Jelena Orelj, Univerzitet u Kragujevcu, Fakultet tehničkih nauka Čačak, Srbija*

*Branko Koprivica, Univerzitet u Kragujevcu, Fakultet tehničkih nauka Čačak, Srbija*

U radu su ispitivani torusni uzorci legure Fe<sub>49</sub>Co<sub>49</sub>V<sub>2</sub> proizvedene PIM/MIM tehnologijom koja je završena visokotemperaturnim sinterovanjem tokom 3,5 sata na temperaturama od 1370 °C do 1460 °C u atmosferi vodonika, Magnetna svojstva su ispitivana u zavisnosti od temperature sinterovanja i pri različitim vrednostima pobudnog magnetnog polja. Najveća ostvarena relativna magnetna permeabilnost je oko 210 pri magnetnoj pobudi od 3 kA/m i frekvenciji od 5 Hz kod uzorka sinterovanog na temperaturi od 1370 °C. Energetski gubici materijala u magnetnom polju su analizirani preko gubitaka usled magnetnog histerezisa i gubitaka usled vihornih struja. Za analizu frekventne zavisnosti koercitivnosti korišćen je model koji pored napred navedena dva efekta prati i anormalne gubitke usled vihornih struja. Najbolji set magnetnih karakteristika je postignut kod uzorka sinterovanog na 1370 °C.

NM1.3

#### KORELACIJA STEPENA RELATIVNE DEFORMACIJE ŽICE OD NERĐAJUĆEG ČELIKA X5CrNi18-10, TEMPERATURE I PROMENE GUSTINE STANJA ELEKTRONA U BLIZINI FERMIFEJVOG NIVOVA

*Milomir Sarić, Gimnazija "Vuk Karadžić", Loznica, Srbija*

*Dejan Vujičić, Univerzitet u Kragujevcu, Fakultet tehničkih nauka Čačak, Srbija*

*Ivan Milićević, Univerzitet u Kragujevcu, Fakultet tehničkih nauka Čačak, Srbija*

Izvršena su merenja termoelektromotorne sile (TEMS) termopara dobijenog mehaničkim spajanjem bakarnog provodnika prečnika Ø0,8 mm i različito deformisanih uzoraka žice prečnika Ø2,8 mm od nerđajućeg čelika X5CrNi18-10. U radu je utvrđena zavisnost između veličine relativne deformacije i relativne promene gustine stanja elektrona u blizini Fermijevoq nivoa. Ispitani su uzorci žice savijeni u obliku petlje različitih poluprečnika od 5 mm do 17 mm. Pokazano je da sa porastom stepena plastične deformacije relativna gustina stanja elektrona opada. Utvrđena je temperaturna zavisnost relativne promene gustine stanja elektrona pri različitim stepenima deformacije. Uz pomoć kalibracione krive dobijene merenjem TEMS za poznate vrednosti deformacije istezanjem utvrđena je zavisnost veličine relativne deformacije žice u obliku petlje od njenog radijusa.

NM1.4

#### FRAKTALNA KOREKCIJA I SCHOTTKY BARIJERA U HEYWANG MODELU INTERGRANULARNE KAPACITIVNOSTI BaTiO<sub>3</sub>- KERAMIKE

*Zoran Vosika, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

*Vojislav Mitić, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

*Goran Lazović, Univerzitet u Beogradu, Mašinski fakultet, Beograd, Srbija*

*Vesna Paunović, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

U radu je dat fraktalni pristup električnoj dinamici i statički Fermijevoq gasa u BaTiO<sub>3</sub>-keramici dopiranoj Ho<sub>2</sub>O<sub>3</sub> koncentracije od 0.01 do 1.0 wt%. U ovom radu istražene su korelacije mikrostrukturnih i drugih karakteristika materijala. Dopirani BaTiO<sub>3</sub> dobijen je korišćenjem konvencionalnog postupka sinterovanja u čvrstoj fazi na 1320°C tokom četiri sata. SEM analiza je pokazala da se u uzorcima dopiranim jonima retkih zemalja, veličina zrna kretala od 20-40 μm. Kod uzoraka sa većom koncentracijom dopanta abnormalni rast zrna je sprečen i veličina zrna se kod ovih uzoraka kretala između 2- 10 μm. Što se tiče električnih karakteristika kod uzoraka dopiranog BaTiO<sub>3</sub> primećen je pozitivni temperaturni koeficijenta otpora odnosno PTC efekat. Pošto je novi aspekt u analizi fraktalne prirode materijala, prema Mitić-Kocić pristupu, ovde se uvodi fraktalna korekcija koja se ispoljava kroz tri fraktalne korekcije (uticaj površine zrna i pora kao i Brownovog kretanja čestica) koje su odgovorne za kompleksnu geometriju, morfološke, i električne osobine materijala. Kompleksna fraktalna korekcija temperature osnova je za korekciju i Schotky-jeve barijere Heywang-ovog modela BaTiO<sub>3</sub>- keramike.

# **NT Nuclear Engineering and Technology / Nuklearna tehnika**

## **Sesija NT1: Nuklearno inženjerstvo i tehnologije**

Utorak, 12. Jun, 14:30 – 15:10, Sala 4

**Predstavljajući: Miloš Vujisić, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija**

### NT1.1

#### **NUKLEARNA OPCIJA O(P)STAJE u ENERGETSKOJ TRANZICIJI**

*Miodrag Mesarović, Energoprojekt Entel a.d., Bulevar Mihajla Pupina 12, 11070, Beograd, Srbija*

Ni katastrofalni udes u nuklearnoj elektrani (NE) u Černobilju 26.04.1986., niti havarija u NE Fukušima Daiči 11.03.2011. nisu ugrozili, već samo usporili gradnju novih proizvodnih kapaciteta na nuklearno gorivo. U nastojanju da se spreči nepovratna promena klime, nuklearni uz obnovljive izvore energije predstavljaju rešenje koje pravi razliku između onih zemalja koje mogu da ostvare svoj cilj smanjenja emisija gasova sa efektom staklene bašte i onih koje to ne mogu. Sa instalisanom neto snagom od 393.767 MWe u oko 450 reaktora u pogonu i novih 56.081 MWe u 57 reaktora u izgradnji, elektrane na nuklearno gorivo zadržavaju svoju poziciju značajnog izvora električne energije i pored globalnog usmeravanja na obnovljive izvore energije. Izazovi i prepreke koji utiču na o(p)stanak NE u tekućoj tranziciji sa fosilnih na obnovljive izvore energije detaljno su diskutovani u ovom radu.

### NT1.2

#### **ANALIZA DEJSTVA JONSKIH SNOPOVA na GFET STRUKTURE SIMULACIJOM TRANSPORTA ZRAČENJA**

*Ana Kalinić, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*

*Milos Vujisić, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*

Dejstvo snopova protona, alfa čestica, jona ugljenika i gvožđa na grafenski tranzistor sa efektom polja (GFET, graphene field effect transistor), u elektrodnim konfiguracijama sa gornjim i zadnjim gejtom, analizirano je pomoću Monte Carlo simulacija transporta zračenja. Energije upadnih čestica zadavane su u opsegu od 1 keV do 10 MeV. Struktura sa gornjim gejtom modelirana je slojevima Al-SiO<sub>2</sub>-grafen-Si, a sa zadnjim gejtom slojevima grafen-SiO<sub>2</sub>-Si-Al. Snopovi su usmeravani na prednju stranu tranzistora u obe elektrodne konfiguracije. Na osnovu podataka o tačkastim defektima prouzrokovanim zračenjem, dobijenih iz simulacija, izračunata je promena nejonizujućeg gubitka energije (NIEL) po dubini analiziranih struktura, kao i raspodela izmeštenih atoma i vakancija u oblasti izolatorske podloge neposredno uz grafenski monosloj. Pokazano je kako pokretljivost nosilaca naelektrisanja i slojna električna provodnost grafenskog sloja zavise od defekata formiranih u okolini ovog sloja. Identifikovani su opsezi energija upadnog zračenja za koje su očekivane promene električnih osobina GFET-a najizraženije. Cilj rada je da se dve ispitivane elektrodne konfiguracije GFET-a uporede po radijacionoj osetljivosti u modeliranim uslovima ozračenosti.

## **Session NT1: Nuclear Technology**

Tuesday, June 12<sup>th</sup>, 15:10 – 16:05, Hall 4

**Chair: Milos Vujisic, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia**

### NT1.1

#### **LOW-ENERGY X-RAY ANGULAR RESPONSE of OPTICALLY STIMULATED LUMINESCENT DOSIMETERS**

*Filip Haralambos Apostolakopoulos, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Nikola Kržanović, Vinča Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia*

*Luka Perazić, Public company "Nuclear Facilities of Serbia", Belgrade, Serbia*

*Koviljka Stanković, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

Following the requirements of radiation protection international standards, passive dosimetry systems are type tested, which includes the angular dependence. As it represents one of the most important dosimeter characteristics, the angular dependence of commercially available optically stimulated luminescent dosimeters has been examined in this paper. The empirically determined air kerma to the personal dose equivalent conversion coefficients decrease as the angle of incidence increases. It was anticipated that the dosimeter response would show a similar behavior. This expectation has been confirmed for all the used angles of incidence and energies of the primary X-ray beam, except for the 80° angle of incidence and the 33 keV and 48 keV mean photon energies, where an increase in the angular response has been observed.

#### NTI1.2

##### ENERGY, ANGULAR and DOSE RATE DEPENDENCE of a G-M TUBE-BASED SURVEY METER

*Nikola Kržanović, Vinča Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia*

*Filip Haralambos Apostolakopoulos, School of Electrical Engineering, University of Belgrade, Belgrade, Serbia*

*Miloš Đaletić, Vinča Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia*

*Miloš Živanović, Vinča Institute of Nuclear Sciences, University of Belgrade, Belgrade, Serbia*

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

Survey meters represent common radiation protection instruments used for ambient monitoring. They estimate the effective dose of occupationally exposed personnel, by measuring the ambient dose equivalent. A performance testing of a Geiger-Müller tube-based survey meter was realized in this paper. The energy and the dose rate dependence were determined for different thicknesses of lead tube wrappings, in order to achieve the optimal energy compensation. The energy response for higher-energy photons slightly improved by applying these filters, while it significantly worsened for low-energy X-rays. The angular dependence was tested in terms of angular response and its symmetry for different radiation qualities.

#### NTI1.3

##### RADON EXHALATION from SOIL: APPLICATION of the ACTIVE METHOD

*Luka Rubinjon, Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, 11000 Belgrade, Serbia*

*Igor Čeliković, Vinča Institute of Nuclear Sciences, University of Belgrade, Mike Petrovića Alasa 12-14, 11001 Belgrade, Serbia*

*Dunja Antonijević, Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, 11000 Belgrade*

*Boris Lončar, Faculty of Technology and Metallurgy, University of Belgrade, Karnegijeva 4, 11000 Belgrade, Serbia*

Radon is a radioactive noble gas, its isotopes being the progeny of radium in the decay series of uranium and thorium. It is a potent alpha emitter, and presents an occupational hazard in uranium mining, and other activities involving radium and its progeny. Due to exhalation from ground and building materials, chronic exposure to indoor radon is a major factor in lung cancer risk in affected households. Voluntary exposure to radon occurs in radon spas, stressing the issue of received dose by both patients and staff. Precise measurements of radon activity in the air are the basis of its risk assessment, or effective avoidance. Sealed chamber active alpha spectrometry was examined as the method of measurement of radon exhalation from soil and travertine samples.

# RO Robotics and Flexible Automation / Robotika i fleksibilna automatizacija

## Sesija RO1:

Sreda, 13. Jun, 08:00 – 08:30, Sala 1

**Predstavljajući: Vladimir Kvrđić, Institut Mihajlo Pupin - Beograd, Srbija**

### RO1.1

#### ADAPTIVNO UPRAVLJANJE ROBOTIMA S ELASTIČNIM POGONOM

*Maja Trumić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

*Adriano Fagiolini, Univerzitet u Palermu, Italija*

*Kosta Jovanovic, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

Roboti sa elastičnim pogonom su deo futurističke zamisli u kojoj će roboti i ljudi u neposrednom okruženju obavljati različite poslove bez straha za bezbednost čoveka. Zahvaljujući fleksibilnosti robota sa elastičnim pogonom njihova uloga je takođe značajna u rehabilitaciji. U radu je izložen pregled najnovijih istraživanja u oblasti automatskog upravljanja robotima sa elastičnim pogonom. Opisani su roboti sa električnim pogonom, gde se preko elastične opruge prenosi sila. Dat je osvrt na primenu sistema sa adaptivnim upravljanjem kao perspektivnog rešenja za kontrolu robota sa elastičnim pogonom.

### RO1.2

#### ALGORITMI VEŠTAČKE INTELIGENCIJE I NJIHOVA PRIMENA ZA ANALIZU LJUDSKIH POKRETA

*Anita Lupšić, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

*Marija Tomić, Institut Mihajlo Pupin, Beograd*

*Goran Kvaščev, Elektrotehnički fakultet, Univerzitet u Beogradu, Srbija*

У овом раду су представљени алгоритам фази логике и алгоритам редукције димензија на бази матрица расејања за задатак израчунавања оптималне комбинације тежинских коефицијената за генерисање покрета хуманоидних робота налик људском кретању. Комбинација критеријума која је анализирана у овом случају се састоји од критеријума минимизације кинетичке енергије, минимизације брзине у зглобовима, максимизације манипулабилности и тежња ергономичној позицији човека. База података се састоји од путања седам зглобова руку и трупа (Sholder Pitch, Sholder Yaw, Sholder Roll, Elbow Yaw, Wrist Pitch, Wrist Yaw, Trunck Pitch). Ове трајекторије су снимљене на скупу од петнаест испитаника за седам различитих покрета: отварање и затварање фиоке, окретање вентила, управљање воланом, пумпање душека ручном пумпом, сецање, рендање хране и веслање. Генерисани алгоритми су примењени на непознатим покретима и тиме проверена валидност добијених резултата.

## Session RO11:

Wednesday, June, 13<sup>th</sup>, 08:30 – 09:30, Hall 1

**Chair: Veljko Potkonjak, School of Electrical Engineering, University of Belgrade, Serbia**

## ROI1.1

### AUTONOMOUS CAR DRIVING – ONE POSSIBLE IMPLEMENTATION USING MACHINE LEARNING ALGORITHM

*Igor Ciganović, Faculty of computing, Belgrade, Serbia*

*Aleksandar Pluskoski, Faculty of computing, Belgrade, Serbia*

*Miloš Jovanovic, Mihajlo Pupin Institute, Belgrade, Serbia*

Different approaches to developing the AI systems for self-driving vehicles exist and almost all of them are very complex and with very high hardware requirements. The solution presented in this paper proposes the machine learning based system to be as simple as possible with very low hardware requirements. A simple three layers deep, fully connected neural network was trained to map input images from a front facing QVGA camera to steering commands. Based on a input image the neural network should choose one of the four available commands (forward, left, right or stop). With minimum of the training data (250 images) the system learned to follow the road ahead and stay in its lane. The system automatically learns necessary road features with only the steering angle as the input from the human driver. It was never explicitly trained to detect lines on the road. Compared to much more complex solutions like explicit decomposition of the problem, such as lane detection and control, and convolutional neural networks like the end to end learning proposed by the nVidia this system proved to be surprisingly robust and efficient. We try to prove that this approach would lead to better performance and lower hardware requirements thus making the development of the self-driving vehicles simpler and more cost-effective. Simple artificial neural network, like the one presented in this paper, is enough for relatively complex process like lane keeping.

## ROI1.2

### VEHICLE COLLISION AVOIDANCE IN A DYNAMIC ROAD TRAFFIC SCENARIO

*Abdalgalil Abdulla, School of Electrical Engineering, University of Belgrade, Serbia*

*Aleksandar Rodić, Mihajlo Pupin Institute, Belgrade, Serbia*

*Stevica Graovac, School of Electrical Engineering, University of Belgrade, Serbia*

Lane changing and psycho-physical vehicle-following models tries to capture both the physical elements of vehicle motion as well as the human components in overcrowded traffic simulations. These models determine the reactions of the vehicle driver depending on the vehicle's state. Lane-changing models describe driver's behavior when deciding whether to change lane or not on a multi-lane road, e.g. when traveling on a highways or two-way roads. The purpose of this paper is to provide a case-study to vehicle collision avoidance at dynamic circular road of two lanes with different traffic scenarios. This case-study includes a description, some discussion of the important behaviors for the mentioned models, a derivation, and some examples with assumed road traffic scenarios & results. Derived models are the basis for autonomous guidance of road vehicles.

## ROI1.3

### APPLICATION OF UNMANNED GROUND VEHICLE IN PLANT DIAGNOSIS

*Dragan Dragicevic, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Igor Baranovski, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Dragana Oros, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Gordana Ostojic, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Stevan Stankovski, Faculty of Technical Sciences, University of Novi Sad, Serbia*

This paper presents application of unmanned ground vehicle (UGV) in plant diagnosis. The aim is to develop a mobile system which will be able to autonomously reach desired GPS locations in the field and analyze plants with attached equipment. Collected data are sent via GSM modem or Wi-Fi to server so it can be used for further analysis. Collected data should give an insight into the health of plants and locate areas in the field

which needs to be treated. This approach gives a possibility to apply plants treatment only in the areas where it is actually needed which leads to optimal usage of fertilizers, pesticides, fungicides and other chemicals.

ROI1.4

#### KINEMATIC PARAMETERS FOR GENERATION OF ACCELERATION FORCE PROFILE OF A CENTRIFUGE FLIGHT SIMULATOR

*Vladimir Kvrgić, Mihajlo Pupin Institute, Belgrade, Serbia*

*Jelena Vidaković, Lola institute, Belgrade, Serbia*

Pilots of modern combat aircrafts are exposed to the devastating effects of high acceleration forces. The pilots' ability to perform tasks under these extreme flight conditions must be examined. For the purpose of pilot training, a centrifuge flight simulator (CFS) for pilot training is designed as a 3DoF manipulator with rotational axes. Through rotations about these axes, acceleration forces that act on the aircraft pilots are simulated. The CFS must achieve velocity, acceleration and acceleration rates (jerks) of the pilot through rotation of its arm. A constant increase/decrease in the acceleration force acting on a pilot is required according to specifications. To prevent the abrupt change in the arm angular velocity before and after the desired linear change in the acceleration force, smoothing of the acceleration force profile through arm motion is necessary. The roll and pitch angles (the angles of the second and the third link) and the arm angular velocity define the orthogonal components of the resultant vector of the acceleration force that are experienced by the simulator pilot. The determination the arm angular velocity and angular acceleration profiles and the roll and pitch angles needed for achieving the desired acceleration force components of the CFS is presented in this paper.

ROI1.5

#### AUTOMATIC ADAPTATION OF NAO ROBOT GAIT TO DIFFERENT FLOOR FRICTION CONDITIONS

*Guilherme Franco, University of Coimbra, Coimbra, Portugal*

*Luis Almeida, University of Aveiro, Aveiro, Portugal*

*João Ferreira, Instituto Politécnico de Coimbra, Coimbra, Portugal*

*Aleksandar Rodić, Mihajlo Pupin Institute, Belgrade, Serbia*

When walking on flat and slippery surfaces, bipedal robots find it hard to stay upright. Humans, on the other hand, have evolved to adapt to this situation. This paper proposes a controller that alters a humanoid robot's gait in order to adapt itself to different friction coefficients between the robot's foot and the floor, based on human walking analysis and adaptation to slippery surfaces.

ROI1.6

#### COLLISION DETECTION ON INDUSTRIAL ROBOT USING DYNAMIC TIME WARPING

*Zaviša Gordić, School of Electrical Engineering, University of Belgrade, Serbia*

*Kosta Jovanović, School of Electrical Engineering, University of Belgrade, Serbia*

This paper proposes a simple algorithm for collision detection based on comparison of reference signal sequence with current signal measurements from the robot. Dynamic Time Warping (DTW) is used to find best matching samples of the two signal sequences and to identify samples which might indicate collision. As part of solution for real-time implementation, the paper proposes modification of the DTW method. The signal used for comparison can be current or torque measurement, making the algorithm adaptable to various brands of robots, regardless of their configuration. The performance of the algorithm is validated with measurements from real industrial robot, and results are discussed. The paper also considers real-time implementation issues and proposes solutions.

### **Session ROI2:**

Wednesday, June, 13<sup>th</sup>, 09:30 – 10:30, Hall 1



**Chair: Aleksandar Rodić, Institut Mihajlo Pupin - Beograd, Srbija**

ROI2.1

**REAL-TIME CONTROL OF HUMAN-LIKE ROBOT JOINT BASED ON ONLINE MEASUREMENT OF JOINT POSITION AND MUSCLE ACTIVITY**

*Nikola Knežević, School of Electrical Engineering, University of Belgrade, Serbia*

*Marija Novičić, School of Electrical Engineering, University of Belgrade, Serbia*

*Milica Janković, School of Electrical Engineering, University of Belgrade, Serbia*

*Kosta Jovanović, School of Electrical Engineering, University of Belgrade, Serbia*

In this paper authors present human-like robot joint controlled based on measurement of joint position and muscle activity in real-time. Human-like joint that was used in this paper, was developed at ETF Robotics Laboratory. Measurement had been acquired by Xbox360 Kinect module for joint position and electromyography (EMG) sensor for biceps brachii muscle activity. Kinect is used to capture arm motion. A dedicated algorithm, which from depth image generates coordinate of all human joints, was used to define characteristic points of the arm. Based on obtained coordinate positions of shoulder, elbow and wrist, the angle between the forearm and the upper arm is estimated and used to control robot joint position. EMG signals are used for controlling stiffness of the robot joint due to amplitude change which occurs due to muscle strain.

ROI2.2

**CASCADE CONTROL DESIGN FOR ANTAGONISTIC ROBOT JOINT BASED ON ARX MODEL CHARACTERIZATION**

*Branko Lukić, School of Electrical Engineering, University of Belgrade, Serbia*

*Kosta Jovanović, School of Electrical Engineering, University of Belgrade, Serbia*

*Tomislav Šekara, School of Electrical Engineering, University of Belgrade, Serbia*

*Veljko Potkonjak, School of Electrical Engineering, University of Belgrade, Serbia*

This paper presents controller tuning approach for simultaneous position and stiffness cascade control of variable stiffness antagonistic joint, which can be easily applied to other types of Variable Stiffness Joints (VSJ). The first step is tuning of inner loops (motors positions) controllers. Controllers of inner loops are realized in form of a PID controller with filtration. The criterion for controller tuning is satisfying maximal value for sensitivity function ( $ms$ ), where  $ms$  is calculated for the second order transfer function motor model. Value for  $ms$  is selected to present a good trade-off between motor trajectory tracking and robustness. The second step is characterization of the system with internal loops around the predefined nominal set points. System inputs are desired motors positions, while outputs are shafts position and stiffness. Input is generated as Pseudo Random Binary Signal (PRBS). For this system high order ARX model is obtained, which is then reduced to lower level model that describes dominant dynamic behavior. Model reduction is performed using information from Gramian matrix. The third step is adaptive controller design for fine tuning of system dynamics in different set points. Therefore, bank of controllers is formed and it is used to tune outer loop controllers' (shaft position and stiffness). Outer loop controllers are realized in form of a PID controller with filtration. Again, criterion for controller tuning is satisfying maximal value for equivalent sensitivity function  $ms_e$ , where  $ms_e$  is calculated for dynamics obtain in system characterization in the second step.  $ms_e$  value is selected to present a good trade-off between shaft position/stiffness tracking and robustness.

### ROI2.3

#### ROBUST PID CONTROL FOR ROBOT MANIPULATORS WITH PARAMETRIC UNCERTAINTIES

*Petar Mandić, Faculty of Mechanical Engineering, University of Belgrade, Serbia*

*Mihailo Lazarević, Faculty of Mechanical Engineering, University of Belgrade, Serbia*

*Tomislav Šekara, School of Electrical Engineering, University of Belgrade, Serbia*

*Boško Cvetković, Faculty of Mechanical Engineering, University of Belgrade, Serbia*

Most of industrial robots use a classical PID-type controller for positioning tasks. Main reason for this is its effectiveness in regulation tasks, simple linear structure, and easy implementation. Moreover, it is well known that the robustness properties of a PID controller makes it an excellent choice for set point control of robot manipulators. In this paper, a robust PID controller is designed in order to cope with modeling uncertainties and unmodelled dynamics. First, dynamic model of robot manipulator is derived using the Rodriguez approach. Then, a PID controller is applied to feedback linearized robotic system in order to suppress constant disturbance and achieve good set-point control. The proposed controller contains one adjustable parameter  $\lambda$ , which has direct influence on the time constant of the closed loop system. By adjusting it, one can accomplish a compromise between the robustness and performance indices. Using this algorithm, simulation results of a NeuroArm robotic manipulator executing positioning tasks are shown to demonstrate the efficiency of the proposed controller.

### ROI2.4

#### SENSORY-BASED REHABILITATION SYSTEM FOR MOVEMENT ASSESSMENT IN NEUROLOGICAL DISORDERS

*Sofija Spasojević, Mihajlo Pupin Institute, Belgrade, Serbia*

*Aleksandar Rodić, Mihajlo Pupin Institute, Belgrade, Serbia*

*José Santos-Victor, Universidade de Lisboa, Portugal*

In this paper, we present the rehabilitation system for movement assessment in neurological disorders. We propose multi-sensory system composed of three sensor devices, which combines several types of sensor data. Additionally, we propose performance indicators, extracted from the sensor signals and intended for movement characterization. The focus is on the Parkinson's disease and stroke patients. Sensor recordings are collected in the hospital settings for outpatients with the supervision of medical doctors and movement disorder specialists. The proposed system and approach for movement quantification are intended to support the clinical evaluations and to monitor the patients' state over time relying on the specially designed software application.

### ROI2.5

#### ROBOTIC EYE WITH 4DOFs: KINEMATIC ANALYSIS AND MOTION SIMULATION

*Marko Penčić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Maja Čavić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Branislav Borovac, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Zhenli Lu, Changshu Institute of Technology, People Republic of China*

The paper presents the kinematic analysis and motion simulation of the robotic eye with neutral canthal tilt. The eyeball/eyelids drive system with total 4 DOFs is proposed. Eyeball drive system has 2 DOFs and enables rotation of the eye around the pitch and yaw axes. The proposed solution enables the installation of camera directly into the eyeball. Eyelids drive system has also 2 DOFs and enables independent rotation of the upper and lower eyelid. Output kinematic parameters of the eyeball and the upper/lower eyelids are formed by kinematic analysis. Based on that, motion simulation of eyeball and upper/lower eyelid was performed. For the interval of motion which corresponds to the human eye, angular velocities of the eyeball and upper/lower eyelids are within the human eye kinematic parameters, which was the main design request.

ROI2.6

## REPRESENTATIONAL LEARNING IN CONVERSATIONAL AGENTS

*Srđan Savić, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Milan Gnjatović, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Dragiša Mišković, Faculty of Technical Sciences, University of Novi Sad, Serbia*

*Branislav Borovac, Faculty of Technical Sciences, University of Novi Sad, Serbia*

In this paper, we report on a prototype conversational agent for natural language human-robot interaction, integrated with the assistive human-like robot MARKO. The presented prototype conversational agent is based on an extended and upgraded functional architecture encapsulating the novel functionality of representational learning in natural language human-machine interaction, primarily based on semantic categorization and associative learning of mental representations. The proposed approach is domain-independent, and in this paper it is illustrated for an interaction domain related to robot-supported therapy.

## **Session ROI3:**

Wednesday, June, 13<sup>th</sup>, 11:00 – 11:30, Hall 1

**Chair: Veljko Potkonjak, School of Electrical Engineering, University of Belgrade, Serbia**

ROI3.1

## COMPUTER-AIDED REHABILITATION WITH A NEURO-MUSCULO-SKELETAL MODEL (Invited Paper)

*Kazunori Hase, Department of Mechanical Systems Engineering, Tokyo Metropolitan University, Tokyo, Japan*

This paper describes a computer simulation model of the neuro-musculo-skeletal system for human locomotion that seeks to improve the practicability of the simulation method for application to rehabilitation. The musculo-skeletal system was represented by a three-dimensional, 14-rigid-link model and 60 muscle models. Muscular forces were controlled by a neuronal system model consisting of 16 pairs of the neural oscillators. Neuronal control parameters were adjusted based on an optimization method. This simulation model was applied to investigate biomechanical relationship between walking stability and body dynamics properties related with aging. Spastic gait was also synthesized using the proposed model. These computer simulation models would clarify causal relationship between walking pattern and mechanical properties of the neuro-musculo-skeletal system for aging and spasticity. Such simulation methods will provide us with a novel computational assessment tool of human walking and other movement in rehabilitation.

# RT Computer Science / Računarstvo

## Sesija RT1: Računarska grafika i multimedija

Ponedjeljak, 11. Jun, 11:00 – 12:00, Sala 2

**Predsedavajući: Milan Bjelica, RT-RK.doo, Novi Sad, Srbija**

### RT1.1

#### JEDNO REŠENJE APLIKACIJE VIRTUELNE STVARNOSTI ZA PRIKAZ GEOGRAFSKIH MAPA

*Uros Visekruna, Fakultet Tehničkih Nauka, Univerzitet u Novom Sadu*

*Milan Bjelica, RT-RK.doo, Novi Sad, Srbija*

*Goran Stupar, Fakultet Tehničkih Nauka, Univerzitet u Novom Sadu*

*Milan Savic, RT-RK.doo, Novi Sad, Srbija*

#### Abstrakt:

U ovom radu je realizovano rešenje aplikacije virtuelne stvarnosti u operativnom sistemu Android. Aplikacija omogućava pregled trodimenzionalnog modela planete Zemlje koji je augmentiran korisnim informacijama, poput vremenske prognoze i naseljenosti gradova. Ove informacije aplikacija dobavlja korišćenjem Web servisa.

### RT1.2

#### PREGLED I KOMPARATIVNA ANALIZA TEHNIKA I ALATA ZA VIZUELIZACIJU ONTOLOGIJA

*Jelena Ćurguz, Pošte Srpske a.d. Banja Luka*

U ovom radu je dat pregled postojećih tehnika i alata za vizuelizaciju ontologija kao i rezultati njihove komparativne analize. Analiziran je veliki broj alata i tehnika, a predmeti analize su bili osnovne karakteristike, prednosti, nedostaci, zajednička obilježja kao i mogućnost kombinovanja njihovih karakteristika u jedinstven metod. Uzimajući u obzir navedena istraživanja kao i rezultate analize, vizuelizacija ontologija je predstavljena kao ontologija upotrebom Protégé alata.

### RT1.3

#### JEDNO REŠENJE GRAFIČKE KORISNIČKE PODRŠKE ZASNOVANE NA ANDROID PROGRAMSKOM STEKU

*Milan Novaković, Fakultet Tehničkih Nauka, Univerzitet u Novom Sadu*

*Darko Dejanović, RT-RK.doo, Novi Sad, Srbija*

*Ilija Bašičević, Fakultet Tehničkih Nauka, Univerzitet u Novom Sadu*

U ovom radu je prikazano jedno rešenje implementacije reda za preporuke u startnoj aplikaciji na Android AOSP platformi. Cilj ovog rada jeste prilagođavanje i izmena startne aplikacije krajnjim korisnicima u cilju boljeg korisničkog ugođaja, kao i prilagođavanje TV operaterima zarad lakšeg plasiranja proizvoda. Dato rešenje je implementirano u modulima koji su međusobno povezani radi ostvarivanja željene funkcionalnosti.

### RT1.4

#### DEVELOPMENT OF APPLICATION FOR RECORDING MPEG-DASH DATA STREAMS AND PROTECTION OF RECORDED DATA ON DEVICES WITH ANDROID OPERATING SYSTEM

*Branimir Lazarević, RT-RK.doo, Novi Sad, Srbija*

*Marija Jovanović, RT-RK.doo, Novi Sad, Srbija*

*Dušan Živkov, RT-RK.doo, Novi Sad, Srbija*

*Đorđe Glišić, RT-RK.doo, Novi Sad, Srbija*

Ideja ovoga rada je proširenje ExoPlayer biblioteke u cilju realizacije aplikacije koja pruža neophodne funkcionalnosti za savremene korisnike digitalne televizije. PVR (eng. personal video recorder) aplikacija je sve popularnija među korisnicima. Da bismo napravili aplikaciju koja ima PVR funkcionalnost, koristeći ExoPlayer biblioteku neophodno je bilo obezbediti podršku za snimanje audio i video sadržaja. Audio i video koji smo snimali je predstavljen u vidu adaptivnog toka podataka (MPEG-DASH). Realizovana je i podrška za zaštitu sadržaja koji se snima.

## **Sesija RT2: Ugrađeni računarski sistemi**

Ponedjeljak, 11. Jun, 12:00 – 13:00, Sala 2

**Predsedavajući: Vladan Vučković, Univerzitet u Nišu, Elektronski fakultet**

RT2.1

PORTING ANDROID OREO OPERATING SYSTEM FOR CI20 PROGRAM PLATFORM

*Lazar Tršić, RT-RK.doo, Novi Sad, Srbija*

*Dragan Čečavac, RT-RK.doo, Novi Sad, Srbija*

*Dejan Jovičević, RT-RK.doo, Novi Sad, Srbija*

*Miodrag Dinić, RT-RK.doo, Novi Sad, Srbija*

*Petar Jovanović, RT-RK.doo, Novi Sad, Srbija*

Ovaj rad opisuje postupak dodavanja i testiranja Android Oreo podrške na CI20 programskoj platformi koja već ima Android Nougat operativni sistem. Rad se osvrće na najbitnije razlike i ograničenja između pomenutih verzija. Promene se najvećim delom odnose na reorganizaciju arhitekture pristupa bibliotekama fizičke arhitekture sa ciljem da ceo sistem postane fleksibilniji i da se sa manje resursa ažurira u budućnosti. Rad navodi izmene koje treba da primene svi uređaji pri prelasku na Oreo ili kasnije verzije operativnog sistema Android. Provera ispravnosti realizovane podrške je potvrđena grupama testova CTS, VTS i VINTF, kao i ručnim ispitivanjem kritičnih funkcionalnosti.

## RT2.2

### PRILAGOĐAVANJE WEB ČITAČA COBALT ZA PROGRAMSKU PLATFORMU CI2

*Milko Leporis, RT-RK.doo, Novi Sad, Srbija*

*Gordana Cmiljanović, RT-RK.doo, Novi Sad, Srbija*

*Dejan Latinović, RT-RK.doo, Novi Sad, Srbija*

*Dragan Mladenović, RT-RK.doo, Novi Sad, Srbija*

U ovom radu je prikazana problematika prilagođavanja web čitača Cobalt programskoj platformi CI20 (MIPS). Web čitač Cobalt je prilagođen za izvršavanje na platformama koje imaju ograničene resurse. Prilikom prilagođavanja, kao referentne programske platforme su korišćene PC (x64) i Raspberry PI (ARM). Razmatran je niz problema koji se javljaju zbog ograničenja ciljne programske platforme CI20, kao i zbog ograničenja korišćenih alata za prevođenje i uvezivanje. Za pronađene probleme ponuđena su rešenja koja omogućavaju izvršavanje web čitača na platformi CI20.

## RT2.3

### UNAPREĐENJE PROGRAMSKOG PREVODIOCA JAVASCRIPTCORE-A ZA MIPS32R1 ARHITEKTURU

*Branimir Vasic, RT-RK.doo, Novi Sad, Srbija*

*Stanislav Ocovaj, RT-RK.doo, Novi Sad, Srbija*

*Radovan Birdic, RT-RK.doo, Novi Sad, Srbija*

*Petar Jovanovic, RT-RK.doo, Novi Sad, Srbija*

Cilj ovog rada je da prikaže korake prilikom unapređenja programskog prevodioca JavaScriptCore za MIPS32r1 arhitekturu procesora. MIPS je arhitektura sa procesorom smanjenog skupa naredbi (RISC) i jedna je od dominantnih arhitektura na tržištu ugrađenih (eng. embedded) uređaja potrošačke elektronike (digitalni televizori, prijemnici digitalnog TV signala (engl. set-top box, STB), igračke konzole, itd.). JavaScriptCore (JSC) je JavaScript prevodilac koji leži u osnovi WebKit-a. Veoma je brz, prvenstveno zbog prevodioca koji je realizovan u tri nivoa: interpretatora niskog nivoa (eng. Low Level Interpreter, skr. LLint), osnovnog prevodioca (eng. Baseline Just-In-Time, skr. Baseline JIT) i optimizovanog prevodioca (engl. Data Flow Graph Just-In-Time, skr. DFG JIT). Svaki nivo uzima bajt kod kao ulaz koji se dalje ili interpretira ili prevodi. Nakon optimizacije za MIPS platformu prevodilac je ubrzan oko 10%.

## RT2.4

### DODAVANJE PODRŠKE DINAMIČKOM ANALIZATORU PROGRAMSKOG KODA VELGRIND ZA ABI N32 MIPS ARHITEKTRE

*Dimitrije Nikolic, RT-RK.doo, Novi Sad, Srbija*

*Aleksandar Rikalo, RT-RK.doo, Novi Sad, Srbija*

*Aleksandra Karadžić, RT-RK.doo, Novi Sad, Srbija*

*Tamara Vlahović, RT-RK.doo, Novi Sad, Srbija*

*Petar Jovanović, RT-RK.doo, Novi Sad, Srbija*

Pojava 64-bitnih MIPS procesora devedesetih godina 20. veka dovodi do velikog jaza između postojećeg 32-bitnog ABI-ja (o32) i novonastalog 64-bitnog ABI-ja (n64). Prilikom portovanja 32-bitnih programa na 64-bitne sisteme nastaje problem usled razlike u veličini long tipa i veličini pokazivača. Kako većina 32-bitnih programa nema potrebu za većim adresnim prostorom, MIPS uvodi novi ABI – n32, koji predstavlja umanjenu verziju n64 ABI-ja. Ovaj rad opisuje izmene načinjene u alatu za dinamičku analizu binarnog koda Velgrind, sa ciljem dodavanja podrške za ABI n32 za arhitekturu MIPS.

## **Sesija RT3: Sistemi zasnovani na računarskim mrežama**

Ponedjeljak, 11. Jun, 14:30 – 15:30, Sala 2

**Predstavljajući: Ilija Bašičević, Fakultet tehničkih nauka, Novi Sad**

RT3.1

JEDNO REŠENJE INTEGRACIJE MODULA ZA NADZOR I KONFIGURACIJU UREĐAJA ZASNOVANOG NA TR-069 PROTOKOLU

*Milan Ivanković, Fakultet tehničkih nauka, Novi Sad*

*Darko Dejnović, Fakultet tehničkih nauka, Novi Sad*

*Ilija Bašičević, Fakultet tehničkih nauka, Novi Sad*

U ovom radu je prikazano proširenja postojećeg rešenja za integraciju modula za konfiguraciju i nadzor uređaja zasnovanog na TR-069 komunikacionom protokolu u formi sistemskog servisa za set-top-boks (STB) uređaje zasnovane na Android platformi. Rešenje je identično prilagođeno za dve nove platforme i prošireno specifičnim funkcijama za Android Nougat. Nadograđen je komunikacioni sloj između TR-069 servisa i Android aplikacija. Dobavljanje i ažuriranje programske podrške, odnosno instaliranje aplikacije prilagođeno je Android Nougat-u. U okviru TR-069 klijent servisa dodat je STUN klijentski modul.

RT3.2

LANAC ALATA ZA INKREMENTALNO AŽURIRANJE CILJNE PLATFORME

*Srba Sanader, RT-RK.doo, Novi Sad, Srbija*

*Marko Krnjetin, RT-RK.doo, Novi Sad, Srbija*

*Nenad Četić, RT-RK.doo, Novi Sad, Srbija*

*Dragan Samardžija, RT-RK.doo, Novi Sad, Srbija*

U ovom radu je prikazano jedno programsko rešenje inkrementalnog ažuriranja ciljne platforme pomoću lanca alata čiji zadatak je konverzija raznih tipova ulaznih datoteka u jedinstven XML format, obrada i organizacija ulaznih podataka, kao i upisivanje ovih podataka na ciljnu platformu. Izlazni podaci su organizovani u pakete radi efikasnijeg upisivanja na ciljnu platformu. Realizovani alati se koriste iz komandne linije i pisani su u Java programskom jeziku. U okviru rada vršeno je istraživanje integracije koda pisanog u CPython programskom jeziku i koda pisanog u Java programskom jeziku, kao i JEP biblioteke koja je korišćena u tu svrhu.

RT3.3

OPTIMIZACIJA UPOTREBE DELTA PATCH-EVA ZA AŽURIRANJE FIRMVERA BAZIRANOG NA OTP

*Jovan Zelenković, RT-RK.doo, Novi Sad, Srbija*

*Momčilo Krunić, RT-RK.doo, Novi Sad, Srbija*

*Nemanja Lukić, RT-RK.doo, Novi Sad, Srbija*

*Marko Kovačević, RT-RK.doo, Novi Sad, Srbija*

U radu je opisano jedno rešenje za optimizaciju upotrebe delta patch-eva za ažuriranje firmvera baziranog na OTP memoriji. OTP (One Time Programmable) memorija predstavlja memoriju u koju je moguće pisati samo jednom. Zbog ograničene veličine OTP memorije na uređaju i nemogućnosti brisanja podataka sa željenih lokacija, optimizacija upotrebe memorijskog prostora u OTP-u je izuzetno važan korak pri projektovanju i upotrebi uređaja ovog tipa. Cilj istraživanja je ušteda memorijskog prostora u OTP-u optimizacijom generisanih delta patch-eva. Opisano rešenje je testirano pomoću programskog alata Matlab

RT3.4

MODEL REPRODUKCIJE ZAŠTIĆENOG MULTIMEDIJALNOGSADRŽAJA NA ANDROID BAZIRANIM UREĐAJIMA

*Emilija Kostic, RT-RK.doo, Novi Sad, Srbija*

*Nikola Bezanic, RT-RK.doo, Novi Sad, Srbija*

*Nikola Vranic, RT-RK.doo, Novi Sad, Srbija*

Android platforma koja se tipično koristi na mobilnim telefonima, sve više je zastupljena i na drugim uređajima, pri čemu se u ovom radu koristi u kontekstu digitalne televizije i zaštite multimedijalnih sadržaja. U oblasti digitalne televizije se često koriste metode zaštite na bazi sprege sa pametnim karticama ili na bazi komunikacije sa serverom licenci. Ovakva rešenja su tipično praćena oskudnom dokumentacijom koja dolazi od strane proizvođača, pa je jedan od glavnih ciljeva ovog rada da pruži opšti pregled načina realizacije jednog takvog sistema. Prvobitno je dat opšti opis Android platforme i mogućnostima zaštite sadržaja, a zatim je dat opis realizacije rešenja koje se zasniva na komunikaciji sa serverom licenci baziranom na Node.js JavaScript okruženju. Opis rešenja daje detalje režima rada aplikacije, komunikacije sa serverom, sekvence šifrovanja/dešifrovanja i formata korišćenih datoteka.

## **Sesija RT4: Programski prevodioci**

Ponedjeljak, 11. Jun, 15:30 – 16:15, Sala 2

**Predstavljajući: Miodrag Đukić, Fakultet tehničkih nauka, Novi Sad**

### RT4.1

UVODENJE PODRŠKE ZA KOMPLEKSNE BROJEVE SA NEPOKRETNIM ZAREZOM U PREDNJI DEO C PREVODIOCA ZA DSP-OVE

*Aleksandar-Vuk Pavlović, RT-RK.doo, Novi Sad, Srbija*

*Miodrag Đukić, Fakultet tehničkih nauka, Novi Sad*

*Dejan Bokan, Fakultet tehničkih nauka, Novi Sad*

*Vladimir Marinković, Fakultet tehničkih nauka, Novi Sad*

Programski jezik C nudi podršku za kompleksne brojeve, ali je ta podrška zasnovana na brojevima sa pokretnim zarezom. Namenski procesori, zbog ograničenja finansijske i fizičke prirode, poseduju mogućnost korišćenja samo brojeva sa nepokretnim zarezom. Ovaj rad opisuje proces uvođenja podrške za kompleksne brojeve zasnovane na brojevima sa nepokretnim zarezom u prednji deo jednog prevodioca za namenski DSP (engl. Digital Signal Processing — Digitalna obrada signala) procesor. Ova podrška uključuje, između ostalog: deklarisanje, definisanje i inicijalizaciju, osnovne aritmetičke operacije, prosleđivanje u funkcije, objedinjavanje u slogove i nizove itd.

### RT4.2

UNAPREĐENJE INFORMACIJA ZA TRAŽENJE GREŠAKA UNUTAR PROGRAMSKOG PREVODIOCA LLVM

*Nikola Prica, RT-RK.doo, Novi Sad, Srbija*

*Dorđe Todorović, RT-RK.doo, Novi Sad, Srbija*

Tokom traženja grešaka u visoko optimizovanim programima, koristeći alate koji se oslanjaju na dodatne informacije za traženje grešaka koje proizvodi programski prevodilac, može se naići na situaciju u kojoj je ispis određene promenljive nepoznat u određenom trenutku. Cilj ovog rada jeste da prikaže reprezentaciju informacija o lokaciji promenljive, kao i tehnike očuvanja ovih informacija kroz različite faze optimizacije programskim prevodiocem LLVM. Kroz rad će biti prikazan i jedan od načina za traženje propusta u prenošenju informacija o promenljivama kroz različite delove prevođenja.

### RT4.3

SERVIS ZA INDEKSIRANJE RAZLIČITIH TIPOVA DATOTEKA I PODATAKA IZ BAZA PODATAKA



*Zoran Denda, Ministarstvo odbrane, Beograd, Srbija*

*Željana Vučetić, Ministarstvo odbrane, Beograd, Srbija*

Ovaj rad sadrži prikaz implementacije servisa za indeksiranje datoteka i podataka iz baza podataka. Servis se koristi kao deo sistema koji se sastoji od datoteka smeštenih na deljenim lokacijama u lokalnoj računarskoj mreži, različitih baza podataka, elasticsearch klastera kao softvera za pretragu kompletnog teksta i Kibane kao klijentske veb aplikacije za analizu, vizuelizaciju i pretragu indeksiranih podataka. Servis je implementiran u C# programskom jeziku.

## **Session RTI1: IoT Systems**

Tuesday, June, 12<sup>th</sup>, 08:30 – 09:30, Hall 2

**Chair: Ivan Milentijević, Faculty of Electronic Engineering, University of Nis, Nis, Serbia**

### RTI 1.1

#### ON THE BORDERS OF EDGE COMPUTING AND IOT (INVITED PAPER)

*Marjan Gusev, University Ss Cyril and Methodius, Faculty of Computer Science and Engineering, Skopje, Macedonia*

Modern mobile and wireless ubiquitous solutions are actually IoT application, brought by the advances of the technology in cloud-based systems. Edge computing idea to bring the computing closer to the user can be realized by several computer architectures, including, cloudlets, when the intermediate server is owned by an IT provider, mobile edge computing and fog computing, when the intermediate server is owned by the mobile operator, and recently the idea of dew computing appears as a solution that brings the computing even closer to the user. In this paper, we discuss different architectural approaches for IoT solutions explaining details on the organizational overview of micro services, server architectures, etc. The intermediate and dew computing layers are explained in the overall cloud-based architecture for IoT solutions. Specific goals and requirements are specified to extract the differences along with a discussion of benefits, advantages and disadvantages. We also focus on data processing and communication needs in order to collect, process and/or offload data from the IoT sensors and devices.

### RTI 1.2

#### MODEL-BASED LOAD TESTING IN IOT SYSTEM

*Eleonora Nan, OBLO Living, Novi Sad, Serbia*

*Marija Antić, Faculty of Technical Sciences, Novi Sad, Serbia*

*Una Radosavac, OBLO Living, Novi Sad, Serbia*

*Boris Petelj, OBLO Living, Novi Sad, Serbia*

*Roman Pavlović, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

The increasing number of physical objects are being connected to the Internet at an incredible rate, forming the Internet of Things (IoT). This phenomenon not only increases the volume of data on the Internet, but also requires the development of complex software solutions, which need to be thoroughly tested. Testing of IoT systems represents a challenge, since it requires connecting a variety of physical devices to the system. Also, some problems can only be detected if there are a large number of active users in the system, or there are some users generating large data volumes. Simulations and software modeling of system components play an important role in the testing process. They allow to scale the usage of the system at a very low cost, and to perform various testing scenarios. In this paper, software models of components are proposed, which simulate real users' behavior in a home automation IoT system. Using the created models, the high load for the IoT cloud is created, and the system behavior is observed.

### RTI 1.3

## MODEL-DRIVEN APPROACH FOR DEPLOYMENT OF CONTAINER-BASED APPLICATIONS IN FOG COMPUTING

*Nenad Petrović, Faculty of Electronic Engineering, University of Nis*

Fog Computing extends the Cloud Computing to the Edge of the network, closer to the things that produce and act on data including different types of devices, ranging from personal computers, laptops, workstations to IoT devices, wearable gadgets and sensors. The heterogeneity and variety of devices doesn't make just the activities of application design harder, but serious effort is also required when it comes to configuration, deployment, re-deployment and testing of the applications executed in Fog environments and it is often time-consuming, trial and error process. As the data could be produced and consumed at both Edge and Cloud, it means that application also needs to be compliant with given data privacy and security policies due to legal constraints, laws and regulations which restrict the freedom of data movement. Therefore, it should also be possible to move computation tasks between devices regardless of their location (Cloud or Edge), even in the case of different computing architectures, which means that the applications should be as flexible as possible. In this paper we focus on automating the deployment activities and increasing the flexibility of applications executed in Fog environment by providing a visual tool utilizing the concepts of metamodeling, automated code generation and container-based virtualization.

## Session RTI2: Parallel and Distributed Systems

Tuesday, June, 12<sup>th</sup>, 09:30 – 10:30, Hall 2

**Chair: Miroslav Popović, Faculty of Technical Sciences, Novi Sad, Serbia**

### RTI 2.1

#### A SOLUTION OF CONCURRENT LIST ON PSTM

*Marko Popovic, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

*Branislav Kordic, Faculty of Technical Sciences, Novi Sad, Serbia*

*Miroslav Popovic, Faculty of Technical Sciences, Novi Sad, Serbia*

*Ilija Basicovic, Faculty of Technical Sciences, Novi Sad, Serbia*

Although TM makes parallel programming easier, designing even simple concurrent data structures, such as lists, queues etc., pose still open research challenges. In this paper, we developed the two concurrent lists in Python, namely the concurrent list on Python STM, and the lock-based concurrent list in Python Array. We also developed the four benchmark workloads: conflict-free, conflicting adds, conflicting removes, and conflicting adds and removes. Finally, we conducted a case study, on small lists and three concurrent processes, in order to evaluate the performance of the two concurrent lists. The case study shows that for all the workloads, concurrent list on Python STM is superior to concurrent list in Python Array. The relative speedup is 1.24 on average.

### RTI 2.2

#### PERFORMANCE COMPARISON OF HYPERVISOR-BASED AND CONTAINER-BASED VIRTUALIZATION

*Borislav Djordjevic, Institute Mihailo Pupin, Belgrade, Serbia*

*Aleksandar Marinkovic, National Bank of Serbia, Belgrade, Serbia*

*Nikola Davidovic, University of East Sarajevo, Faculty of Electrical Engineering, East Sarajevo, RS, Bosnia and Herzegovina*

*Valentina Timcenko, Institute Mihailo Pupin, Belgrade, Serbia*

The focus of this paper is on a performance comparison of hypervisor-based virtualization, with Linux KVM as a representative, and container-based virtualization represented by Docker. The file system performance

has been selected from a range of performance classes. The measurements are carried out under equivalent conditions and applying the same test method, using the Filebench software, which guarantees equality and independence from the impact of hardware or other system environments. We have used the latest CentOS Linux version 7.4.1708 with the newest updates as the basis for all test procedures, taking a role of the HostOS for both KVM and Docker. Performances are compared for the native host, KVM with one, two and three virtual machines (VM) and for Docker with one, two and three containers. We have analysed the expected behaviour, verified the assumptions with Filebench test software, and provided the concluding remarks.

#### RTI 2.3

##### DESIGN AND IMPLEMENTATION OF NETWORK INTRUSION DETECTION SYSTEM ON THE APACHE HADOOP PLATFORM

*Vladimir Ciric, Faculty of Electronic Engineering, University of Nis, Nis, Serbia*

*Dusan Cvetkovic, Faculty of Electronic Engineering, University of Nis, Nis, Serbia*

*Ivan Milentijevic, Faculty of Electronic Engineering, University of Nis, Nis, Serbia*

Growing influence of computer networks and Internet to everyday life, with more and more devices connected to global network, opens a new possibilities for malicious activities, while exposing the users to attacks even more, including their data and privacy. Due to the amount of data that need to be processed in order to detect such activities, intrusion detection and prevention systems become a challenging topic. The goal of this paper is the implementation of Intrusion Detection System (IDS) on the Apache Hadoop platform. The Hadoop implementation will enable task parallelization on multi-core processors. The proposed system will be evaluated and compared with popular Snort IDS on a two-core i3 processor. The obtained results show that proposed Hadoop based IDS is about 25% faster then the Snort IDS.

#### RTI 2.4

##### ADDING SUPPORT FOR GLOBAL INSTRUCTION SELECTION PASS FOR MIPS32 ARCHITECTURE IN LLVM

*Petar Avramovic, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

*Milena Vujošević Janičić, Faculty of Mathematics, University of Belgrade, Serbia*

*Gordana Cmiljanović, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

*Marija Antić, Faculty of Technical Sciences, Novi Sad, Serbia*

LLVM is one of the most popular compiler infrastructures. By adding new features and with improvements of existing ones, it tends to keep the reputation of the most modern and innovative figure on the market. In this paper we present a new approach proposed for improving instruction selection in LLVM back-end, called Global Instruction Selection or GlobalISel. Some of its most important goals are transparent algorithm, human readable intermediate representation, easier debugging and compilation speed. The main contribution of this paper is a successful implementation of these concepts for MIPS architecture. We present our results showing that we notably improved compilation speed with a reasonable cost on code quality.

### **Session RTI3: Software Systems**

Tuesday, June, 12<sup>th</sup>, 14:30 – 15:30, Hall 2

**Chair: Marjan Gušev, University Ss Cyril and Methodius, Faculty of Computer Science and Engineering, Skopje, Macedonia**

### RTI 3.1

#### DEVELOPMENT OF CONTEXT-AWARE APPLICATIONS FOR SMART MOBILE PHONES

*Bojan Rakita, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

*Zlatko Bundalo, University of Banja Luka, Faculty of Electrical Engineering, Bosnia and Herzegovina*

*Dužanka Bundalo, University of Banja Luka, Faculty of Philosophy, Banja Luka, Bosnia and Herzegovina*

*Mirko Sajić, Sberbank a.d. Banja Luka, Bosnia and Herzegovina*

This paper considers and describes the advantages of contextual awareness use in development and design of mobile applications. The basic concepts in context awareness domain are defined: the context information, their sources, the context itself, and the process of constructing the context. The general requirements that one conceptual generic framework for the development and design of context-aware applications for smart mobile phones should meet are investigated and described. A model for such generic approach in mobile applications development for smart mobile phones using Android operating system is proposed, implemented and described. Special care was given to ensure fast and quality development, reduction of complexity, improvement of possibilities of maintaining and further development of context-aware software. It was achieved through introduction of formalism in the representation of information and the introduction of a higher level of abstraction to the processing of this information.

### RTI 3.2

#### AUTOMATING OF NANOINDENTATION RAW RESULTS PROCESSING WITH PYTHON MODULE

*Jovana Lazarević, Faculty of Technical Sciences, Novi Sad, Serbia*

*Mihailo Drljača, BioSense Institute, University of Novi Sad, Novi Sad, Serbia*

*Sanja Brdar, BioSense Institute, University of Novi Sad, Novi Sad, Serbia*

*Bojan Petrović, Faculty of Technical Sciences, Novi Sad, Serbia*

*Sanja Kojić, Faculty of Technical Sciences, Novi Sad, Serbia*

*Goran Stojanovic, Faculty of Technical Sciences, Novi Sad, Serbia*

For more than 100 years, researchers in the mechanical sciences have acknowledged that surface contacts between materials are highly reliant on their mechanical properties. In that light, Nanoindentation at small scales has become a conventional tool for the measurement of mechanical properties. Continuing advancements in indentation data analysis increased the method's utility in the characterization of biomaterials. The mechanical characterization of tissues and other biological materials is of utmost importance in clinical medicine and the field of biomaterials. Since the interpretation of nanoindentation raw results appeared as time consuming, the necessity for more rapid approach was recognized. With that in mind the Python module with specific functionality was developed. The enclosed results for multiple test processing with and without proposed optimization show that presented method demonstrates faster and more accurate performance in all cases.

### RTI 3.3

#### IMPROVEMENT OF SENTIMENT CLASSIFICATION ACCURACY IN SERBIAN LANGUAGE BY STEMMER USAGE

*Petra Antić, Faculty of Electronic Engineering, University of Nis, Serbia*

In this paper, the effects of stemming in sentiment classification of documents in the Serbian language were analyzed. The dataset used for training and validation was Serbian Movie Review Dataset. The stemmer for the Serbian language was iteratively upgraded with new rules, based on the list of the most predictive attributes obtained using attribute selection. The final results showed that introducing particular rules for stemming can enhance classification accuracy significantly, which can be compared to the effects of using more advanced machine learning methods.

### RTI 3.4

## SMART TRANSPORTATION IN THE SERVICE OF IMPROVING HEALTHCARE IN SMART CITIES

*Željko Jovanović, Faculty of Technical Sciences, University of Kragujevac, Čačak, Serbia*

*Aldina Avdić, Department of Technical Sciences, State University of Novi Pazar, Novi Pazar, Serbia*

*Dragan Jankovic, Faculty of Electronic Engineering, University of Nis, Serbia*

*Dejan Vujičić, Faculty of Technical Sciences, University of Kragujevac, Čačak, Serbia*

The daily increase in the percentage of urban population in the world, as well as the increasing use of information technology has led to the creation of a new concept - the concept of smart cities. The basic idea of smart cities is to improve the quality of life of population in various fields, such as economy, administration, health, traffic, education, etc. This paper shows the synergy between the components of smart cities, smart transport, and smart healthcare. Service proposals which are presented are one of the results of this synergy and their implementation in the form of an information system can provide better quality, safer, and more efficient transport to the patient.

## Session RTI4: Computer Systems and Services

Tuesday, June, 12<sup>th</sup>, 15:30 – 16:30, Hall 2

**Chair: Zora Konjović, University Singidunum, Belgrade, Serbia**

### RTI 4.1

#### STUDENTS' MOBILITY MANAGEMENT PORTAL BASED ON MICROSERVICE ARCHITECTURE

*Nina Marjanović, Faculty of Technical Sciences, Novi Sad, Serbia*

*Milan Segedinac, Faculty of Technical Sciences, Novi Sad, Serbia*

*Goran Savić, Faculty of Technical Sciences, Novi Sad, Serbia*

*Zora Konjović, University Singidunum, Belgrade, Serbia*

As digital representation of learning opportunities specification contributed to easier advertising, finding and comparing learning opportunities, a portal that enables advertising of learning opportunities and students' mobility management has been developed. The portal provides students with an insight into offered learning opportunities, tools enabling comparing and recommending learning opportunities, as well as applying for a particular study program. The portal also provides institutions with an opportunity to advertise their learning opportunities and improve communication with prospective students. Because using microservices as an alternative approach to scalable application development, offers a number of benefits like application modularity, parallel development, less-effort testing and maintenance, etc., this paper presents an approach to creating students mobility management portal relying upon microservice architecture.

### RTI 4.2

#### USE OF QT FRAMEWORK IN UNIVERSITY COURSES ON DEVELOPMENT OF NETWORK SOFTWARE

*Milos Pilipovic, Faculty of Technical Sciences, Novi Sad, Serbia*

*Tijana Srejjic, Faculty of Technical Sciences, Novi Sad, Serbia*

*Marko Vucicevic, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

*Ilija Basiccevic, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

*Miroslav Popovic, Faculty of Technical Sciences, Novi Sad, Serbia*

At Faculty of Technical Sciences, Novi Sad, we started using Qt framework in the context of Intercomputer Communications and Computer Networks course. The students are introduced to the area of development of network software using Qt framework, which they also use for implementation of their project assignments. This paper presents an overview of the findings in the process of preparation of Qt-based labs and

assignments. Qt is now used in parallel with FSM Library framework that has been developed at our department and used both in education and in commercial projects. The methodology for development of network based applications starting from a graphical form version of languages for formal specification of protocols, particularly, SDL (Specification and Description Language) and MSC (Message Sequence Chart) diagrams, using Qt and FSM Library framework is presented. The paper presents a comparison of the two frameworks, as well.

#### RTI 4.3

##### SERBIAN AIRPORTS WEATHER ACQUISITION SYSTEM SAWASII

*Una Kisic, Institute Mihailo Pupin, University of Belgrade, Serbia*

*Andjelka Markovic, Institute Mihailo Pupin, University of Belgrade, Serbia*

*Olivera Kadic, Institute Mihailo Pupin, University of Belgrade, Serbia*

*Ina Masnkosa, Institute Mihailo Pupin, University of Belgrade, Serbia*

*Marija Minic, Institute Mihailo Pupin, University of Belgrade, Serbia*

*Sinisa Marinkovic, Institute Mihailo Pupin, University of Belgrade, Serbia*

The Serbian Airports Weather Acquisition System (SAWASII) is a meteorological information system which collects data from automatic weather stations, process collected data, generates derived values and metrological reports and makes all information available for users in Air Traffic Control tower and airport's meteorological service. It enables generation and distribution of important meteorological reports (METAR, SYNOP, TAF, AIRMET, SIGMET, GAMET, OTHER, WRNG and ADWRNG) for local and international exchanges of meteorological data. Data obtained from the SAWASII automated subsystem meets appropriate standards and recommendations of international organizations World Meteorological Organization (WMO) and International Civil Aviation Organization (ICAO) and implements the adopted procedures of local aviation authorities of Serbia and Montenegro Air Traffic Services SMATSA llc. In this paper we are presenting overall architecture of SAWASII software system.

#### RTI 4.4

##### ONE BIT PER POSITION ENAX ENDGAME DATABASES

*Vladan Vuckovic, Faculty of Electronic Engineering, University of Nis, Serbia*

This paper introduces a new format of uncompressed endgame databases named ENAX endgame with a very fast linear access using only one bit per position to memorize. Unlike traditional retrograde approach for the construction of the database, we applied a very efficient linear translation algorithm using Nalimov 5-men endgame database as the core. In the construction stage of ENAX database, the algorithm passes once through all defined positions in Nalimov database and sets the appropriate bit positions in the ENAX database using their evaluations. This new type of endgame database was successfully tested and applied in the author's experimental program Axon.

## **Session RTI5: Computer Networks and Applications**

Tuesday, June, 12<sup>th</sup>, 16:30 – 17:15, Hall 2

**Chair: Vladimir Ćirić, Faculty of Electronic Engineering, University of Nis, Serbia**

#### RTI 5.1

##### INTERNET AS INFRASTRUCTURE FOR DIGITAL TELEVISION

*Ilija Bašičević, Faculty of Technical Sciences, Novi Sad, Serbia*

*Nenad Lovčević, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

*Nenad Šoškić, Faculty of Technical Sciences, Novi Sad, Serbia*

*Milan Ačanski, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

This paper contains a perspective on an important trend in digital television - transition to Internet-based network. An analysis of certain issues related to this transition is provided, as well as an overview of two competing technologies for transmission of TV content over IP networks, namely IPTV and Internet television. The zapping delay problem and some existing solutions are presented.

RTI 5.2

#### FRAMEWORK LIBRARY WITH GUIDELINES FOR EFFECTIVE TV APPLICATION DEVELOPMENT

*Nemanja Kovacev, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

*Veljko Ilkić, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

*Dejan Nađ, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

*Nikola Vranić, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

TV application development is becoming an important field of software industry. As with the software development in general, the aim is to build a high-quality and cost-effective application which is as fast to build and as easy to maintain as possible. We noticed several issues with the existing approaches to TV application development. This paper presents a framework with guidelines for effective TV application development along with benefits of using this kind of framework in solving those issues.

RTI 5.3

#### ONE SOLUTION FOR RECOMMENDING TV CONTENT BASED ON MACHINE LEARNING ALGORITHMS IN ANDROID TV

*Vladimir Zbiljić, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

*Dorđe Glišić, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia*

*Nikola Vranić, RT-RK Institute for Computer Based Systems, Novi Sad, Serbia,*

Paper presents one solution for recommending digital television content to the end user based on their preferences, integrated into a set top box device. Designed environment is equipped with necessary tools for collecting and processing accumulated user data making it convenient for machine learning algorithms.

## **Sesija RT5: Distribuitani sistemi**

Sreda, 13. Jun, 08:30 – 09:30, Sala 2

**Predsedavajući: Ivan Milentijevic, Elektronski fakultet, Univerzitet u Nišu, Niš, Srbija**

RT 5.1

#### POREĐENJE PERFORMANSI HOMOGENOG I HETEROGENOG HADOOP KLASTERA NA PRIMERU TERASORT ALGORITMA

*Strahinja Djurkovic, Elektronski fakultet, Univerzitet u Nišu, Niš, Srbija*

*Vladimir Ciric, Elektronski fakultet, Univerzitet u Nišu, Niš, Srbija*

*Natalija Stojanovic, Elektronski fakultet, Univerzitet u Nišu, Niš, Srbija*

Popularnost Apache Hadoop okruženja je u poslednjih nekoliko godina značajno porasla. Razlog tome je dobra skalabilnost i otpornost na otkaze, što ga čini dobrim kandidatom za kreiranje klastera sa velikim brojem računara. Obično se u takvim klasterima novi čvorovi dodaju nakon nekog vremena, kada se za to ukaže potreba, pa se samim tim razlikuju po performansama od čvorova koji se već nalaze u klasteru. Zbog ovoga većina klastera sa velikim brojem čvorova ima čvorove koji se međusobno razlikuju po performansama. Cilj ovog rada je testiranje i poređenje performansi heterogenog i homogenog Hadoop klastera sa standardnim YARN (eng. Yet Another Resource Negotiator) sistemom za upravljanje resursima

klastera. Testiranje će biti izvršeno TeraSort algoritmom nad skupovima podataka različitih veličina, od 100MB do 5GB. Biće pokazano da se neravnomernom raspodelom zadataka na čvorove klastera može postići značajno ubrzanje.

#### RT 5.2

### REALIZACIJA MOBILNE APLIKACIJE UPOTREBOM KOTLIN PROGRAMSKOG JEZIKA I RAČUNARSKOG OBLAKA

*Mihailo Matijević, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*

*Marija Punt, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*

*Drazen Drasković, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*

Android operativni sistem je danas najpopularnija platforma za razvoj mobilnih aplikacija i veliki broj kompanija koristi takve aplikacije u poslovnoj primeni. Aplikacije za ovu platformu mogu da se pišu u Android izvornoj tehnologiji, baziranoj na programskom jeziku Java i XML tehnologiji, ili u kombinaciji Android tehnologije sa drugim jezicima ili radnim okvirima. U ovom radu prikazano je softversko rešenje, realizovano u potpunosti upotrebom Kotlin programskog jezika, kod kojeg je klijentska strana realizovana kao Android mobilna aplikacija, a serverska strana kao Spring aplikacija koja se izvršava u računarskom oblaku. Prednost ovakvog softverskog sistema je u dobro definisanoj arhitekturi, sastavljenoj od komponenti klijentske i serverske strane i sloja podataka, koje čine jedan modularan sistem, u kome su primenjene najmodernije klijent-server i mobilne tehnologije.

#### RT 5.3

### INTEGRACIJA PARTICLE PHOTON IOT UREĐAJA SA GOOGLE CLOUD PLATFORMOM

*Dejan Vujičić, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Čačak, Srbija*

*Dijana Jagodić, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Čačak, Srbija*

*Željko Jovanović, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Čačak, Srbija*

*Siniša Randić, Fakultet tehničkih nauka u Čačku, Univerzitet u Kragujevcu, Čačak, Srbija*

U ovom radu je opisan Particle Photon uređaj sa aspekta IoT sistema. Prikazane su njegove osnovne karakteristike, kao i način povezivanja sa računarom, pisanje programa i prikazivanje prikupljenih podataka. Kreiran je jednostavan sistem za merenje temperature i relativne vlažnosti vazduha koristeći senzor SHT11 i Particle Photon uređaj. Prikazana je mogućnost prikaza podataka preko iOS ili Android aplikacije, kao i slanje izmerenih podataka na Google Cloud platformu. Podaci se čuvaju u Firebase bazi podataka, a potom se mogu prikazivati i nad njima vršiti dalja obrada.

#### RT 5.4

### JEDNA IMPLEMENTACIJA RTSP PROTOKOLA ZA DIGITALNE TV PRIJEMNIKE SA OGRANIČENIM RESURSIMA

*Nebojsa Rablov, Fakultet tehničkih nauka, Novi Sad, Srbija*

*Radovan Marković, RT-RK.doo, Novi Sad, Srbija*

*Milan Acanski, RT-RK.doo, Novi Sad, Srbija*

*Ilija Basicević, Fakultet tehničkih nauka, Novi Sad, Srbija*

U ovom radu je predstavljeno jedno rešenje implementacije RTSP protokola za digitalne TV prijemnike. Rešenje je implementirano i optimizovano za rad na sistemima sa ograničenim resursima. Cilj ovog rada jeste prikaz proširenih mogućnosti RTSP protokola primenjenog u digitalnoj televiziji, sa ciljem poboljšanja kvaliteta i usluge koje digitalna televizija omogućava minimizujući utrošak radne memorije i centralnog procesora što je problem identifikovan korišćenjem dostupnih RTSP biblioteka. Takođe još jedan od ciljeva jeste i unapređenje interakcije sa korisnicima.



## Sesija RT6: Softverski sistemi

Sreda, 13. Jun, 09:30 – 10:30, Sala 2

**Predsedavajući: Miroslav Popović, Fakultet tehničkih nauka, Novi Sad, Srbija**

### RT6.1

#### SYSTEM FOR TESTING VOICE COMMANDS IN SMART HOMES

*Nebojsa Rajic, Fakultet tehničkih nauka, Novi Sad, Srbija*

*Nenad Cetic, RT-RK.doo, Novi Sad, Srbija*

*Miroslav Popovic, Fakultet tehničkih nauka, Novi Sad, Srbija*

*Sreten Tanackovic, RT-RK.doo, Novi Sad, Srbija*

U ovom radu je prikazano jedno rešenje za ispitivanje uspešnosti sistema za upravljanje glasom u pametnim kućama. Glas kao moderna sprega sa korisnikom sve više pronalazi primenu u uređajima potrošačke elektronike. Po našem mišljenju, glavni pokretač ovog fenomena je snaga udaljenih računarskih sistema – sistema u oblaku (eng. Cloud). Ovaj pristup problemu analize govora postaje sve prihvatljiviji kako za korisnike tako i za same proizvođače i dobavljače usluga. Primena glasovnih komandi u životnom prostoru sa sobom i dalje nosi velike izazove. U ovom radu dajemo prikaz ispitivanja uspešnosti prepoznavanja komandi u različitim situacijama.

### RT6.2

#### SISTEM ZA AUTOMATSKO GENERISANJE, SKENIRANJE I PREGLEDANJE TESTOVA

*Jovan Đukić, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*

*Kristijan Žiža, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*

*Marija Punt, Elektrotehnički fakultet, Univerzitet u Beogradu, Beograd, Srbija*

U ovom radu predstavljen je realizovani softverski sistem za potrebe automatskog generisanja, skeniranja i pregledanja testova. Sistem je implementiran sa ciljem da se upotrebljava na Elektrotehničkom fakultetu u Beogradu, na Katedri za računarsku tehniku i informatiku prilikom pregledanja masovnih ispita i u slučajevima kada nije moguće organizovati polaganje ispita korišćenjem računara. Sistem je realizovan kao klijent-server aplikacija u kom je klijentski deo zadužen za skeniranje testova, a serverski deo za generisanje testova, ocenjivanje i vođenje evidencije o rezultatima. Korišćenjem realizovanog rešenja moguće je generisati i oceniti različite vrste testova.

### RT6.3

#### NAPREDNA KONTROLA UREĐAJA NA OSNOVU LOGIČKIH ZONA U PAMETNIM SISTEMIMA

*Aleksandar Tanasković, Fakultet tehničkih nauka, Novi Sad, Srbija*

*Miodrag Đukić, Fakultet tehničkih nauka, Novi Sad, Srbija*

*Miloš Milanović, OBLO Living, Novi Sad*

*Ištvan Pap, OBLO Living, Novi Sad*

U ovom radu opisan je koncept i implementacija rešenja koji unapređuje postojeći sistem logičkog grupisanja uređaja u pametnim sistemima uvodeći koncept zona i kontrolera zona. Kontroleri zona mogu da realizuju složene operacije nad srodnim uređajima, bez značajne intervencije korisnika. Poboľšanje je imenovano Advanced Zone Control (AZC). Iznete su osnovne razlike i prednosti podele kuće po zonama u odnosu na postojeće rešenje gde su uređaji raspoređeni po spratovima i sobama. Opisan je osnovni protokol komunikacije MQTT (engl. Message Queue Telemetry Transport). Dat je uvid u strukturu postojećeg rešenja pametne kuće i sprega između glavnih komponenti sistema u kome učestvuju: Gejtvej (engl. Gateway – GTW), aplikacija za mobilni telefon i cloud.

#### RT6.4

##### ANALIZA EFIKASNOSTI IZVRŠAVANJA FUNKCIONALNIH TEST PLANOVA NA NEDELJNOM NIVOU

*Dako Banika, RT-RK.doo, Novi Sad, Srbija*

*Zvonimir Kaprocki, RT-RK.doo, Novi Sad, Srbija*

*Vukota Pekovic, RT-RK.doo, Novi Sad, Srbija*

*Djordje Miljkovic, RT-RK.doo, Novi Sad, Srbija*

*Gordana Velikic, RT-RK.doo, Novi Sad, Srbija*

Ograničenost resursa dostupnih za sprovođenje testnih aktivnosti, diktira da vreme i resurse kojim raspoložemo moramo iskoristiti što efikasnije, kako bi krajnji proizvod dostigao zadovoljavajući nivo kvaliteta. U radu su dati rezultati analize, koja je rađena u cilju praćenja efikasnosti izvršavanja testnog plana. Efikasnost vezujemo za broj detektovanih grešaka sa svakim izvršavanjem testnog plana, što je u ovom slučaju bilo na nedeljnom nivou. Testni plan je bio fokusiran na funkcionalno testiranje, gde je deo testova pokretan sa ciljem pronalaska regresija, a deo sa ciljem verifikacije novih funkcionalnosti.

### Sesija RT7: Sistemi za testiranje

Četvrtak, 14. Jun, 11:00 – 12:00, Sala 2

**Predsedavajući: Jelena Kovačević, Fakultet tehničkih nauka, Novi Sad, Srbija**

#### RT 7.1

##### PROGRAMSKA PODRŠKA ZA GENERISANJE TESTNIH SEKVENCI ZA MIKROKONTROLERE

*Jozef Sandor, RT-RK.doo, Novi Sad, Srbija*

*Milan Stankic, RT-RK.doo, Novi Sad, Srbija*

*Dragan Samardzija, RT-RK.doo, Novi Sad, Srbija*

*Ivan Petrovic, RT-RK.doo, Novi Sad, Srbija*

U ovom radu predstavljeno je jedno rešenje programskog alata za generisanje testnih sekvenci u svrhu konfigurisanja mikrokontrolera. Generisanje izlaznog toka podataka se vrši na osnovu ulaznih podataka organizovanih u obliku XML sadržaja. Cilj je da se predstavi mehanizam, koji će krajnjim korisnicima omogućiti jednostavan i intuitivan način organizovanja ulaznih podataka. Izlazni sadržaj predstavlja uređenu strukturu niza podataka u obliku koji odgovara Intelovoj MCS-51 (8051) opštonamenskoj familiji mikrokontrolera.

#### RT 7.2

##### AUTOMATIZACIJA PROCESA PRIPREME I PROVERE JEDINIČNIH TESTOVA

*Sladjan Jordaković, RT-RK.doo, Novi Sad, Srbija*

*Srdan Tikvić, RT-RK.doo, Novi Sad, Srbija*

*Velibor Ilić, RT-RK.doo, Novi Sad, Srbija*

*Bogdan Pavković, RT-RK.doo, Novi Sad, Srbija*

Sa porastom zahteva tržišta raste i funkcionalna kompleksnost namenskih sistema, posebno u oblasti automobilske industrije gde je potrebno zadovoljiti visoke standarde bezbednosti korisnika. Primarni cilj postaje obezbediti visok kvalitet softvera, što se postiže verifikacijom i testiranjem u više iteracija tokom razvoja sistema. Bitan korak svake iteracije je testiranje jediničnih funkcionalnosti (eng. Unit testing) sistema pomoću alata za testiranje kao što je VectorCast. Testiranju jedinice prethodi priprema testnog okruženja koja podrazumeva dobavljanje odgovarajućih biblioteka, a nakon testiranja je potrebno i dokumentovati na

koji su način jedinične funkcionalnosti testirane. U ovom radu su prepoznate i automatizovane procedure koje su se obavljale ručno čime je postignuto značajno ubrzanje procesa testiranja.

#### RT 7.3

### TESTIRANJE KOMUNIKACIJE IZMEĐU SOFTVERSKIH KOMPONENTI NA ELEKTRONSKIM UPRAVLJAČKIM JEDINICAMA

*Grujica Corluka, RT-RK.doo, Novi Sad, Srbija*

*Malisa Marijan, RT-RK.doo, Novi Sad, Srbija*

*Velibor Ilic, RT-RK.doo, Novi Sad, Srbija*

*Danijel Spasojevic, RT-RK.doo, Novi Sad, Srbija*

Za razvoj elektronskih upravljačkih jedinica (ECU) potrebno je angažovati veći broj timova koje se bave razvojem pojedinih segmenata ili modula sistema. ECU se upotrebljavaju u savremenim proizvodima i uređajima kako bi se dodale nove i automatizovale postojeće funkcije. Svaki od učesnika u procesu razvoja vrši nezavisno testiranje delova sistema ili komponenti koje razvija. Za ovakva testiranja neophodno je koristiti automatizovana okruženja za testiranje koja generišu detaljne izveštaje o svakom segmentu sistema. U ovom radu je opisano okruženje koje koristimo za testiranje komunikacije između softverskih komponenti na ECU kao i generisanje sumiranih izveštaja koji pojednostavljaju tumačenje rezultata testova.

#### RT 7.4

### RAZVOJ ALATA ZA PROVERU BEZBEDNOSTI AUTOMOBILSKE PROGRAMSKE PODRŠKE

*Ivan Lazarević, RT-RK.doo, Novi Sad, Srbija*

*Radovan Prodanović, RT-RK.doo, Novi Sad, Srbija*

*Mališa Marijan, RT-RK.doo, Novi Sad, Srbija*

*Danijel Spasojević, RT-RK.doo, Novi Sad, Srbija*

Savremeni ugrađeni sistemi u automobilskoj industriji koji imaju uticaj na bezbednost učesnika u saobraćaju regulisani su standardom ISO 26262. Ovaj standard definiše nekoliko nivoa integriteta programske podrške u zavisnosti od štete koja bi mogla da nastane usled otkaza iste. Samim tim, tokom izrade programske podrške, neophodno je vršiti proveru da li je ona u skladu sa ISO 26262 standardom. Proces izrade programske podrške se znatno može ubrzati korišćenjem alata koji proveravaju usklađenost sa principima ISO 26262 standarda. U radu je predstavljeno jedno rešenje alata koji omogućava proveru programske podrške ispitujući da li se u njoj pojavljuju neregularnosti predviđene standardom. Ukoliko se neregularnosti pojavljuju, alat generiše izveštaj sa jasnim naznakama gde i zbog čega dolazi do sukoba sa standardom. Korišćenjem alata kroz grafičko korisničko okruženje korisniku je omogućeno da kroz par jednostavnih koraka odabere programsku podršku za proveru, dodeli nivoe integriteta funkcijama i globalnim promenljivama, kao i da pristupi izveštaju. Na taj način se štedi na vremenu koje bi bilo utrošeno na usklađivanje programske podrške i ISO 26262 standarda.

# TE Telecommunications / Telekomunikacije

## Session TEI1: Telecommunications

Monday, June, 11<sup>th</sup>, 14:30 – 16:30, Hall 3

**Chair: prof. Dejan Milić, School of Electronics, University of Niš, Serbia**

### TEI1.1

#### A SCHEME FOR CONGESTION AVOIDANCE USING OPENFLOW

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

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

Introduction of OpenFlow enables vendor independent implementation of network algorithms. This paper presents one solution for adaptive congestion avoidance, in which controller constantly monitors links, and reroutes flows as needed based on flow throughputs. The paper presents implementation which enables lossless rerouting of flows and reduced amount of communication between controller and switches. The implementation is based on Ryu controller. The paper also contains description of the development and testing environment.

### TEI1.2

#### EVALUATION OF SDNET PACKET PROCESSORS ON XILINX CHIPS

*Mihailo Vesović, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

*Aleksandra Smiljanic, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

*Andreja Radošević, SANS R&D, LLC, 4901 Morena Blvd. #128, San Diego, CA*

In this paper, we examine packet processing on the advanced Xilinx UltraScale+ chips. Xilinx developed flexible SDNet platform for programming of high-speed data plane. It includes programming of the widely used protocols, as well as the programming of the new protocols designed by users. We will evaluate the SDNet platform, and examine its performance. The memory requirements will be analyzed for the critical functionalities: IP lookup and packet classification.

### TEI1.3

#### ADDRESS RESOLUTION PROTOCOL IMPLEMENTATION TO NETMAP PLATFORM ROUTER DATA PLANE

*Hasan Redžović, Innovation Center of School of Electrical Engineering, University of Belgrade, 73 Bulevar kralja Aleksandra, Belgrade, Serbia*

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

*Stevan Simić, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

The netmap platform bypasses slow kernel network stack and implements different optimization methods in order to provide fast packet exchange between network cards and applications in user space of operating systems. The netmap platform also has some downsides. Applications based on netmap API receive unprocessed Ethernet packets, so it is necessary to implement packet-processing functions for ensuring correct packet receiving. Also, the concurrent usage of same physical network port in netmap mode between multiple applications demands implementation of complex algorithms. We developed Netmap Packet Forwarding (NPF) application that provides fast packet processing and forwarding between physical ports, but also connectivity to all applications in user space. We used NPF as a fast router data plane connected to Quagga software, which represents router control plane in user space. The development challenge of NPF is implementation of Address Resolution Protocol (ARP), which is necessary for creating completely functional

router data plane. In this paper, we describe in detail implementation and testing of ARP within NPF application.

TEI1.4

#### MODEL DRIVEN TELEMETRY USING YANG FOR NEXT GENERATION NETWORK APPLICATIONS

*Mioľjub Jovanovic, Cisco Systems, Belgium*

*Milan Cabarkapa, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

*Benoit Claise, Cisco Systems, Belgium*

*Natasa Neskovic, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

*Milan Prokin, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

*Djuradj Budimir, University of Westminster, Faculty of Science and Technology, United Kingdom*

This paper describes recent developments and methods in the field of model driven telemetry using YANG data modelling language for next generation networking. It also outlines advantages of using YANG models to configure network elements as compared to traditional approaches of using Command-Line Interface (CLI) and Simple Network Management Protocol (SNMP) in order to manage network elements. The explanation of shortcomings of SNMP when it is used for telemetry purposes with the recent scale of modern networks is also given. Finally, this paper provides outline on recent tool chain available to easily produce YANG based code as well as process model-driven telemetry data.

TEI1.5

#### EDUCATIONAL PLATFORM FOR VOIP COMMUNICATION LEGAL EAVESDROPPING

*Marko Nerandžić, Vlatacom Institute of High Technologies, Belgrade, Serbia*

*Strahinja Trifunović, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

*Ranko Petrović, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

*Branka Stojanović, Vlatacom Institute of High Technologies, Belgrade, Serbia*

*Miroslav Perić, Vlatacom Institute of High Technologies, Belgrade, Serbia*

Protection against global terrorism requires constant trade-off between privacy and data accessibility for law enforcement agencies – LEA. Legal eavesdropping - LE is present in primary law documents of almost all countries with different degrees of LEA authorization. Introduction of Internet and wide usage of VoIP communication leads to special security requirements in telecommunication domain. This paper presents laboratory environment for educational purpose simulation of LE scenario with additional voice analysis capabilities and alarming on keywords. All used components (VoIP server, voice recording of specified target phone, voice to text conversion and alarming) are either from open-source market or are developed for this particular project. Experimental results of LE system, with alarming on predefined words in English language are included. Additionally, two speech recognition engines are compared and their respective accuracy with three different accents, where accuracy represents the percentage of words correctly recognized and converted from speech to text.

TEI1.6

#### ANALYSIS OF THE EFFECT OF WHITE BALANCE AND COLOR TEMPERATURE ON IMAGE COMPRESSION USING DIFFERENT ALGORITHMS

*Vladimir Maksimovic, University of Priština, Faculty of Technical Sciences, Kosovska Mitrovica, Serbia*

*Mile Petrovic, University of Priština, Faculty of Technical Sciences, Kosovska Mitrovica, Serbia*

*Petar Spalevic, University of Priština, Faculty of Technical Sciences, Kosovska Mitrovica, Serbia*

*Branimir Jaksic, University of Priština, Faculty of Technical Sciences, Kosovska Mitrovica, Serbia*

*Ivana Milosevic, High School of Electrical Engineering and Computing of Vocational Studies, Belgrade*

In this paper, using multiple compression algorithms (JPEG, JPEG2000 and SPIHT), an analysis of the effect of the white balance and the color temperature on image compression was performed. The analysis was done for different values of color temperature and number of bits per pixel (bpp). Image compression quality is evaluated with the PSNR (Peak Signal Noise Ratio) parameter. The results are tabulated and graphically presented on the basis of which it is possible to determine the quality of the applied compression algorithm for different values of color temperature. JPEG2000 and SPIHT give approximately similar results but significantly better than JPEG. These algorithms are not fully developed for values below 3000 K and over 6000 K.

TEI1.7

#### SIMPLE DETECTION OF BOTTLENECKS IN ZIGBEE NETWORKS USING THE DIAGNOSTIC CLUSTER

*Bogdan Pavkovic, RT-RK Computer Based Systems, Novi Sad, Serbia*

*Ivan Cvetkovic, University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia*

*Djordje Glisic, University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia*

*Istvan Papp, RT-RK Computer Based Systems, Novi Sad, Serbia*

The aim of this paper is to detect and offer hints on how to mitigate a commonly observed problem in ZigBee networks: bottleneck nodes that can lead to traffic congestion and increased competition for the radio resources. We provide several simple algorithms that are able to detect bottleneck nodes by collecting and analyzing commonly available Diagnostic Cluster in ZigBee networks. We have demonstrated efficiency of proposed solutions in detecting bottleneck nodes on application support (APS) and medium access control (MAC) layer in simple topologies. Finally, we have offered a couple of simple actions that a user can perform in order to alleviate detected and signaled problem.

TEI1.8

#### ANALYSIS OF JAMMING SUCCESSFULNESS AGAINST RCIED ACTIVATION

*Mladen Mileusnić, Institute IRITEL, Belgrade, Serbia*

*Branislav Pavić, Institute IRITEL, Belgrade, Serbia*

*Verica Marinković-Nedelicki, Institute IRITEL, Belgrade, Serbia*

*Predrag Petrović, Institute IRITEL, Belgrade, Serbia*

*Dragan Mitić, Institute IRITEL, Belgrade, Serbia*

*Aleksandar Lebl, Institute IRITEL, Belgrade, Serbia*

In this paper we first briefly present main features of active and reactive jamming of remote controlled improvised explosive devices activation. We emphasized main problems in such systems implementation. The characteristics of frequency sweep as the most widely used technique of active jamming are analyzed: 1) sweep speed, 2) condition for certainly successful jamming, 3) successful jamming probability if jamming is not certainly successful, and 4) step of stepwise frequency change in practical frequency sweep realization. The separate paper section is devoted to the successful jamming probability calculation in general. The presented results are the contributions to jamming equipment development in IRITEL, but also are more widely applicable to the analysis of the other similar jamming systems development.

## **Session TEI2: Telecommunications**

Tuesday, June, 12<sup>th</sup>, 8:00 – 10:30, Hall 3

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

## TEI2.1

### RELIABLE ELECTRONIC DEVICES, CIRCUITS, AND SYSTEMS (Invited paper)

*Zoran Stamenković, IHP, Frankfurt, Germany*

The paper describes a comprehensive approach (at the device, circuit, and system levels) to design, implementation, integration, and verification of reliable communication systems on chips. The approach will be illustrated on three examples: a middleware switch processor for reliable internal satellite communications, a baseband processor for RF-MIMO wireless LAN transceiver, and a MAC processor for reliable industrial wireless communications. The high reliability of the middleware switch processor is achieved exploiting radiation-hard devices, redundant circuits, latchup protection switches, and power gating. The RF-MIMO baseband processor based on an innovative spatial multiplexing in the analog domain offers a higher reliability in advanced communication systems. The proposed MAC processor supports the flexibility, mobility, and scalability of the industrial wireless LAN, approaching the reliability of the industrial wired LAN.

## TEI2.2

### EVALUATION OF NONLINEARITIES IN A CLASS-J BALANCED POWER AMPLIFIER FOR WIRELESS APPLICATIONS

*Branko Bukvic, IMTEL komunikacije, Belgrade, Serbia*

*Milan Ilic, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

*Djuradj Budimir, University of Westminster, Faculty of Science and Technology, United Kingdom*

In this paper we present an evaluation of nonlinearities of a Class-J power amplifier in balanced configuration for wireless applications. The simulation studies are performed using 3 MHz and 10 MHz LTE signal sets at 1.5 GHz center frequency. We show the simulated output power, gain, drain efficiency, and power spectra densities of the designed balanced power amplifier, as device under test (DUT).

## TEI2.3

### SPECTRUM SENSING IN COGNITIVE RADIO BASED ON SIXTH ORDER CUMULANTS OF VARIOUS STRUCTURES

*Rade Bozovic, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

*Mirjana Simic, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

In this paper, spectrum sensing method based on higher order cumulants is proposed. The method was analysed in an ideal channel with additive white Gaussian noise (AWGN), under the uncertainty noise conditions. Under the assumption that a detected signal can be modelled according to an autoregressive model, noise variance is estimated from that noisy signal. Spectrum sensing was done by statistical processing based on the sixth order joint cumulants of different structures estimated values. Performances evaluation expressed through probability of successful detection, done in MATLAB, confirmed high reliability for wide range of signal to noise values.

## TEI2.4

### PERFORMANCE OF FREE SPACE OPTICAL COMMUNICATION IN MALAGA CHANNEL WITH ZERO/NON ZERO BORESIGHT POINTING ERROR

*Marko Smilic, Faculty of Natural Sciences and Mathematics, University of Priština, Kosovska Mitrovica, Serbia*

*Dejan Milic, Faculty of Electronic Engineering, University of Niš, Aleksandra Medvedeva 14, Niš, Serbia*

*Petar Spalevic, Faculty of Technical Sciences, University of Priština, Kneza Miloša 7, Kosovska Mitrovica, Serbia*

*Zorica Nikolic, Faculty of Electronic Engineering, University of Niš, Aleksandra Medvedeva 14, Niš, Serbia*

In this paper, the bit error rate (BER) of intensity modulated Free-Space Optical (FSO) with direct detection

(IM/DD) in single-input single-output (SISO) over Malaga atmospheric turbulence channels has been investigated. Analytical expressions in closed form for probability density function (PDF) over Malaga atmospheric turbulence channels for zero boresight pointing error and non-zero boresight pointing error are represented. Also, analytical expression in closed form for BER for zero boresight pointing error and nonzero boresight pointing error are given. The results are evaluated numerically and graphically presented in terms of BER and power penalty due to zero boresight pointing error and non-zero boresight pointing error.

#### TEI2.5

##### PERFORMANCE ANALYSIS OF TRANSMISSION VISIBLE WATERMARKED IMAGE OVER RICEAN TURBULENCE CHANNE

*Bojan Prlinčević, Higher Technical Professional School in Zvečan, Zvečan, Serbia*

*Zoran Milivojević, College of Applied Technical Sciences, Niš, Serbia*

*Petar Spalević, University of Priština, Faculty of Technical Sciences, Kosovska Mitrovica, Serbia*

In this paper we analyse transmission of visible watermarked image over Ricean turbulence channel. First, we present visible watermarking (VWM) algorithm, and algorithm for FSO transmission simulation. Second, we propose Ricean turbulence channel model. Further, we will observe standard performance criterions of transmitted and recovered image, such are Bit Error Rate (BER), Mean Square Error (MSE), Peak Signal-to-Noise Ratio (PSNR) Similarity versus parameter of observed FSO link  $k$  in order to determine whether the visible watermarked image can be successfully transmitted through FSO channel, and recover image for corresponding values of link parameters. Finally, performance analysis has been carried out, and it has been shown that the image can be successfully recovered from transmitted image transmitted through FSO channel with parameter value of  $k = 5$  and block size parameter  $k = 2$ .

#### TEI2.6

##### PERFORMANCE OF WIRELESS TRANSMISSION UNDER WEIBULL FADING CONDITIONS IN THE PRESENCE OF $\alpha$ - $\mu$ INTERFERENCE

*Danijel Djosić, University of Priština, Faculty of Natural Sciences and Mathematics, Kosovska Mitrovica, Serbia*

*Dejan Milic, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

*Zorica Nikolic, University of Niš, Faculty of Electronic Engineering, Niš, Serbia*

*Petar Spalević, University of Priština, Faculty of Technical Sciences, Kosovska Mitrovica, Serbia*

In this paper, wireless mobile communication system operating over interference limited environment in the presence of fading is considered. Received signal experiences Weibull fading, and co-channel interference experiences  $\alpha$ - $\mu$  small scale fading, resulting in system performance degradation. First and second order performance measures are considered and efficiently evaluated. The influence the Weibull fading severity parameter and  $\alpha$ - $\mu$  fading severity parameter on level crossing rate is analyzed and discussed.

#### TEI2.7

##### TOA/TDOA ESTIMATION BASED ON CARRIER PHASE OF ARRIVAL

*Nenad Vukmirović, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

*Miloš Janjić, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

*Miljko Erić, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

This paper analyzes the performance of two coherent time (difference) of arrival (TOA/TDOA) estimation algorithms based on carrier phase of arrival (CPOA) principle, previously proposed by the authors. The algorithms are applied to a time and phase synchronized two-channel system. TDOA estimation is performed when the both channels are receivers, whereas TOA estimation is performed in the case of one transmitter and one receiver. The paper presents a detailed analysis of estimation error distribution using estimated cumulative density functions (CDFs) when the ambiguity is or is not resolved, for different system parameters



(such as carrier frequency, signal bandwidth, and signal-to-noise ratio (SNR)). The results are compared with the Cramér-Rao Bounds (CRBs), previously derived by the authors, and with the results of non-coherent estimation.

TEI2.8

#### SOFTWARE FOR MONITORING OF DIRECT PATH TEST DATA FOR HFSW OVER THE HORIZON RADAR

*Pavle Petrović, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

*Nemanja Grbić, University of Belgrade, School of Electrical Engineering, Belgrade, Serbia*

*Bojan Džolić, Vlatacom Institute of High Technologies, Belgrade, Serbia*

*Nikola Lekić, Vlatacom Institute of High Technologies, Belgrade, Serbia*

*Miroslav Perić, Vlatacom Institute of High Technologies, Belgrade, Serbia*

High frequency surface wave over the horizon radar - HFSW-OTHR is very effective solution for monitoring sea area of exclusive economic zone. With a range of up to 200 NM HFSW-OTHR has a considerable advantage over conventional microwave radars. Unfortunately, HF propagation and overall noise levels are very dependent on the time of day/night, season of the year and geographic location where it is installed. Thus, usage of the HFSW-OTHR requires constant monitoring, adjustment and optimization of system parameters in order to achieve maximum performance. In this paper we describe the software solution which primarily monitors noise level, transmitter to receiver crosstalk and nonlinear distortion. Experimental results obtained from the HFSW-OTHR installation on the equatorial area coast line are given.

### Session TEI3: Telecommunications

Tuesday, June, 12<sup>th</sup>, 16:00 – 16:30, Hall 3

**Chair: Zoran Stamenković, IHP, Frankfurt (Oder), Germany**

TEI3.1

#### SIMULATION OF SIMULTANEOUSLY FED 16-CHANNEL DWDM EDFA USING DIFFERENT PUMPING SCHEMES

*Hisham Alhejazi, Alfa BK University, Faculty of Information Technology, Belgrade, Serbia*

*Nebojsa Denic, Alfa BK University, Faculty of Information Technology, Belgrade, Serbia*

In this paper, we present the performance of a simultaneously fed 16 channel dense wave division multiplexing (DWDM) erbium-doped fiber amplifier (EDFA) using different pumping schemes (co-directional pumping, counter-directional pumping and bi-directional pumping). The performance of the amplifier is evaluated by means of simulation models in Optisystem software. The amplifier is characterized in terms of its gain and noise figure under different pumping power (75 mW and 150 mW) and laser wavelength (980nm and 1480 nm). A comparison study between the different schemes is presented.

TEI3.2

#### PERFORMANCE OPTIMIZATION OF MULTICHANNELS DWDM EDFA BASED ON DIFFERENT PUMPING WAVELENGTH

*Hisham Alhejazi, Alfa BK University, Faculty of Information Technology, Belgrade, Serbia*

*Nebojsa Denic, Alfa BK University, Faculty of Information Technology, Belgrade, Serbia*

In this paper, we present the performance of a simultaneously fed multi channels (16 channels) dense wave division multiplexing (DWDM) erbium-doped fiber amplifier (EDFA) using two different pump wavelengths (980 and 1480nm). The performance of the amplifier will be evaluated by means of simulation models in

Optisys software. The amplifier is characterized in term of its gain and noise figure under different pump wavelengths. A comparison study between the different schemes is investigated.

## **Sesija TE1: Telekomunikacije**

Utorak, 12. Jun, 16:30 – 18:00, Sala 3

**Predsedavajući: Zoran Stamenković, IHP, Frankfurt (Oder), Germany**

### TE1.1

#### ANALIZA PERFORMANSI TAKTIČKIH RADIO-KOMUNIKACIONIH MREŽA U PRENOSU PODATAKA

*Sasa Devetak, Univerzitet odbrane u Beogradu, Vojna akademija, Beograd, Srbija*

*Radovan Dragovic, Univerzitet odbrane u Beogradu, Vojna akademija, Beograd, Srbija*

*Jovan Bajcetic, Univerzitet odbrane u Beogradu, Vojna akademija, Beograd, Srbija*

U radu su prikazani rezultati istraživanja performansi vojnih taktičkih radio-komunikacionih mreža VF i VVF opsega u cilju analize prenosa podataka primenom e-mail servisa. U cilju analize prenosa podataka formirane su dve radio-komunikacione mreže, konfigurisani vojni radio-komunikacioni uređaji VF i VVF opsega u različitim režimima rada i istražene veličine potrebnih datoteka (poruka) za prenos na osnovu dokumenata koja se razmenjuju u vojnim operacijama. Na opisanom scenariju izvršena su merenja vremena prenosa podataka za različite veličine datoteka (dokumenata) i analizirane performanse prenosa. Komparativnom analizom rezultata analize izvedeni su značajni zaključci vezani za mogućnosti prenosa podataka u taktičkim radio-komunikacionim mrežama.

### TE1.2

#### MODELOVANJE PERIODIČNIH PROMENA NIVOVA PRIJEMNOG SIGNALA USMERENE MIKROTALASNE RADIO KOMUNIKACIJE IZAZVANIH SUNČEVIM ZRAČENJEM

*Jovan Bajcetić, Univerzitet odbrane u Beogradu, Vojna akademija, Beograd, Srbija*

*Milenko Andrić, Univerzitet odbrane u Beogradu, Vojna akademija, Beograd, Srbija*

*Branislav M. Todorović, Univerzitet odbrane u Beogradu, Vojna akademija, Beograd, Srbija*

*Aleksandra Nina, Univerzitet odbrane u Beogradu, Vojna akademija, Beograd, Srbija*

Rad predstavlja model jutarnjeg slabljenja prijemnog nivoa radio signala usmerene mikrotalasne komunikacije koji je razvijen na bazi višegodišnjeg istraživanja uticaja Sunčevog zračenja na propagacione karakteristike troposfere. U istraživanju su korišćeni nemođulisani, horizontalno polarizovani elektromagnetski talasi u frekventijskom opsegu od 2,4 do 5 GHz čiji je nivo signala na prijemu celodnevno meren. Da bi se adekvatno modelovala ustanovljena promena zavisna od frekvencije nosioca radio signala, period u kojem prikazani model važi je ograničen na vreme od trenutka izlaska Sunca do kraja vremenskog intervala od 5 sati i 30 minuta.

### TE1.3

#### UTICAJ QUIC PROTOKOLA NA TRADICIONALNE MEHANIZME NADGLEDANJA MREŽNIH TOKOVA

*Pavle Vuletic, Univerzitet u Beogradu, Elektrotehnički fakultet, Beograd, Srbija*

*Slavko Gajin, Univerzitet u Beogradu, Elektrotehnički fakultet, Beograd, Srbija*

QUIC protokol je nov transportni protokol čija standardizacija još uvek nije završena. Uprkos tome već danas čini značajan deo Internet saobraćaja i neophodno mu je posvetiti pažnju zbog njegove interakcije sa uređajima i alatima koji su nastali u vreme kada nije bio uveden. Zbog promena koje nosi u načinu rada poput kontrole toka na aplikativnom nivou, enkripcije kontrolnih poruka ili multipleksiranja više tokova u okviru jedne sesije, QUIC protokol je manje transparentan i predstavlja izazov za tradicionalne mehanizme

nadgledanja mreža. U ovom radu je data kratka analiza dinamike QUIC protokola i načina na koji se uočava njegovo prisustvo u računarskim mrežama zabeležena na reprezentativnom uzorku AMRES mreže, kao i diskusija o pravcu u kojem bi trebalo da se promene tradicionalni mehanizmi praćenja rada mreža kako bi se na kvalitetniji način nadgledao i ovaj protokol.

#### TE1.4

##### ROMING U IEEE 802.11 MREŽAMA

*Danilo Lazović, Vojska Srbije, Beograd, Srbija*

*Zoran Stanković, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

*Jovan Bajčetić, Univerzitet odbrane u Beogradu, Vojna akademija, Beograd, Srbija*

Savremene Wi-Fi mreže koje su zasnovane na IEEE 802.11n, IEEE 802.11ac standardima predstavljaju

važnu klasu bežičnih računarskih mreža koje danas imaju sve masovniju upotrebu u svim sferama društvenog života. Arhitekture ovih mreža imaju sve veću zonu pokrivenosti i u sebe ugrađuju sve veći broj AR (access point) uređaja preko kojih klijenti mreže pristupaju Internet servisima. Veoma važna osobina ovih mreža je mogućnost rominga korisnika između AR uređaja bez gubitka Internet sesije i značajne degradacije u saobraćaju prema Internetu koji bi korisnici servisa mogli da primete. Stoga se danas alatima za analizu rada i merenje performansi mreže u uslovima vršenja rominga posvećuje velika pažnja. U skladu sa tim, ovaj rad je posvećen proučavanju mehanizama izvršenja rominga u IEEE 802.11 mrežama i njegovoj eksperimentalnoj karakterizaciji.

#### TE1.5

##### ANALIZA PAKETSKOG SAOBRAĆAJA VVF RADIO MREŽE MALOG KAPACITETA

*Danilo Stanojević, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

*Dimitrije Stojanović, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija*

*Boban Pavlović, Univerzitet odbrane u Beogradu, Vojna akademija, Beograd, Srbija*

Bežične radio mreže za prenos paketskih podataka zasnivaju se na brzom formiranju i sa zaštićenim komunikacionim tokovima. Ovakve mreže se formiraju u VVF frekvencijskom opsegu primenom frekvencijskog skakanja i tehnike pristupa medijumu zasnovane na CSMA/CD (Carrier Sense Multiple Access – Collision Detection) principu. Komunikaciju je moguće ostvariti na udaljenosti do nekoliko desetina kilometara. Prenos je zaštićen primenom modulacionih tehnika za prenos i ključevima koji se implementiraju u same uređaje za prenos informacija. Ovakve mobilne zaštićene ad-hoc mreže imaju brzine prenosa svega nekoliko desetina kb/s, što je često ograničavajući faktor prilikom prenosa paketa. Za realizaciju ovog istraživanja izrađena je aplikacija u programskim paketima Microsoft Visual Studio 2013 i Microsoft SQL Server 2012. U radu je prikazan i analiziran jedan realni mrežni scenario zaštićene ad-hoc radio mreže u kojoj su ispitane mogućnosti mreže sa aspekta prenosa fajlova u novoizrađenoj aplikaciji. Rezultati testiranja radio mreže su omogućili definisanje optimalne količine informacija koja može da se prenese u zahtevanom vremenu kroz radio mrežu.

#### TE1.6

##### REALIZACIJA SERVERA ZA REPRODUKCIJU ADAPTIVNIH AUDIO I VIDEO TOKOVA

*Nikola Mitic, Naučno istraživački institut RT-RK, Beograd, Srbija*

*Nikola Bezanic, Naučno istraživački institut RT-RK, Beograd, Srbija*

*Nikola Vranic, Naučno istraživački institut RT-RK, Beograd, Srbija*

*Djordje Glisic, Naučno istraživački institut RT-RK, Beograd, Srbija*

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U radu je dat opis realizacije servera za adaptivnu isporuku video/audio sadržaja u uslovima promenljivog propusnog opsega mrežne veze sa udaljenim serverom. Adaptivna isporuka doprinosi unapređenju

korisničkog iskustva prilikom reprodukcije multimedijalnih sadržaja koji obezbeđuje udaljeni servis. Serverski deo rešenja je implementiran u formi Node.js JavaScript servera koji originalni video/audio snimak prevodi u niz segmenata pogodnih za adaptivni prenos, koristeći nekoliko alata i tehnika koje su u radu detaljno opisane. Takođe, dat je i opis klijentske aplikacije, koja vrši reprodukciju sadržaja sa servera na dva načina: 1) uz pomoć popularne Android ExoPlayer biblioteke i 2) pomoću Android biblioteke za integraciju ulaznog televizijskog sadržaja poznate pod nazivom TV Input Framework (TIF).

# VI Artificial Intelligence / Veštačka inteligencija

## Session VIII1: Artificial intelligence and machine learning

Thursday, June, 14<sup>th</sup>, 8:00 – 9:30, Hall 2

**Chair: Milan Milosavljević, Singidunum University – Technical Faculty, Belgrade, Serbia**

### VIII.1

#### DEEP NEURAL NETWORK SPEECH SYNTHESIS BASED ON ADAPTATION TO AMATEUR SPEECH DATA

*Tijana Delić, Faculty of technical sciences, University of Novi Sad, Novi Sad, Serbia*

*Siniša Suzić, Faculty of technical sciences, University of Novi Sad, Novi Sad, Serbia*

*Milan Sečujski, Faculty of technical sciences, University of Novi Sad, Novi Sad, Serbia*

*Vladimir Ostojić, Faculty of technical sciences, University of Novi Sad, Novi Sad, Serbia*

The paper investigates problems related to the automatic creation of personalized text-to-speech (TTS) synthesizers using small amounts of speech data recorded by amateur speakers in home conditions. The personalization of a synthesizer is based on the adaptation of a neural network based model pretrained on a large quantity of high-quality speech data recorded by a professional voice talent. In practice, both the quantity and the quality of target speaker's data used in the adaptation process are significantly inferior to the original training material. This research analyses the quality of synthesis created by adaptation on amateur data with the quality of synthesis created by adaptation on a high-quality speech dataset of the same size. The results of subjective and objective evaluation confirm the usability of the proposed adaptation method for efficient creation of new amateur TTS voices using a limited amount of adaptation data.

### VIII.2

#### POTENTIALS OF USING ARTIFICIAL INTELLIGENCE AND EEG DATA IN ELECTRONIC ASSESSMENTS

*Milos Antonijevic, Informatics and Computing Department, University Singidunum, Belgrade, Serbia*

*Goran Shimic, Center for Simulations and Distance Learning, Military Academy, University of Defense, Belgrade, Serbia*

*Aleksandar Jevremovic, Informatics and Computing Department, University Singidunum, Belgrade, Serbia*

*Mladen Veinovic, Informatics and Computing Department, University Singidunum, Belgrade, Serbia*

One of the important goals of electronic assessments is to achieve the smallest measurement error, with as simple and shorter tests as possible. Activities for achieving this goal are usually directed towards the iterative optimization of the pool of questions. An aspect that is not often considered is an analysis of the psychological state of the respondents during the answering of questions. In this paper, we present our current results in examining the potential of EEG data for the optimization of electronic ratings, as well as the technical platform for this purpose.

### VIII.3

#### SECRET KEY AGREEMENT BY PUBLIC DISCUSSION FROM EEG SIGNALS OF PARTICIPANTS

*Milan Milosaljević, Technical Faculty, Singidunum University, Belgrade, Serbia*

*Saša Adamović, Informatics and Computing Department, University Singidunum, Belgrade, Serbia*

*Aleksandar Jevremovic, Informatics and Computing Department, University Singidunum, Belgrade, Serbia*

*Miloš Antonijević, Informatics and Computing Department, University Singidunum, Belgrade, Serbia*

This paper presents a new protocol for establishing sheared secret cryptographic keys based on common randomness with an unlimited public discussion over an authenticated channel. The source of common randomness lies in the mental states of the participants, measured by multi-channel EEG transducers. The

first experimental results show that just one session of 10 to 15 minutes, can produce an absolutely secret shared key which size is over one hundred bits. A third party, which follows all the steps of the protocol, except the knowledge of the image that causes the mental states of the legal parties, does not have the ability to obtain any information about the established secret key

#### VIII.4

##### DETECTION OF CAUSAL RELATIONSHIPS BASED ON MATCHED PAIRS DESIGN

*Nebojša Milosavljević, BetterDoctor, Inc. 945 Bryant St, San Francisco, CA 94103*

*Milan Milosavljević, Technical Faculty, Singidunum University, Belgrade, Serbia*

In this paper we demonstrate power of so called matched pairs design (MPD), a special case of the randomized block design in revealing hidden causality links. However, unlike the others, this design explicitly controls for potential lurking variables. Detecting causal relationships becoming very important step in designing invariant machine learning systems. We illustrate power of this method answering particular question: does the price of totaled cars depends on selling location t.

#### VIII.5

##### ASSOCIATIVE WORD GROUPING ANALYSIS USING NATURAL LANGUAGE PROCESSING

*Nebojša Grujić, College of Applied Technology Science, Aranđelovac, Serbia*

*Gradimir Milovanović, Faculty of Engineering, University of Kragujevac, Kragujevac, Serbia*

In this work we analyze the possibility of machine learning solution in the area of natural language processing, applied on solving the association puzzle from the popular television quiz “Slagalica”. We find that it is possible to predict a correct solution at a certainty of about 70% within 100 most probable words. We also delve into the cases that did not fare well, and look into ideas of improving the result.

#### VIII.6

##### EKSTRAKCIJA KLJUČNIH IZRAZA IZ TEKSTA ANALIZOM GRAFA SUSEDSTVA IZRAZA

*Željana Vučetić, Ministarstvo odbrane, Beograd, Srbija*

*Zoran Denda, Ministarstvo odbrane, Beograd, Srbija*

U ovom radu biće opisan postupak ekstrakcije ključnih izraza iz teksta. Ekstrakcija ključnih izraza iz teksta biće realizovana kombinovanom primenom metoda i tehnika procesiranja teksta i metrika centralnosti definisanih nad grafovima, i implementirana u formi RESTful Veb servisa korišćenjem Java programskog jezika. Kako bi se stekao uvid u performanse i mogućnosti servisa, biće data uporedna analiza uspešnosti ekstrakcije ključnih izraza iz različitih tipova teksta..