ПРОГРАМ
И ЗБОРНИК АПСТРАКАТА
LXIX конференције ЕТРАН
и 12. међународне конференције ИцЕТРАН

PROGRAM
AND BOOK OF ABSTRACTS
LXIX ETRAN Conference
and 12th International Conference IcETRAN

Чачак, 9 - 12. јуна 2025. године
Čačak, Serbia, 9 - 12, June, 2025.

ICETRAN

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Електроника
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Програм и зборник апстраката
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Поштовани учесници LXIX конференције ЕТРАН и XII конференције ИцЕТРАН,

Пред вама су најновији резултати истраживања близу шест стотина педесет научника, истраживача, стручњака и докторских студената из земље и иностранства представљени у 230 прихваћених научних радова и саопштења. Они представљају најновија достигнућа у раду истраживачких тимова и тиме дају прилику да се добије преглед стања данашње науке из области електротехнике и рачунарства у Србији, региону, па и свету.

За овогодишње конференције ЕТРАН и ИцЕТРАН поднето је 260 пријава радова, од којих је после вишеструких рецензија прихваћено 232 (проценат прихваћености је 89,2 %). Од тога је за конференцију ЕТРАН примљено 75 радова, а за ИцЕТРАН 157 радова. Радови долазе од аутора из 22 земље, што указује на широк интерес и висок међународни карактер конференција. У том процесу на располагању је био пул од 689 међународно признатих рецензената, од којих је активно учествовало 237. Прихваћени радови су уврштени у програм у склопу две пленарне, пет специјалних и тридесет редовних седница (сесија) унутар четири конференцијска дана.

На уводном, пленарном заседању три позвана (Key Note) предавања дају приказ најновијих, врхунских истраживања у областима вештачке интелигенције, енергетске електронике и телекомуникација од стране високо цењених научника и истраживача из САД, Аустрије и Израела. Поред тога, у уводном излагању председник ЕТРАН-а подсећа на седам деценија од прве конференције, на бурну и богату историју нашег удружења. Још једно позвано пленарно предавање даје увид у савремене трендове примене нуклеарне енергије у свету. Посебну вредност и актуелност имају чак десет позваних радова и саопштења истакнутих домаћих и страних аутора из Канаде, Северне Македоније, Чешке, Немачке и Србије реферисаних у склопу одговарајућих секција ЕТРАН-а. Додатно, на специјалним и придруженим сесијама представљају се новине из области техника херитологије, форензике, дигитализације у науци, топлотних преформанси сложених структура, те мулти-дисциплинарних истраживања, као и примене најновијих метода у едукацији студената.

У склопу „Индустријског дана“, програм је обогаћен великом изложбом најновијих достигнућа познатих компанија из области електротехнике и рачунарства, и низом предавања присутних фирми намењених студентима и инжењерима из области. Ово је већ други пут да се оваква представљања организују у склопу конференција ЕТРАН/ИцЕТРАН, али сада са значајнијим присуством излагача, на преко двадесет штандова. У оквиру тога одржава се и панел сесија „Индустрија будућности: Улога вештачке интелигенције у модернизацији савремене превреде“, прилика да домаћи и страни стручњаци размене мишљења и искуства о овој технологији будућности.

Као и увек, секције ће на посебним састанцима изабрати најбоље радове (Best Paper Award), као и најбоље радове младих аутора (Best Young Author Award), а уручење награда ће бити на посебној свечаности конференције. Удружење за ЕТРАН одржаће своју редовну годишњу скупштину, а још низ

паралелних активности, као састанци подружница и група ИЕЕЕ секције за Србију и Црну Гору, те презентације међународних пројеката DGTRANS (Transport of Dangerous Goods), PELMOB (Partnership for Promotion and Popularization of Electrical Mobility through Transformation and Modernization of WB HEIs Study Programs) и SPHERE (Sustainable transportation within the framework of green deal) додатно обогаћују програм рада. Није запостављен ни стручно-културни аспект чачанског краја – предвиђен је обилазак Овчарско-кабларске клисуре са посетом хидроелектрани „Овчар бања“, природњачком музеју у Овчар бањи и манастиру Благовештење.

Овогодишње ЕТРАН и ИцЕТРАН конференције указују да се наставља раст интересовања за овакав вид научне комуникације, односно жеље да се у директном контакту размене и продискутују најновији научни резултати, истраживачка достигнућа и практична искуства, као и да се успоставе контакти за будућу сарадњу и пројекте. Број пријављених и прихваћених радова је значајан, упркос сложеној ситуацији у савременом друштву, а очекује се присуство близу 350 учесника.

Конференције се организују под покровитељством Министарства науке, технолошког развоја и иновација Републике Србије, те уз техничку подршку научних удружења ЦИРЕД, ТЕЛФОР, МТТС и Енергетска електроника. Поред тога, технички коспонзор је и најпознатије светско удружење инжењера електротехнике и електронике ИЕЕЕ, преко своје регионалне организације ИЕЕЕ – Регион 8, односно својих секција и подружница у Србији и Црној Гори, те Босни и Хецеговини. Кроз сарадњу са ИЕЕЕ омогућено је да се радови са конференције ИцЕТРАН уврсте у дигиталну библиотеку IEEE Xplore и тиме добију најширу светску видљивост, те потенцијану цитираност у најзначајнијим светским цитатним базама Web of Science, Scopus и Google Scholar.

После 20 година ЕТРАН се враћа у Чачак, сада са две своје конференције у сарадњи са Факултетом техничких наука, који слави 50 година постојања, као и са Универзитетом у Приштини са привременим седиштем у Косовској Митровици. То је пре свега заслуга великог ентузијазма и енергије декана факултета, проф. др Владимира Младеновића, као и његових сарадника проф. др Марка Росића, проф. др Небојше Митровића, проф. др Бранка Копривице, проф. др Јелене Пуреновић и других на чему смо им веома захвални. Посебну захвалност дугујемо ректору Универзитета у Приштини са привременим седиштем у Косовској Митровици проф. др Небојши Арсићу на активној улози у организацији и реализацији ових конференција.

Чачак, као овогодишња национална престоница културе, за ових неколико конференцијских дана постаће и престоница науке Србије. Традиционална гостољубивост Чачана, изузетни просторни и технички услови на месту одржавања, те пријатна атмосфера гарантују успех конференције.

Председник Друштва за ЕТРАН
проф. др Владимир Катић

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ДЕСК ЗА РЕГИСТРАЦИЈУ

Радно време Деска:	
Недеља 8. јун 2025.	17:30 - 18:00
Понедељак, 9. јун 2025.	08:45 - 13:00 и 15:00 - 16:30
Уторак, 10. јун 2025.	08:45 - 13:00 и 15:00 - 16:30
Среда, 11. јун 2025.	08:45 - 10:30

Скраћенице:

	IcETRAN	ЕТРАН
Електроника	ELI	ЕЛ
Телекомуникације	TEI	ТЕ
Рачунарство	RTI	РТ
Аутоматика	AUI	АУ
Нуклеарна техника	NTI	НТ
Акустика	AKI	АК
Антене и простирање	API	АП
Вештачка интелигенција	VII	ВИ
Електрична кола, електрични системи и обрада сигнала	EKI	ЕК
Електроенергетика	EEI	ЕЕ
Биомедицинска техника	BTI	БТ
Метрологија	MLI	МЛ
Нови материјали	NMI	НМ
Микроелектроника и оптоелектроника	MOI	МО
Микроталасна техника, технологије и системи	MTI	МТ
Роботика и флексибилна аутоматизација	ROI	РО
Едукација	EDUI	ЕДУ

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15. Београдска академија пословних и уметничких струковних студија, Београд
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19. Државни Универзитет у Новом Пазару, Нови Пазар
20. Факултет техничких наука, Косовска Митровица
21. Академија струковних студија косовско метохијска, Лепосавић
22. Машински факултет, Београд
23. НТ парк Чачак
24. Институт за нуклеарне науке „Винча“, Универзитет у Београду, Институт од националног значаја за Републику Србију

Распоред дешавања на LXIX Конференцији ЕТРАН

Понедељак, 9. јун 2025 у 17:00 (Сала 1)
СВЕЧАНО ОТВАРАЊЕ
Проф. др. Владимир Младеновић: Поздравне речи
Проф. др Небојша Арсић: Поздравне речи
Проф. др Владимир Катић: Поздравне речи

Понедељак, 9. јун у 17:30 (Сала 1)
УВОДНА ПРЕДАВАЊА

Ron Dabora
Ben Gurion University and Princeton University Beersheva, Israel
„Interference-limited communications: Models, Inherent Limits, and Insights“

Војислав Кецман
Virginia Commonwealth University (VCU) in Richmond, USA
„Artificial Intelligence – Myth or reality: The Third Golden Age”

Петар Грбовић
Innsbruck Power Electronics Laboratory (i-PEL), Institute of Mechatronics, University of Innsbruck
„Current Source PWM Converters -From Past to the Future-”

Понедељак, 9. јун 2025. у 19:00
КОКТЕЛ

Уторак, 10. јун 2025. у 9:00 – 16:00 (Атријум културног центра Чачак)
Изложба компанија – спонзора
Координатор: проф. др Марко Росић

Уторак, 10. јун 2025. у 10:00 – 12:00 (КЦ Чачак)
Представљање компанија:
Златни спонзори

Уторак, 10. јун 2025. у 12:00 – 13:00 (КЦ Чачак)
Представљање компанија:
Сребрни спонзори

Уторак, 10. јун 2025. у 12:45 – 13:00 (КЦ Чачак)
Презентација тима ФТН освајача Главне награде на престижном међународном такмичењу Huawei ICT Competition 2024–2025 Global Final

Уторак, 10. јун 2025. у 13:00 – 14:00 (КЦ Чачак)
Индустријска сесија – панел дискусија
„Индустрија будућности: Улога вештачке интелигенције у модернизацији савремене привреде
Панелисти:
Представници компанија
Модератор: проф. др Недељко Дучић

Уторак, 10. јун 2025. у 14:00 – 15:00
КОКТЕЛ КОМПАНИЈА

Уторак, 10. јун 2025. у 15:00 – 16:00 (Сала 6)
Придружена сесија - Дигитализација у науци
Координатор: проф. др Даница Мамула Тартаља

Уторак, 10. јун 2025. у 16:00 – 17:15 (Сала 6)
Придружена сесија - Херитологија
Координатор: проф. др Магдалена Драговић

Уторак, 10. јун 2025. у 17:30 – 18:15 (Сала 1)
УВОДНО ПРЕДАВАЊЕ

Весна Спасић-Јокић
Универзитет у Новом Саду, ФТН, Нови Сад
„Савремени трендови у активностима међународне агенције за атомску енергију“

Уторак, 10. јун 2025. у 18:15 (Сала 1)
СКУПШТИНА ДРУШТВА ЗА ЕТРАН
Проф. др Владимир Катић

In Memoriam: проф. др Милић Ђекић
In Memoriam: др Зоран Јакшић

Уторак, 10. јун 2025. у 20:00 ресторан „МОРАВА“
ДОДЕЛА НАГРАДА ЗА НАЈБОЉЕ РАДОВЕ ЕТРАН-ИЦЕТРАН 2025

СВЕЧАНА ВЕЧЕРА

Среда, 11. јун 2025. у 9:00 -11:00 (Сала 1)

Придружена сесија - Форензика

Координатор: проф. др Радован Радовановић

Среда, 11. јун 2025. у 9:00 -11:00 (Сала 2)

Придружена сесија – Топлотне перформансе

Координатор: проф. др Радован Госпавић

Среда, 11. јун 2025. у 9:00 -11:00 (Сала 3)

Мултидисциплинарна

Координатор: проф. др Милеса Срећковић

Среда, 11. јун 2025. у 11:15 - 16:00

Излет – Овчар бања – обилазак ХЕ

Среда, 11. јун 2025. у 16:00 - 17:00

Састанак IEEE

Четвртак, 12. јун 2025. од 9:00 - 10:45 (Сала 1)

ПРЕЗЕНТАЦИЈА ПРОЈЕКАТА ERASMUS +

PROJECT: DGTRANS *од 9:00 – 9:45*

„Transport of Dangerous Goods - Modernization of Curricula and Development of Trainings for Professionals in the Western Balkans HEIs"

PROJECT: PELMOB *од 9:45 – 10:15*

" Partnership for Promotion and Popularization of Electrical Mobility through Transformation and Modernization of WB HEIs Study Programs"

PROJECT: SPHERE *од 10:15 – 10:45*

"Sustainable transportation within the framework of green deal"

Модератор: проф. др Небојша Арсић, ректор Универзитета у Приштини са привременим седиштем у Косовској Митровици

Четвртак, 12. јун 2025. од 12:45 - 13:45

*** ПОСЕТА НТ ПАРКУ У ЧАЧКУ**

* Опционо, према броју пријављених

Electronics
Telecommunications
Computing
Automatics
Nuclear engineering

Program and

Book of Abstracts

LXIX Conference ETRAN
and
12th International Conference IcETRAN 2025

Čačak, Republic of Serbia
June 9 - 12, 2025.

Dear participants of the 69th ETRAN Conference and the 12th IcETRAN Conference,

Before you are the latest research results of nearly six hundred and fifty scientists, researchers, experts, and doctoral students from the country and abroad, presented in 230 accepted scientific papers and communications. They represent the latest achievements in the work of research teams and thus provide an opportunity to obtain an overview of the state of the art of today's science in the field of electrical and computer engineering in Serbia, the region, and even the world.

In total, 260 papers for this year's ETRAN and IcETRAN conferences were submitted, of which 232 were accepted after multiple reviews (the acceptance rate is 89.2%). Of these, 75 papers are included in the program of the ETRAN, while 157 papers are in the program of the IcETRAN conference. The papers arrived from authors from 22 countries, which indicates the broad interest and high international character of the conferences. A pool of 689 internationally recognized reviewers was available in this process, of which 237 actively participated. Accepted papers are included in the program as part of two plenary, five special, and thirty regular sessions within four conference days.

At the opening plenary session, three Keynote lectures provide an overview of the latest, cutting-edge research in the fields of artificial intelligence, power electronics, and telecommunications by highly respected scientists and researchers from the USA, Austria, and Israel. In addition, in the introductory speech, the President of ETRAN recalls the seven decades since the first conference and the turbulent and rich history of our association. The fourth Keynote lecture provides insight into contemporary trends in the application of nuclear energy. Of particular value and relevance are ten invited papers and lectures by prominent authors from Canada, North Macedonia, the Czech Republic, Germany, and Serbia, referred to in the relevant sections of the ETRAN. In addition, special and associated sessions present novelties in the field of heritology techniques, forensics, digitalization in science, thermal performance of complex structures, and multidisciplinary research, as well as the application of the latest methods in student education.

As a part of the "Industrial Day", the program was enriched with a large exhibition of the latest achievements of well-known companies in the field of electrical and computer engineering, and a series of lectures by the attending companies intended for students and engineers in the field. This is the second time that such an exhibition has been organized as part of the ETRAN/IcETRAN conferences, but now with a more significant participation of exhibitors at over twenty stands. As a special event, a panel session "Industry of the Future: The Role of Artificial Intelligence in the Modernization of Modern Industry" is organized, at which domestic and foreign experts will exchange opinions and experiences on this technology of the future.

As always, the ETRAN´s sections will award the best papers (Best Paper Award) at their special meetings, as well as the best papers by young authors (Best Young Author Award), and the awards will be presented at a special conference ceremony. The ETRAN Association will hold its regular annual assembly, and several parallel

activities, such as meetings of branches and affinity groups of the IEEE Serbia and Montenegro Section are planned. Also, the presentations of international EU projects DGTRANS (Transport of Dangerous Goods), PELMOB (Partnership for Promotion and Popularization of Electrical Mobility through Transformation and Modernization of WB HEIs Study Programs), and SPHERE (Sustainable transportation within the framework of the Green Deal), further enrich the work program.

The professional and cultural aspect of the Čačak region has not been neglected either – a tour of the Ovčar-Kablar Gorge with a visit to the Ovčar Banja hydroelectric power plant, the Ovčar Banja Natural History Museum, and the Blagoveshtenje Monastery is planned.

This year's ETRAN and IcETRAN conferences indicate that interest in this type of scientific communication continues to grow and that the desire to exchange and discuss the latest scientific results, research achievements, and practical experiences in direct contact, as well as to establish new contacts for future cooperation and projects is very much "alive". The number of submitted and accepted papers is significant, despite the complex situation in society, so the attendance of nearly 350 participants is expected.

The conferences are organized under the patronage of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, and with the technical support of the scientific associations CIRED, TELFOR, MTTS, and Power Electronics. In addition, the most famous world association of electrical and electronics engineers, the IEEE, technically co-sponsors the IcETRAN conference, through its regional organization IEEE – Region 8, its chapters and branches in Serbia and Montenegro, and Bosnia and Herzegovina. Through cooperation with IEEE, it was possible to include the papers from the IcETRAN conference in the IEEE Xplore digital library, thereby gaining the widest global visibility and potential citation in the most important world citation databases Web of Science, Scopus, and Google Scholar.

After 20 years, the ETRAN is back in Čačak, in cooperation with the Faculty of Technical Sciences, which is celebrating its 50th anniversary, as well as with the University of Priština with its temporary seat in Kosovska Mitrovica. This is primarily due to the great enthusiasm and energy of the Dean of the Faculty, Prof. Dr. Vladimir Mladenović, as well as his associates Prof. Dr. Marko Rosić, Prof. Dr. Nebojša Mitrović, Prof. Dr. Branko Koprivica, Prof. Dr. Jelena Purenović and others, for which we are very grateful. We owe special gratitude to the Rector of the University of Priština with its temporary seat in Kosovska Mitrovica, Prof. Dr. Nebojša Arsić, for his active role in the organization and implementation of these conferences.

Čačak, as this year's National Capital of Culture, will also become the Capital of Science of Serbia during the conferences´ few days. The traditional hospitality of the people of Čačak, exceptional spatial and technical conditions at the conference venue, and the pleasant atmosphere guarantee the conference's success.

President of the Society for ETRAN

Prof. dr Vladimir Katic

IcETRAN – International Conference on Electrical, Electronic and Computing Engineering

Kneza Miloša 9/IV, 11000 Belgrade, Serbia
Phone: +381 11 3233 957, E-mail: office@etran.rs, https://www.etran.rs

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Prof. Jelica Protić, Belgrade, Serbia

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Mr. Zlatko Jarnević, ETRAN

CONFERENCE DESK

The registration desk of the IcETRAN conference will operate:	
Sunday, June 8th, 2025	17:00 – 18:00
Monday, June 9th, 2025	08:45 – 13:00 & 15:00 – 16:30
Tuesday, June 10th, 2025	08:45 – 13:00 & 15:00 – 16:30
Wednesday, June 11th, 2025	8:45 – 10:45
Thursday, June 12th, 2025	8:45 – 10:45

Acronyms:

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

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22. Faculty of Mechanical Engineering, University of Belgrade, Serbia
23. Science Technology Park Čačak
24. Vinča Institute of Nuclear Sciences, University of Belgrade, National Institute of Republic of Serbia

IcETRAN Events Program

Monday, June 9th, 2025, 17:00 (Hall 1)

OPENING CEREMONY

Prof. dr. Vladimir Mladenović: Welcome speech
Prof. dr. Nebojša Arsić: Welcome speech
Prof. dr Vladimir Katić: Welcome speech

Monday, June 9th, 2025, 17:30 (Hall 1)

KEY NOTE LECTURES

Ron Dabora
Ben Gurion University and Princeton University Beersheva, Israel
„Interference-limited communications: Models, Inherent Limits, and Insights“

Vojislav Kecman
Virginia Commonwealth University (VCU) in Richmond, USA
„Artificial Intelligence – Myth or reality: The Third Golden Age”

Petar Grbović
Innsbruck Power Electronics Laboratory (i-PEL), Institute of Mechatronics, University of Innsbruck
„Current Source PWM Converters -From Past to the Future-”

Monday, June 9th, 2025, 19:00

COCKTAILS

Tuesday, June 10th, 2025, 9:00 – 16:00 (The Cultural Centre of Čačak (Atrium))

EXHIBITION OF COMPANIES (SPONSORS)

Coordinator: Prof. dr Marko Rosić

Tuesday, June 10th, 2025, 10:00 – 12:00 (CC Čačak)

Company Presentations:
Gold sponsors

Tuesday, June 10th, 2025, 12:00 – 13:00 (CC Čačak)

Company Presentations:
Silver sponsors

Tuesday, June 10th, 2025, 12:45 – 13:00 (CC Čačak)

Presentation of the Team of FTS Čačak who won the Grand Prize at the presigious international Huawei ICT Competition 2024–2025 Global Final

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Tuesday, June 10th, 2025, 13:00 – 14:00 (CC Čačak)

INDUSTRY SESSION – PANEL DISCUSSION

„Industry of the Future: The Role of Artificial Intelligence in Modernizing the Economy"

Panelists: Company representatives

Moderator: Prof. dr Nedeljko Dučić

Tuesday, June 10th, 2025, 14:00 – 15:00 (CC Čačak)

COMPANY COCTAIL

Tuesday, June 10th, 2025, 15:00 – 16:00 (Hall 6)

ASSOCIATED SESSION - DIGITALISATION

Moderator: Prof. dr Danica Mamula Tartalja

Tuesday, June 10th, 2025, 16:00 – 17:15 (Hall 6)

ASSOCIATED SESSION - HERITOLOGY

Moderator: Prof. dr Magdalena Dragović

Tuesday, June 10th, 2025, 17:30 – 18:00 (Hall 3)

KEY NOTE LECTURES

Prof. Vesna Spasić Jokić

Faculty of Technical Sciences, University of Novi Sad, Serbia

„Modern activities of the International Atomic Energy Agency"

Tuesday, June 10th, 2025, 18:15 (Hall 1)

GENERAL ASSEMBLY of ETRAN SOCIETY

Prof. dr Vladimir Katić

In Memoriam: Prof. dr Milić Đekić

In Memoriam: Dr Zoran Jakšić

Tuesday, June 10th, 2025, 20:00, Restaurant „MORAVA"

AWARDS FOR BEST PAPERS ETRAN/ICETRAN2025

GALA DINNER

Wednesday, June 11th, 2025, 9:00 - 11:00 (Hall 1)

ASSOCIATED SESSION - FORENSICS

Moderator: Prof. dr Radovan Radovanović

Wednesday, June 11th, 2025, 9:00 - 11:00 (Hall 2)

ASSOCIATED SESSION - THERMAL PERFORMANCES

Moderator: Prof. dr Radovan Gospavić

Wednesday, June 11th, 2025, 9:00 – 11:00 (Hall 3)

ASSOCIATED SESSION - MULTIDISCIPLINARY

Moderator: Prof. dr Milesa Srećković

Wednesday, June 11th, 2025, 11:15 - 16:00

Excursion - Visit to Ovčar Spa and visit to PP

Wednesday, June 11th, 2025, 16:00 - 17:00 (Hall 1)

IEEE meeting

Thursday, June 12th, 2025, 9:00 – 10:45 (Hall 1)

ERASMUS + PROJECT PRESENTATIONS

PROJECT: DGTRANS *9:00 – 9:45*

„Transport of Dangerous Goods - Modernization of Curricula and Development of Trainings for Professionals in the Western Balkans HEIs"

PROJECT: PELMOB *9:45 – 10:15*

" Partnership for Promotion and Popularization of Electrical Mobility through Transformation and Modernization of WB HEIs Study Programs"

PROJECT: SPHERE *10:15 – 10:45*

"Sustainable transportation within the framework of green deal"

Moderator: Prof. dr Nebojša Arsić, Rector of University of Priština

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Thursday, June 12th, 2025, 12:45 – 13:45

*** Visit to STP Čačak**

*** Optional, according to number of aplicants**

ЗБОРНИК АПСТРАКАТА

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BOOK OF ABSTRACTS

OTVARANJE / OPENING SESSION

UVODNI RAD / INTRODUCTION PAPER

Понедељак, 9. јун / Monday, June 9th Сала 1 / Hall 1 17.00-17.30

Chair/Predsedavajući:
Vladimir Katić, Univerzitet u Novom Sadu, Fakultet tehničkih nauka, Novi Sad, Srbija
Dragan Mančić, Univerzitet u Nišu, Elektronski fakultet, Niš, Srbija

SEDAM DECENIJA KONFERENCIJE ETRAN

Vladimir Katić, Mirjana Jovanić

Ove godine navršava se sedam decenija od prve konferencije ETRAN-a, tada posvećene samo prvom slovu ETRAN-ove skraćenice - elektronici, održane davne 1955. god. u Beogradu. U burnoj i bogatoj istoriji, konferencija, koju je prvih godina vodilo i organizovalo Jugoslovensko društvo za ETAN, a danas Udruženje za ETRAN, postala je ključno i kultno mesto sastajanja naučnika, istraživača, stručnjaka i doktorskih studenata iz zemlje i inostranstva. Pokrenuta iz potrebe brzog razvoja jugoslovenske privrede, a inicirana iz tadašnje naučne i akademske zajednice, konferencija se ubrzo proširila na sve tadašnje nove, brzorastuće oblasti elektrotehnike - elektroniku, telekomunikacije, automatiku i nuklearnu tehniku, i postala poznata pod skraćenicom ETAN. Raspadom zajedničke države SFR Jugoslavije, konferencija je nastavila da živi u Srbiji. Tu je promenjen naziv u ETRAN, kako se danas zove konferencija, odnosno udruženje. U radu je dat kratak osvrt na stanje u društvu, istraživačkoj i akademskoj javnosti, koje je dovelo do prvih ideja o ovakvoj konferenciji, o osnivanju i radu Jugoslovenskog društva za ETAN, kao i daljem razvoju konferencije. Razmotreni su i razlozi za njenu internacionalizaciju i održavanje paralelne međunarodne konferencije IcETRAN. Ažurirani su i statistički podaci o radovima i autorima svih dosadašnjih konferencija, te diskutovani njeni dalji mogući pravci razvoja, kao vrhunskog i jedinstvenog naučnog okupljanja iz oblasti elektrotehnike i računarstva.

Ključne reči: ETAN/ETRAN konferencije, 70 godina, ETRAN/IcETRAN konferencije, Udruženje ETRAN

UVODNA PREDAVANJA / KEYNOTE LECTURES

Понедељак, 9. јун / Monday, June 9th Сала 1 / Hall 1 17.30-19.00

KEYNOTE (#7820)
INTERFERENCE-LIMITED COMMUNICATIONS: MODELS, INHERENT LIMITS, AND INSIGHTS

Ron Dabora

In this talk, we study the capacity of interference-limited channels with memory. These channels model non-orthogonal communications scenarios, such as the non-orthogonal multiple access (NOMA) scenario, and underlay cognitive communications, in which the interference from other communications signals is much stronger than the thermal noise. As communications signals are inherently cyclostationary in continuous time (CT), then, after sampling at the receiver, the discrete-time (DT) received signal model contains the sampled desired information signal with additive sampled CT cyclostationary noise. We first explain why the sampled noise can be modeled either as a DT cyclostationary process with memory or a DT almost-cyclostationary process with memory, where the latter case results in a channel that is not information-stable. Thus, analyzing this model requires the development of a new approach for channels with additive non-stationary noise that has memory. Our results show, for the first time, the relationship between memory, sampling frequency synchronization, and capacity, for interference-limited communications. The insights from our work provide a link between the analog and digital time domains, which has been missing in most previous works on capacity analysis. We also discuss related the design of DNN- aided network clock synchronization motivated by these results, and subsequent work on source coding for such processes.

Keywords: interference-limited channels, non-orthogonal multiple access (NOMA), additive non-stationary noise, DNN-aided network clock synchronization

KEYNOTE (#0700)
ARTIFICIAL INTELLIGENCE – MYTH OR REALITY: THE THIRD GOLDEN AGE

Vojislav Kecman

The lecture will present the origins of today's artificial intelligence (AI). It will present its roots in neural networks (NN), the blossoming period of NN, the appearance of support vector machines followed by a retreat of NN, the introduction of NN with many hidden layers coined as deep learning (DL), and rebirth of AI based on DL algorithms.

Keywords: artificial intelligence (AI), neural networks (NN), vector machines, deep learning (DL)

KEYNOTE (#3628)
CURRENT SOURCE PWM CONVERTERS - FROM PAST TO THE FUTURE -

Petar Grbović

Conversion efficiency, power density and converter cost are, today the most critical requirements for new applications. The first power converters were Voltage Source Converters, (VSC) based on the vacuum tubes as power switches and the, first work was reported in early 1930s. With the invention, of Bipolar Junction Transistor and Silicon Controlled, Rectifiers, the Current Source Converter topology become, dominant again.

Until late 1980s, the CSC dominated in most, of industrial applications. With the invention of the, MOSFETs in late 1970s and the IGBTs in late 1980, the VSC, become again dominant. Majority of power conversion, applications are based on PWM VSC with MOSFETs, IGBTs or, IGCTs. In recent years we have seen strong intertest in PWM, CSCs. It can be proven that in some applications the CSCs, could be superior over the VSCs. So far, there is not, significant penetration of CSCs into real applications., Until today there is not available switch with, Bi-Directional voltage blocking capability. The Key Note, starts with a introduction and comparison of VSCS and CSCs., Then, One-Quadrant (1Q) and multi-Quadrant (2Q &4Q), CSCs will be presented. Analysis of CSC cell and design, guidelines will be given. Three-phase single-cell and, multi-cell interleaved CSCs will be briefly addressed. Power semiconductor switches with Bi-Directional voltage, blocking capability, switch will be addressed. Finally, the, Key Note will be concluded with several case studies and, design details.

Keywords: power conversion, Power semiconductor switches, Bi-Directional voltage blocking

Уторак, 10. јун / Tuesday, June 10th Сала 1 / Hall 1 17.30-18.15

KEYNOTE (#0322)
САВРЕМЕНИ ТРЕНДОВИ У АКТИВНОСТИМА МЕЂУНАРОДНЕ АГЕНЦИЈЕ ЗА АТОМСКУ ЕНЕРГИЈУ

Весна Спасић-Јокић

Савремени трендови у активностима међународне агенције за атомску енергију.

Кључне речи: савремени трендови. међународна агенција, атомска енергија

ЕЛЕКТРОНИКА / ELECTRONICS

СЕСИЈА / SESSION (ЕЛ1+ELI1)

Понедељак, 9. јун / Monday, June 9th Сала 1 / Hall 1 9.00-10.45

Председавајући / Chair:
Marko Dimitrijević, Univerzitet u Nišu - Elektronski fakultet, Niš, Srbija

ELI1.1 (#2343)

EVALUATION OF MACHINE LEARNING MODELS FOR ENHANCING SYSTEM RELIABILITY

Jelena Nedeljković, Goran Nikolić, Marko Anđelković and Tatjana Nikolić

Ensuring hardware reliability in embedded systems with limited power is challenging, especially in error-prone environments. Traditional fault tolerance methods, like redundancy, are effective but costly in power and computation. This paper proposes a machine learning-based approach for real-time error detection in fixed-function computational blocks. Using supervised learning, the method predicts hardware behavior by comparing functional block outputs with a trained model. Various machine learning models are evaluated, with polynomial regression achieving the highest accuracy in approximating nonlinear functions like x^n. It achieved an R^2 of 1.000 on both training and test datasets, making it ideal for real-time error detection in embedded applications.

Keywords: System reliability, Machine learning models, Polynomial regression

EL1.1 (#2393)

RAZVOJ REGULATORA ZA BRZINU OBRTANJA JEDNOSMERNOG MOTORA

Vladimir Lapčević

U ovom radu je predstavljen razvoj uređaja za brzinu obrtanja jednosmernog motora. Uređaj je zasnovan na impulsno širinskoj modulaciji i integrisanom kolu L6203 koje predstavlja H-most. Ovaj rad predstavlja spoj energetske elektronike, DC motora i mikrokontrolera. Dva tastera se koriste da povećaju i smanje rotacionu brzinu koja se vidi na ugrađenom displeju.

Keywords: DC motor, H most, PWM signal, mikrokontroler

ELI1.2 (#2500)

UTILITY LOSSES DUE TO ELECTRIC VEHICLE CHARGING

Milan Stojanovic, Dejan Stevanovic, Marko Dimitrijevic and Dragan Vuckovic

The increasing presence of nonlinear loads in modern power systems has significantly changed energy consumption patterns. As these loads increase, active power becomes less dominant in the overall power delivery, leading to a greater dominance of reactive and distortion power components. Since utility mainly measures active power/energy, unaccounted losses result in grid inefficiency. This paper will focus on the losses introduced by electric vehicle chargers due to their nonlinear characteristics. The impact of reactive and distortion power on overall energy losses will be highlighted, emphasizing the need for improved measurement techniques and loss reduction strategies to enhance power system efficiency.

Keywords: Electric vehicle charging, Utility losses, Non-linear loads, Power measuring

ELI1.3 (#6319)

EFFECT OF SOLAR AND WEATHER PARAMETERS ON LSTM-BASED MODEL PREDICTIONS OF SOLAR POWER PRODUCTION

Novak Radivojević, Uroš Ilić, Andrija Petrušić and Miona Andrejević Stošović

This paper discusses the process of training a neural network intended for predicting power generation in a solar power plant based on meteorological data and the historical data of power measurement readings. Initially, the neural network was trained on a wide array of different solar and weather quantities as inputs (26 in total), but since the prediction errors of this model were considerably large, the model was retrained, but on a much smaller subset of critical input variables, which resulted in an increase of accuracy where MAE dropped significantly.

Keywords: solar, weather, prediction, neural network, accuracy

ELI1.4 (#3617)

ADVANCED COLOR DIFFERENTIATION APPROACH FOR BASKETBALL HOOPS DETECTION

Petar Ristić, Miljana Milić and Dejan Madić

Accurate basketball hoop detection is essential for automated score detection systems. This paper presents an advanced color differentiation approach to enhance hoop visibility in challenging scenarios, such as when both basketball hoop and a court are painted with the same color. The proposed method applies additional mathematical transformations to the input image, and ensures precise differentiation of the hoop from the background. The approach uses image color segmentation and edge detection techniques in order to reliably determine the coordinates of the hoop. The entire score detection system is based on Raspberry Pi 5 platform. Experimental results demonstrate the effectiveness of this approach.

Keywords: digital image processing, computer vision, IoT, edge detection, Raspberry Pi, neural network

ELI1.5 (#8219)

MODELLING AND SIMULATION OF THE DYNAMICS WITHIN THE LiFePO4 BATTERY CHARGER

Jelena Milojković, Slobodan Bojanić, Octavio Nieto-Taladriz Garsia, Miljana Milić and Vančo Litovski

This is a case study of the transients within a simple charger/discharger circuit synthesized for a LiFePO4 battery. Given the restriction of the variations of the input voltage (coming from the DC/DC converter) and the load resistance (with 2.5 V <Vos< 6.5 V, and 0.25 Ω <RL< 1.25 Ω), we created a simple controlling circuit that charges the battery loaded by RL so that the output voltage remains as 3.3 V <Vout< 3.6 V. Than using a model of the battery from literature, we simulated the circuit and created some knowledge about the charging process.

Keywords: LiFePO4 battery, modelling, simulation, charging, discharging

СЕСИЈА / SESSION (ЕЛІ2+ELI2)

Понедељак, 9. јун / Monday, June 9th Сала 1 / Hall 1 15.00-16.45

Председавајући / Chair:
Vladimir Milovanović, Fakultet inženjerskih nauka u Kragujevcu, Srbija

ELI2.1 (#9030)

DIGITAL FILTERS IN CMOS TECHNOLOGY: DESIGN, TOPOLOGY AND PERFORMANCE (INVITED PAPER)

Dejan Mirković and Milena Stanojlović Mirković

Considering the importance and role of a digital filters in contemporary electronic systems, this paper explores the influence of filter's class and topology on performance of filter realized in CMOS technology. After the general overview of the two main-stream approaches to digital filter design, the impact of filter's class and topology will be examined through three filter realizations. Two infinite impulse response filters based on critical monotonic amplitude characteristic analog prototypes with bilinear and custom developed s-to-z transformations will be presented. For finite impulse response realization famous Parks-McCllelan optimization algorithm is used. The presented design examples are implemented using the front- and back-end industry-standard tools. The impact of design choice on final, physical, form (layout) of the presented filters will be shown considering the key parameters such as cost of fabrication, silicon area and power consumption in 65nm CMOS process node.

Keywords: digital filters, integrated circuits, CMOS, design. layout

ELI2.2 (#9545)

DIGITAL TRANSMITTER IMPLEMENTED USING FPGA AND ANALOG FRONT END DEVELOPMENT BOARDS

Borisav Jovanovic and Srdjan Milenkovic

In embedded systems, digital transmitters play a crucial role in interfacing with sensors and communication protocols. Digital transmitters are particularly relevant in high-speed data acquisition and signal processing applications. The paper describes design and implementation of a high-performance digital transmitter which is realized using development boards TI AFE7900EVM and AMD KCU116. This transmitter is capable of operating in frequency range 0 – 7.4 GHz. All types of modulations are supported, with the signal bandwidth of up to 200MHz.

Keywords: RF transmitter, Analog Front End, FPGA, JESD communication interface

ELI2.3 (#5124)

FABRICATION AND CHARACTERIZATION OF AN EMBROIDERED FORCE SENSING RESISTOR

Filip Mrkić, Igor Putnik, Saima Qureshi, Dejan Movrin, Sanja Kojić and Goran Stojanović

This paper presents the design, fabrication, and characterization of a textile-based Force Sensing Resistor (FSR). The sensor is composed of conductive threads with an interdigitated pattern, a polyvinyl chloride (PVC) spacer, and a carbon-based screen-printed layer on a Kapton substrate. Four sensors were fabricated, and each was subjected to five load cycles of 0–150 N force. The resistance data of the sensors were acquired

via chronoamperometry. A one-phase exponential decay curve was fitted to the average data with a high coefficient of determination, indicating good reliability of the model. The sensors exhibited sufficient sensitivity and intra-sensor repeatability. The results confirm the utilization of embroidery and screen printing as a reasonable approach for the production of customizable, integrable, and flexible e-textile sensors, even though standardization in manufacturing remains a major challenge to achieve reproducibility of performance from batch to batch.

Keywords: Force sensing resistor, Sensor, Embroidery, E-textile

ELI2.4 (#4915)

COARSE TUNING MECHANISMS IN CMOS STANDARD-CELL LIBRARY RING-BASED DIGITALLY CONTROLLED OSCILLATORS

Đorđe Gačić, Dejan Petković and Vladimir Milovanović

Two distinct ring-based digitally controlled oscillators (DCOs) differing in their coarse frequency tuning mechanisms are elaborated and mutually compared. To comply with agile development methodology and easily adapt to various process technology nodes, DCO implementation using only standard library cells was exercised. Both oscillator topologies are realized in a typical industrial 180 nm CMOS technology, and both have a scaled design to make them comparable to each other. Detailed simulation results provide insight into the pros and cons of each design. A guideline for proper selection of the appropriate topology according to the specification requirements was consequently deduced. Comparisons are given for frequency tuning range and resolution, timing parameters and jitter, phase noise, power consumption and area, design effort, and synthesizability.

Keywords: Digitally controlled oscillator, frequency tuning, tap number, current starving, synthesizability, CMOS technology

EL2.1 (#1814)

PROJEKTOVANJE MREŽNO POVEZANOG FOTONAPONSKOG SISTEMA MALE SNAGE

Aleksandar Panić, Igor Jovanović and Dragan Mančić

U ovom radu prikazan je postupak projektovanja mrežnog fotonaponskog sistema male snage za domaćinstvo, kao i simulacija sistema u softverskom paketu PV*SOL. Glavni ciljevi simulacije su procena isplativosti i analiza performansi sistema. Sistem je dimenzionisan na osnovu godišnje potrošnje domaćinstva i čine ga 12 PV panela CS3L-370M snage 370 W i jedan invertor MOD 4000TL3-XH snage 4 kW. Na osnovu analize performansi sistema procenjena je isplativost ulaganja i izračunat je period otplate sistema od 6,5 godina.

Ključne reči: obnovljivi izvori energije, PV sistemi male snage, mrežno povezani PV sistemi

ТЕЛЕКОМУНИКАЦИЈЕ / TELECOMMUNICATIONS

СЕСИЈА / SESSION (TEI1)

Уторак, 10. јун / Tuesday, June 10th Сала 4 / Hall 4 9.00-10.45

Председавајући / Chair:
Goran Đorđević, Univerzitet u Nišu - Elektronski fakultet, Niš, Srbija

TEI1.1 (#0156)

ITERATIVE DECODING ALGORITHMS POWERED BY DEEP LEARNING

Dimitrije Jovanović and Predrag Ivaniš

In this paper, we analyze the performance of neural belief propagation (BP) decoding on the additive white Gaussian noise (AWGN) channel, compared to the traditional BP algorithm. Previous investigations have shown that assigning pre-trained weights to BP messages can significantly improve the decoding performance in case of high-density parity-check (HDPC) codes, by reducing the negative impact of short cycles. These weights are trained by a neural network whose structure matches the trellis of the decoder. Specifically, we show that medium-density parity-check (MDPC) codes decoded with neural BP algorithm can achieve lower bit error rate versus HDPC codes with the same codeword length and the same code rate.

Keywords: deep learning, neural network, belief propagation, MDPC codes, AWGN channel, TensorFlow

TEI1.2 (#2622)

GRADIENT DESCENT DECODING OF MPDC CODES OPTIMIZED WITH GENETIC ALGORITHM

Dimitrije Jovanović, Jovan Milojković, Zoran Čiča and Predrag Ivaniš

Bit-flipping (BF) is a very simple algorithm for decoding linear block codes. For the BF to achieve high performances of belief-propagation (BP) algorithms, which are far more complex, we apply several optimizations using the genetic algorithm (GA), to optimize the parameters of our decoder. Adaptive diversity gradient descent bit-flipping with momentum (AD-GDBFwM) algorithm is designed as a cascade of multiple decoders with different parameters, which are optimized with GA. In this paper we consider AD-GDBFwM decoding of medium-density parity-check (MDPC) codes. We measure the decoding performance and compare it with the results of various types of decoders, including BP and neural BP.

Keywords: genetic algorithm, gradient descent, bit-flipping, iterative decoding, MDPC codes

TEI1.3 (#5155)

QUANTIZATION ANALYSIS FOR THE CRC AIDED SUCCESSIVE CANCELLATION LIST POLAR DECODER

Nikola Borović, Dragomir El Mezeni and Vladimir Petrović

Polar codes have recently found application as error correction codes for the control information in 5G wireless communication. Stringent requirements for decoding latency, power consumption, and communication reliability demand efficient hardware implementation of communication modules. One of the key aspects of efficient hardware

implementation is a robust quantization scheme. In this paper, we present an empirical approach to analyzing quantization for the Cyclic Redundancy Check-Aided Successive Cancellation List (CA-SCL) decoding algorithm, which is used in the 5G standard. The paper gives detailed quantization analysis of the CA-SCL algorithm for 11-bit CRC and 4 lists. We proposed a quantization scheme with decoding performance within 0.1 dB of the floating point performance for positive Signal-to-noise ratios (SNRs). It is shown that a decoder with one extra bit achieves performance within 0.1 dB of the floating-point model over a wide range of SNRs and code rates.

Keywords: 5G, error rate, polar decoder, quantization

TEI1.4 (#5957)

CONCEPT OF SPECTRUM SHARING IN A NON-COOPERATIVE MULTIUSER SCENARIO BASED ON JOINT SPATIO-TEMPORAL SPECTRUM SENSING

Miljko Erić, Nenad Vukmirović and Miloš Janjić

This paper presents an innovative concept and technical solutions for collaborative interweave dynamic spectrum sharing, leveraging distributed wideband joint spatio-temporal spectrum sensing in a non-cooperative multiuser scenario. The system utilizes direct localization methods and distributed antenna systems to address spectrum sharing challenges. We have implemented and evaluated a sensor network for joint spatio-temporal spectrum sensing, as well as an OFDM-based secondary link, which are essential components for assessing the proposed system's effectiveness. This work demonstrates a promising approach to more efficient spectrum usage, addressing current challenges in multiuser, non-cooperative environments.

Keywords: cognitive radio, spectrum sensing, spectrum sharing, direct localization

TEI1.5 (#6675)

A SOFTWARE TOOL FOR EFFICIENT PLANNING OF HFSWR RECEIVER AND TRANSMITTER SITE LOCATIONS

Darko Marjanović and Dragan Golubović

Monitoring the sea and activities on the sea surface is often a very challenging task because it can be greatly influenced by weather conditions, sea state, level of interference, etc. Of particular interest is the tracking of ships using High Frequency Surface Wave Radars (HFSWR) because targets can be detected beyond the horizon line, achieving very large detection ranges. Planning the radar coverage area is the first task when designing a complete HFSWR system. This paper proposes an efficient and simple software solution for planning transmitter and receiver site locations in HFSWR. In this way, it is possible to easily prepare marketing presentations, draw coverage areas directly in Google Earth, and draw the geometry of transmitter and receiver antenna arrays. This is especially important in practical situations, because the adjustment of input parameters is achieved in a fast way, in order to enable optimal coverage of the entire sea coast using a network of multiple HFSWRs.

Keywords: radar location, HFSWR, OTHR, coverage planning, antenna positioning, antenna arrays

TEI1.6 (#2227)

CORRELATION-BASED KRONECKER MIMO CHANNEL MODELLING AND CAPACITY ESTIMATION IN MATLAB

Dobrislav Drakul

A MIMO (Multiple Input Multiple Output) system uses a larger number of antennas at the transmitter and receiver sides, so the signals can be combined in an optimal way, thus achieving better performance in terms of transmission channel capacity and bit error rate (BER). This paper provides an overview of the main MIMO radio channel models, taking into account their positive and negative properties, as well as the possibilities of their application, with the focus on correlation-based models. The key concepts in channel modeling are shown. Correlation-based models consider the channel matrix statistically, taking into account the correlation between the elements of the matrix, without taking into account the propagation of electromagnetic waves. Such models are often used for the development and verification of new algorithms. One of the most famous correlation-based models is the Kronecker model, which actually proposes an approximation of the full channel correlation matrix as the Kronecker product between the transmitter and receiver correlation matrices. This paper proposes also an efficient and simple MATLAB software solution for Kronecker channel modelling and for the estimation of system capacity using different input parameters.

Keywords: MIMO, channel modelling, capacity estimation, Kronecker model, correlation-based methods, antenna arrays

СЕСИЈА / SESSION (TE1+TEI2)

Уторак, 10. јун / Tuesday, June 10th Сала 4 / Hall 4 15.00-17.15

Председавајући / Chair:
Goran Đorđević, Univerzitet u Nišu - Elektronski fakultet, Niš, Srbija

TEI2.1 (#3493)

AI AGENT-DRIVEN MAINTENANCE: CASE STUDY OF OUTAGE PROBABILITY FOR 5G WIRELESS SYSTEM WITH L-BRANCH SC RECEIVER INFLUENCED BY RICIAN FADING AND RICIAN CO-CHANNEL INTERFERENCE

Suad Suljović, Nenad Petrović, Vuk Vujovic, Miloš Milašinović, Goran Đorđević and Radisa Stefanovic

This paper analyzes the performance of a 5G wireless communication system employing selection combining (SC) at the receiver side with L branches. The transmitted signal is subject to small-scale Rician fading, along with Rician co-channel interference (CCI). By implementing an SC scheme with multiple receiving branches, the detrimental effects of multipath propagation are mitigated, resulting in improved system performance parameters such as outage probability (Pout) and bit error probability (BEP). A mathematical expression for the outage probability will be derived, based on the signal-to-interference ratio (SIR). The influence of Rician fading parameters, interference characteristics, and the number of receiver branches on the outage probability will be examined. We also consider LLM-driven AI agent-based approach to maintenance of mobile network leveraging the previously calculated outage probability relying on Open AI's o1-mini model and provide proof-of-concept implementation.

Keywords: Selection Combining, Rician Fading, Outage Probability, Quality of Service, o1-mini

TEI2.2 (#4787)

GREEN ICT – MEASUREMENT HUBS AND TESTBEDS FOR MM-WAVE AND SUB-THZ COMMUNICATION DEVICES

Goran Panic, Darko Cvetkovski and Nebojsa Maletic

This paper presents the activities of IHP within the Green ICT project, which aims to provide measurement centers and testbeds to collect data relevant for the life cycle assessment of millimeter-wave and sub-THz communication devices. These include the setup of an anechoic chamber and a near-field scanner for the characterization of radios and antennas, as well as the construction of a standalone 5G testbed for real-time outdoor experiments on fronthaul and backhaul data links. The installed measurement infrastructure was validated by measurements on reference designs.

Keywords: anechoic chamber, nearfield scanner, 5G, 6G, life cycle assessment, CO2 footprint mm-Wave, sub-THz, antenna, radio

TEI2.3 (#9708)

LLM-BASED EMR ESTIMATION: CHANNEL CAPACITY IN MRC SYSTEM UNDER K-μ FADING FOR WIRELESS SIGNAL TRANSMISSION CASE STUDY

Nenad Petrović, Dejan Milic, Dario Javor, Milan Jović, Siniša Škrbić and Elida Suljović

This paper investigates the performance of a maximal ratio combining (MRC) receiver with L diversity branches operating over a k-μ fading channel, which is a generalized fading model suitable for various wireless environments. An exact closed-form expression for the channel capacity (CC) is derived based on the signal-to-noise ratio (SNR) at the output of the MRC receiver. Furthermore, the impact of various link-level and system-level parameters on the channel capacity is analyzed through detailed graphical simulations. The presented results provide valuable insights into the design and optimization of wireless communication systems operating over k-μ fading channels. Finally, we also introduce Large Language Model (LLM) based approach to electromagnetic radiation (EMR) estimation, leveraging the previously calculated values of channel capacity among other factors.

Keywords: Channel Capacity, MRC diversity, κ-μ fading, signal-to-noise ratio (SNR), Large Language Model (LLM), Electromagnetic Radiation (EMR)

TE1.1 (#3891)

PREDIKCIJA EFIKASNOSTI RADIO-OMETANJA PRIMENOM ALGORITMA VEŠTAČKE INTELIGENCIJE

Ognjen Pejčić, Nemanja Šepa and Boban Sazdić-Jotić

Savremeni sistemi za elektronsko ratovanje često se suočavaju sa potrebom pouzdanog određivanja položaja elemenata za radio-izviđanje i radio-ometanje.U ovom radu prikazano je simulaciono okruženje koje omogućava početnu procenu efikasnosti radio-ometanja uz analizu osnosa jačine ometačkog i korisnog signala u dvodimenzionom prostoru.Prvo su razmatrane mogućnosti radio komunikacije od interesa za sistem elektronskog ratovanja gde se definišu parametri poput koordinata,snage i dobitka

API.Zatim se vrši procena efikasnosti radio-ometanja kada se koristi jedan ili više stanica radio-ometača.Konačno,razmatrane su dve metode za predikciju položaja stanice radio-ometača:klasična iterativna i napredna metoda veštačke inteligencije.Pokazano je da je moguće izvršiti početnu procenu mogućnosti radio-komunikacije,efikasnosti radio-ometanja,kao i da se predloženim metodama predikcije lokacija stanica radio-ometača dobijaju optimalni rezultati koji se mogu primeniti za rešavanje ovog problema.

Ključne reči: radio-izvidjanje, radio-komunikacija, radio-ometanje, veštačka inteligencija, učenje uslovljavanjem

TE1.2 (#7237)

ANALIZA PERFORMANSI IOT MMIMO SISTEMA U UPLINK SMERU UZ BEŽIČNI PRENOS ENERGIJE NA BAZI HAP TDD

Lazar Mitrović, Djordje Lukic, Vesna Blagojević and Goran Markovic

Razmatran je IoT (Internet of Things) senzorski sistem za podršku velikog broja jednostavnih IoT uređaja, koji se bežično napajaju električnom energijom iz hibridne pristupne tačke (Hybrid Access Point, HAP). HAP obavlja prenos energije ka IoT uređajima (downlink) i prijem podataka od IoT uređaja (uplink) tokom Time-Division Duplex ciklusa, uz komunikaciju na bazi massive MIMO (Multiple-Input Multiple-Output) tehnologije primenjene u uplink smeru. Razvijen je simulacioni model i izvršena analiza performansi prenosa za različite uslove rada u smislu međusobne korelacije kanala, kvaliteta procene stanja kanala, i odnosa predajne snage HAP i trajanja intervala za prenos energije ka IoT uređajima. Dati su rezultati i zaključci analize u pogledu ukupnog kapaciteta sistema za date scenarije rada, kao i prikaz mogućnosti optimizacije parametara HAP.

Ključne reči: Energy harvesting, Hybrid access point, IoT-based sensor systems, massive MIMO, Wireless powered communications

TE1.3 (#9668)

ANALOGNI UNIVERZALNI PRUŽNI TELEFON

Milivoje Ralević, Marko Nikolić, Vladimir Lapčević, Milenko Kabović, Vladimir Čelebić, Veljko Janić and Iva Salom

Svaki infrastrukturni sistem ima svoje specifičnosti, koji se, između ostalog, odnose i na zahteve i realizaciju telekomunikacionog sistema. Jedan od uređaja sa karakterističnim zahtevima je pružni telefon u okviru železničke pružne telefonske mreže. Uslovljeno modernizacijom železničkog sistema, ali i zahtevima za kompatibilnošću sa postojećom infrastrukturom, razvijen je analogni univerzalni pružni telefon. U ovom radu je predstavljen ovaj uređaj, kroz prikaz karakterističnih hardverskih i softverskih komponenti, kao i princip funkcionisanja.

Ključne reči: telefon, železnica, vod, prilagođenje impedanse, mikrokontroler

РАЧУНАРСТВО / COMPUTING AND INFORMATION ENGINEERING

СЕСИЈА / SESSION (RTI1)
SOFTVERSKO INŽENJERSTVO I VEŠTAČKA INTELIGENCIJA / SOFTWARE ENGINEERING AND ARTIFICIAL INTELIGENCE – SEAI

Понедељак, 9. јун / Monday, June 9th Сала 4 / Hall 4 9.00-10.45

Председавајући / Chair:
Valentina Nejković, Univerzitet u Nišu – Elektronski fakultet, Niš, Srbija

RTI1.1 (#1097)

A COMPREHENSIVE REVIEW OF LLMS: ARCHITECTURE, PERFORMANCE, AND APPLICATIONS

Yucel Yilmaz, Muhammed Maruf Ozturk and Valentina Nejkovic

This study presents a comprehensive review of LLMs, which have emerged with the developments in the fields of AI and NLP in recent years and are built on deep learning architectures. LLMs, which have created a revolutionary impact with their recent use in various fields such as code generation, error detection, text summarization, and multilingual support, are actively used in many fields such as healthcare, finance, chatbots, autonomous systems, and academic research. LLMs are divided into three main architectures: decoder, encoder, and decoder-encoder models. Within the scope of the study, a comprehensive comparison of the features of popular methods in these three main architectures has been made. The common features of these methods have been tested in detail under equal conditions. The obtained findings indicate that CodeT5 is the fastest with a runtime of less than a second, while CodeGen outperforms the alternatives with a BertScore value of 0.839.

Keywords: context modeling, large language models (LLMs), transformers, software engineering

RTI1.2 (#1238)

THE COMPUTATIONAL EFFICIENCY OF TASK-BASED PARALLELISM OF SPARK MLLIB

Muhammed Maruf Öztürk and Valentina Nejkovic

Apache Spark is a big data processing framework that provides various tools to practitioners. MLlib is one of the most well-known Spark libraries presenting various machine learning algorithms to process large-scale data. Existing studies generally focus on the configurable hyperparameters of Spark to increase general performance. However, these methods only benefit the way Spark treats data called resilient distributed dataset (RDD). Processing big data on various workers driven by a manager results in remarkable time-saving. However, different from existing studies, this work investigates whether a second task-based parallelization has the potential to increase the computational performance of Spark. To that end, a parallelization algorithm is developed by utilizing the parallel library of R. The experiment enriched with binary classification datasets shows that each algorithm of MLlib does not reduce computation time remarkably.

Keywords: Apache Spark, parallelization, MLlib

RTI1.3 (#1775)

A MULTI-OBJECTIVE APPROACH TO OPTIMIZING CLOUD INFRASTRUCTURE WITH GENETIC ALGORITHMS

Sava Stanisic and Nikola Zogovic

Selecting cost-efficient and highly available cloud infrastructure is a critical challenge for modern applications. This paper proposes a multi-objective optimization framework leveraging genetic algorithms (NSGA-II) to model the trade-off between two conflicting objectives, infrastructure costs and service availability. By analyzing the Pareto front of non- dominated solutions, the optimal virtual machine (VM) configurations are identified under constraints such as the number of CPUs, and RAM capacity per VM instance, and user's budget. Experimental results demonstrate that our approach outperforms single-objective strategies in balancing cost and availability, achieving up to 98.3% service availability at a cost of $0.15/h, compared to 97.8% at $0.10/h with a stricter budget.

Keywords: multi-objective optimization, Pareto optimality, NSGA-II

RTI1.4 (#1833)

A WAY TO IDENTIFY POTENTIAL FUNCTIONS FOR VECTORIZATION FOR RISC-V

Dušan Stojković and Miroslav Popovic

Vectorization is crucial for exploiting the RISC-V Vector Extension to accelerate data-parallel workloads. However, compilers do not always automatically vectorize critical code sections, especially for newer length-agnostic instruction set architectures like RISC-V. In this paper, we propose a methodology to identify functions for vectorization by combining compiler autovectorization analysis with runtime performance profiling. Using the HEVC video encoder as a case study, we compile the code with vectorization diagnostics, and profile its execution on a Banana Pi BPI-F3 board. By correlating compiler reports of which loops were vectorized with perf collected cycle counts for each function, we pinpoint hotspot functions. Impact of RVV extension on performance is highlighted. We discuss how guided interventions improve the performance when using RVV instructions. This approach provides a guideline for performance tuning, and we highlight its generality for other architectures.

Keywords: RISC-V, compiler, optimization, x265, encoder

RTI1.5 (#2223)

LLM-BASED TOOLING FOR SMART CONTRACT AUDITING

Nikola Vukic, Veljko Petrovic, Dinu Dragan and Dusan Gajic

Traditionally, smart contract auditing has been conducted using analysis tools and manual review processes. However, these tools often struggle to detect complex vulnerabilities and novel attack vectors. Advancements in Large Language Models (LLMs) have introduced new possibilities for enhancing smart contract audits by using their contextual understanding and reasoning capabilities. This paper provides a review of existing LLM-based smart contract auditing tools. We analyze key methodologies, strengths, and limitations of six such tools. While LLM-based tools demonstrate significant potential in detecting complex vulnerabilities, challenges such as false positives and token length limitations persist. Our comparative evaluation highlights performance differences, showcasing the potential of LLMs to complement traditional

auditing tools. Finally, we discuss current challenges and future directions for improving LLM-based auditing, aiming to enhance security in blockchain ecosystems.

Keywords: LLM, smart contract, security, blockchain

СЕСИЈА / SESSION (RTI2 + RT1)
RAČUNARSKE MREŽE I SIGURNOST / COMPUTER NETWORKS AND SECURITY – CNS

Понедељак, 9. јун / Monday, June 9th Сала 4 / Hall 4 11.00-14.00

Председавајући / Chair:
Pavle Vuletić, Univerzitet u Beogradu – Elektrotehnički fakultet, Beograd, Srbija

RTI2.1 (#6594)

NEW APPROACHES TO DATA PROTECTION IN THE CLOUD (INVITED PAPER)

Pavle Vuletić and Žarko Stanisavljević

Despite the flexibility and convenience of cloud services, data privacy during processing on untrusted resources, which cloud servers are, has hindered wider adoption. While technologies like network traffic and disk encryption ensure the protection of data-at-rest and data-in-transit, safeguarding data- in-use remained a challenge. Cryptographic methods like homomorphic encryption offer protection but are significantly slower and more resource-intensive than unprotected data processing. Recent advancements in processor capabilities allow for isolating and encrypting the entire memory of a virtual machine running on a server, leading to the emergence of trusted execution environments (TEEs) and confidential computing. These techniques ensure data protection during processing on untrusted resources. This paper provides an overview of current confidential computing concepts, mechanisms for ensuring trust in remote computations, and recently discovered threats.

Keywords: confidential computing, cloud, trusted execution environments

RTI2.2 (#5081)

ASSESSMENT OF WIRELESS NETWORK SECURITY PROTOCOLS

Marija Milosevic, Vukadin Draskovic and Vladimir Ciric

Wireless networks have become an integral part of everyone's lives, facilitating communication between a wide range of devices without the need for physical connections. It is of utmost importance to protect these networks. This paper provides a description of wireless network security protocols and evaluation of their weaknesses. The fundamental characteristics, packet structures, and vulnerabilities of these protocols are examined. Various attack methods are analyzed on wireless networks and the effectiveness of security measures is evaluated by simulating attacks on a wireless network. Key weaknesses are highlighted and insights are offered to improve the security of wireless networks.

Keywords: Network security, Wireless networks, WEP, WPA, WPA2, WPA3

RTI2.3 (#0315)

THE DESIGN AND IMPLEMENTATION OF ELK BASED SYSTEM FOR DETECTION OF UNAUTHORIZED WEB ACCESS

Vukadin Drašković, Vladimir Ćirić, Ivan Milentijević and Natalija Stojanović

Computer networks have become a crucial part of everyday life because many services people depend on are hosted on the Internet. The Internet consists of a large number of services, with the Web being one of the most widespread. This is the reason why the Web attracts the attention of a large number of attackers. The goal of this paper is the design and implementation of ELK based module for detecting malicious user who gained unauthorized access to Web application by guessing other user's credentials. Each component of the ELK stack is described and further used as a foundation for the system design. The proposed system collects Web server logs and analyzes them in order to detect an unauthorized user. The experimental results are given. It is shown that the proposed system can detect malicious user's activities under specific circumstances.

Keywords: Cybersecurity, Web, Logs, ELK stack, Unauthorized Access, Cloud Computing

RTI2.4 (#2231)

PROTECTION OF WEB SERVERS FROM DDOS ATTACKS ORIGINATING FROM THE TOR NETWORK: DETECTION AND MITIGATION USING TOR'S HAMMER

Stefan Ćirković and Saša Cvetković

Distributed Denial-of-Service (DDoS) attacks remain a serious threat to web servers, causing significant consequences. The Tor network, designed for privacy, is increasingly being exploited for launching DDoS attacks. This paper examines the challenges of detecting and mitigating DDoS attacks originating from the Tor network. It analyzes the characteristics of Tor that make it attractive to attackers, existing detection and mitigation methods, and the integration of protective mechanisms—rate limiting, iptables, and blocking Tor exit nodes—to reduce the impact of such attacks. The combination of these techniques for improved protection is considered, and their effectiveness in defending against Tor-based DDoS attacks is evaluated. It has been observed that many websites lack even basic defense mechanisms and that even fundamental DDoS protection can be beneficial.

Keywords: DDoS attacks, Tor network, Nginx protection, Rate limiting, Tor's Hammer

RTI2.5 (#5862)

EXPLORING UNLABELED NETWORK MONITORING DATA IN LARGE-SCALE ACTIVE MONITORING SYSTEMS

Miloš Nastić and Pavle Vuletić

Computer networks produce large amounts of monitoring data daily. Detailed analysis of this data can enable more efficient network operation and management. There are few large-scale active monitoring systems, with tens to thousands of probes scattered throughout the internet which gather various network performance metrics. This paper analyzes performance metrics gathered from two such systems: GÉANT PMP, based on perfSONAR, and RIPE Atlas, and analyzes the reasons for monitored network anomalies without the information about the events in the underlying network. This study confirms that, within the same time frame and across the same autonomous systems,

measurements of the same type have nearly identical values from both platforms proving the reliability of their measurements. However, the exploratory data analysis, although able to find a correlation between the measurements in specific time intervals, shows limits in the ability to interpret the reasons for those anomalies.

Keywords: active monitoring, exploratory data analysis, anomaly detection

RT1.1 (#9111)

UPOREDNA ANALIZA PERFORMANSI GOOGLE CLOUD I LOKALNE INFRASTRUKTURE

Teodora Radaljac, Danko Miladinović, Pavle Vuletić and Žarko Stanisavljević

Ovaj rad se bavi uporednom analizom performansi sigurnih virtuelnih mašina (eng. Confidential Virtual Machines – CVM) u dva različita okruženja – lokalnoj infrastrukturi zasnovanoj na AMD SEV-SNP tehnologiji i javnoj cloud infrastrukturi Google Cloud-a. Poverljivo računanje predstavlja ključni mehanizam zaštite koji omogućava enkripciju memorije virtuelnih mašina i izolaciju podataka čak i od privilegovanog softvera. Rad se fokusira na dva glavna aspekta: vreme potrebno za atestaciju virtuelnih mašina i performanse izvršavanja distribuiranih zadataka putem Ray okvira. Eksperimentalna merenja pokazuju da lokalna SEV-SNP infrastruktura omogućava znatno bržu atestaciju i bolje performanse zadataka u poređenju sa cloud instancama koje koriste virtuelni Trusted Platform Module (vTPM) mehanizam. Iako cloud rešenja nude veću fleksibilnost i jednostavno skaliranje, lokalno okruženje obezbeđuje stabilnije performanse, niže kašnjenje i veću kontrolu nad sigurnosnim procesima.

Ključne reči: AMD SEV-SNP, Google Cloud, Atestacija, Virtuelne mašine, Distribuirano procesiranje, Ray okvir

СЕСИЈА / SESSION (RTI3 + RT2)
RAČUNARSKA TEHNIKA I PRIMENE / COMPUTER ENGINEERING AND APPLICATIONS – CEA

Понедељак, 9. јун / Monday, June 9th Сала 4 / Hall 4 15.00-16.45

Председавајући / Chair:
Dušan Gajić, Univerzitet u Novom Sadu – Fakultet tehničkih nauka, Novi Sad, Srbija

RTI3.1 (#8421)

VISUALIZATION OF NEURAL NETWORKS TRAINING IN REAL-TIME: A WEB BASED EXAMPLE

Dane Milišić, Dinu Dragan, Dušan Gajić and Veljko Petrović

Real-time visualization of neural network training in web applications presents distinct challenges. Existing desktop solutions burden the user's hardware, requiring powerful machines and local model hosting. In contrast, web applications typically lack real-time visualization, showing only static network structures. Proposed web solution overcomes these hurdles by remotely fetching neural network data, easing local resource use, and enhancing accessibility for all user levels. This is especially beneficial for casual users and serves as an educational tool. Solution's effectiveness has been evaluated by analyzing visualization time efficiency and conducting user tests with diverse user profiles. Despite utilizing React.JS for high-quality data presentation, challenges remain in handling large and visualizing datasets. This paper discusses the framework and initial

results, proposing further enhancements for optimizing real-time visualization tools in neural network training.

Keywords: Visualization, Neural network, Web application, React.JS

RTI3.2 (#5209)

OPEN-SOURCE IC DESIGN TOOLS: IMPLEMENTATION OF PICORV32 IN 130NM TECHNOLOGY

Mihailo Knezevic and Lidija Paunovic

The ever lasting demand for cost-effective and customizable integrated circuit design has led to the growing interest in open-source electronic design automation (EDA) tools. This paper explores the feasibility of using open-source solutions for implementation of the PicoRV32 RISC-V processor core in a 130nm technology node using Sky130 PDK.

Keywords: VLSI, PicoRV32, Open-Source, EDA

RTI3.3 (#1497)

ASSESMENT OF THE SMARTPHONE'S ORIENTATION ACURRACY USING AN INDUSTRIAL ROBOT

Uroš Pešović, Nedeljko Dučić, Vojislav Vujičić and Pietro Picerno

Smart phones have integrated sensors which enable estimation of current position and orientation using the sensor fusion algorithms. These algorithms relay on the precise sampling of sensor readings for accurate position estimation. Smart phones operating systems cannot run user applications in real-time to ensure time-critical sensor sampling. In this paper we investigated accuracy of orientation estimation of smart phone which is rotated by industrial robot through several known points at different speeds.

Keywords: smartphone, IMU, sensor fusion, orientation estimation, industrial robot

RTI3.4 (#9825)

DUCKDB-POWERED ANALYTICS PLATFORM: OPTIMIZING SQL QUERIES ACROSS HETEROGENEOUS DATA SOURCES

Miljan Ilic and Zoran Babovic

Analytical workloads commonly found in small or medium enterprises are rarely classified as Big Data, as they typically involve data volumes of up to several hundred gigabytes. Data may be distributed across multiple locations, such as local computers, edge devices, or cloud storage. In such scenarios, employing scalable, cloud-optimized data warehouse solutions like Amazon Redshift or Snowflake is not cost-effective. This work presents the implementation of an analytical platform based on the DuckDB embedded database, designed to support moderate-sized workloads by federatively processing queries from various sources. Performance evaluation demonstrates that this system reduces execution time by up to 92.77% compared to MySQL under the same conditions.

Keywords: online analytical processing, federated queries, multi-layer architecture platform

RT2.1 (#0802)

SOFTVERSKO REŠENJE ZA VIZUELIZACIJU, GRUPISANJE I FILTRIRANJE SAOBRAĆAJNIH NEZGODA

Stefan Ćirković, Marija Blagojević, Milan Ilić and Srećko Ćurčić

Cilj ovog rada je razvoj veb aplikacije koja omogućava preciznu identifikaciju kritičnih tačaka na saobraćajnoj mreži. Analizirani su ključni faktori koji utiču na nastanak saobraćajnih nezgoda. Kroz sprovedenu analizu trendova i obrazaca ponašanja učesnika u saobraćaju, istraženi su faktori kao što su sezonske, vremenske i prostorne varijacije učestalosti nezgoda. Dobijeni rezultati pružaju uvid u najkritičnije dane, mesece i uslove, kao i ulogu osvetljenosti na povećanje rizika tokom noći. Ovi rezultati mogu poslužiti kao osnova za kreiranje preventivnih strategija za obezbeđenje bezbednosti. Predloženi metodološki pristup omogućava primenu u različitim oblastima istraživanja, kao što su napredne tehnike mašinskog učenja i razvoj modela za predikciju nezgoda.

Ključne reči: saobraćajna bezbednost, veb aplikacija, analiza, nezgoda, prostorni podaci, mašinsko učenje

АУТОМАТИКА / AUTOMATION

СЕСИЈА / SESSION (АУ1+AUI1)
AUTOMATIC CONTROL IN THEORY AND PRACTICE

Понедељак, 9. јун / Monday, June 9th Сала 2 / Hall 2 9.00-10.45

Председавајући / Chair:
Željko Đurović, Univerzitet u Beogradu - Elektrotehnički fakultet, Beograd, Srbija

AUI1.1 (#3605)

COMPARISON OF SERIAL AND PARALLEL IMPLEMENTATIONS OF ILC IN A CLOSED-LOOP FEEDBACK SYSTEM

Milan Matijević, Mihailo Lazarević, Vojislav Filipović, Nikola Živković and Dragan Kostić

Iterative Learning Control (ILC) is a data-driven strategy for precise trajectory tracking in systems that operate repetitively under similar reference trajectories, disturbances, and initial conditions. Despite more than three decades of development, some implementation aspects of the learned ILC signals remain underexplored. This paper compares serial and parallel ILC signal implementations within a closed-loop feedback system. Although both approaches have been equally addressed in the literature, our findings show that the serial implementation provides clear advantages in achieving desired performance.

Keywords: Iterative Learning Control (ILC), Serial ILC implementation, Parallel ILC implementation

AUI1.2 (#4080)

SELF-TUNING INTELLIGENT PID CONTROLLER FOR ROBOT MANIPULATORS

Nikola Živković, Mihailo Lazarević, Jelena Vidaković and Andrija Dević

This article tackles the problem of tuning model-free intelligent PID controllers for nonlinear systems such as robot manipulators. Based on the ultra-local model formulation, intelligent PD control parameters are tuned for each time step. The Particle Swarm Optimization (PSO) is used to tune control parameters based on chosen objective function. Finally, the performance of the proposed tuning approach is verified by simulation.

Keywords: model-free control, PID controller, tuning, optimization

AUI1.3 (#4558)

GAIN-SCHEDULING FUZZY PI CONTROLLER FOR A TWO TANK SYSTEM

Đuro Dušanić, Jovan Babić, Velibor Đalić, Aleksandar Rakić and Igor Krčmar

Many industrial systems consist of hydrodynamic processes, making the ability to control these processes essential. Hydrodynamic processes are characterized by pronounced nonlinearity, which complicates the design of adequate control. The system's nonlinearity and unmodeled dynamics pose a challenge for the design of conventional PI controllers. To retain the advantages of these controllers and extend their application to nonlinear systems, controllers based on fuzzy logic, so-called fuzzy controllers, are designed. There are several types of fuzzy controllers depending on their output variable. One of them is a fuzzy controller whose output variables are the parameters of a PI controller. The successful application of this controller is experimentally confirmed on the DTS 200 system, which represents a benchmark hydrodynamic system. The controller provides an adequate control signal for successfully tracking a step reference value and suppressing disturbances.

Keywords: fuzzy control, gain-scheduling, adaptive PI controller, hydrodynamic process, two-tank system

AUI1.4 (#5652)

SUPPRESSION OF TORSIONAL OSCILLATIONS IN SYSTEMS WITH FLEXIBLE COUPLINGS AND REPEATED ITERATIVE OPERATIONS

Milan Matijević, Vojislav Filipović and Dragan Kostić

This paper addresses the problem of mechanical resonance in high-performance servo drives operating under repeated iterative tasks. The elastic coupling between the motor and the load can cause mechanical resonance, leading to forced torsional oscillations in the system. While various solutions have been proposed to suppress such oscillations, the effectiveness of Iterative Learning Control (ILC)-based structures for this issue has not yet been thoroughly investigated. This paper provides a brief overview of anti-resonant servo system architectures and evaluates the potential of ILC-based serial compensation as a viable anti-resonant control strategy.

Keywords: Torsional resonance, Oscillation suppression, Iterative Learning Control (ILC)

AUI1.5 (#9094)

IDENTIFICATION AND CONTROL OF LARGE TRANSPORT DELAY TEMPERATURE PROCESS

Isidora Petrović, Slobodan Drašković, Željko Đurović, Goran Dikić and Marko Milivojčević

In this paper different design methods for control of large transport delay systems are considered. Processes with large transport delay often present themselves as challenge for developing adequate and functional control. Due to the nature of these processes it is often not time efficient, nor optimal to project control on the process itself, thus did the authors opt for developing a control on a model and comparing the results with real process. Two popular methods were compared for control of black box system with large transport delay. Up first simple and widespread PID controller and then more complex, but better suited for large transport delay, Smith predictor. Results were compared both in simulation and on process itself.

Keywords: Large transport delay systems, PID controller, Smith predictor, System identification

AUI1.6 (#7793)

APPLICATION OF METAHEURISTIC ALGORITHMS FOR A COUPLED-TANK INVERTED CONICAL SYSTEM CONTROL

Sanja Antić, Alenka Milovanović and Olga Ristić

The paper investigates the control of water levels in a coupled-tank inverted conical system (CTICS), which exhibits highly nonlinear mathematical and dynamic characteristics. The system was first linearized using Jacobian linearization around a selected stationary point to develop an effective control strategy. The study explores and compares three control approaches: two metaheuristic algorithms, Particle Swarm Optimization (PSO) and Genetic Algorithm (GA), and a classical Auto-tuning method. The comparison focuses on ITAE values and key transient response parameters.

Keywords: Coupled-tank inverted conical system, PID, Particle Swarm Optimization, Genetic Algorithm, ITAE

AU1.1 (#7360)

ESTIMACIJA POREMEĆAJA U DISKRETNIM SISTEMIMA SA KLIZNIM REŽIMOM

Čedomir Milosavljević, Boban Veselić, Branislava Peruničić-Draženović, Senad Huseinbegović and Anđela Jovanović

U radu se upoređuju tri metode za estimaciju i kompenzaciju poremećaja u diskretnim sistemima sa kliznim režimom (KR). Prva metoda koristi Luenbergerov opserver poremećaja, druga - nominalni model upravljanog objekta, a treća - integral signala klizne funkcije. Cilj rada je da pokaže ekvivalentnost navedenih metoda u primeni na diskretne sisteme upravljanja sa KR u nominalnim uslovima na jednostavnom sistemu upravljanja objektom prvog reda tipa čistog integratora. Poseban doprinos rada je modifikovani estimator poremećaja koji kombinuje Luenbergerov estimator sa estimatorom na osnovu integrala klizne funkcije. Teorijski rezultati su ilustrovani simulacionim eksperimentima.

Ključne reči: estimacija poremećaja, Luenbergerov opserver, klizni režimi

СЕСИЈА / SESSION (AUI2)
APPLICATION OF ARTIFICIAL INTELLIGENCE IN CONTROL AND TARGET TRACKING SYSTEMS

Понедељак, 9. јун / Monday, June 9th Сала 2 / Hall 2 15.00-16.45

Председавајући / Chair:
Boban Veselić, Univerzitet u Nišu - Elektronski fakultet, Niš, Srbija

AUI2.1 (#4782)

DATA DIMENSIONALITY REDUCTION BASED ON THE ICA APPROACH

Aleksa Stojić, Asem Al-Hasaeri, Goran Kvaščev and Željko Đurović

Dimensionality reduction represents an important task in the field of statistical pattern recognition and machine learning in general. One of the most commonly used methods for this purpose is Principal Component Analysis (PCA), which appears under various names in the literature. Its primary goal is to decorrelate the components within the space of newly obtained coordinates. The approach that does not consider decorrelation sufficient, but instead requires that the components in the transformed space be statistically independent, is known as Independent Component Analysis (ICA). In this way, dimensionality reduction is achieved with minimal information loss caused by discarding original coordinates. An analysis of existing literature reveals that the application of this method is highly sensitive not only to the available training dataset, but also to the statistical distribution of data vectors. This paper analyzes the capabilities and limitations of such an approach to dimensionality reduction.

Keywords: ICA, Data Dimensionality Reduction, Data Preprocessing

AUI2.2 (#7387)

HEART FAILURE DETECTION USING PHOTOPLETHYSMOGRAPHY AND DEEP LEARNING

Maša Tiosavljević, Jovana Petrović and Predrag Tadić

Heart failure is widespread, high-mortality condition that is difficult to diagnose early and requires costly clinical evaluations and treatments. This study explores heart failure detection and subtype classification using only photoplethysmogram signals. A 1D convolutional neural network was trained on 13,550 PPG beats from 82 subjects. The model achieved moderate accuracy (63.5% binary, 41.6% multiclass). The results highlight the limitations of using deep learning-based methods with PPG-only datasets of modest size.

Keywords: photoplethysmogram, heart failure, deep learning

AUI2.3 (#9148)

ANALYZIS OF EMOTIONAL SPEECH IN SERBIAN FROM SURPRISAL THEORY PERSPECTIVE

Jelena Lazic, Sanja Vujnovic and Aleksandra Krstic

The analysis of emotional speech has gained significant attention in the fields of speech recognition. Recent research trends emphasize the use of multimodal data, such as audio and video recordings. Although effective, these approaches require additional resources,

which can be time-consuming and costly, especially for low-resource languages. On the other hand, a significant gap exists in understanding cognitive processes involved in human emotional speech production. To address this, surprisal values, estimated using five state-of-the-art language models were analyzed for their correlation with spoken word duration. The results indicated variations in Pearson's coefficient between these parameters in different emotional states, with general multilingual models outperforming Serbian-specific models in surprising estimation. These results can offer valuable insights into emotional speech production in other South Slavic languages as well, such as in Croatian, Bosnian, and Montenegrin.

Keywords: natural language processing, emotional speech analysis, surprisal

AUI2.4 (#3136)

VISUAL OBJECT TRACKING: A SURVEY OF METHODS AND A COMPARATIVE ANALYSIS ON VOT2022

Natalija Đorđević, Nenad Džamić and Željko Đurović

Visual object tracking is a fundamental problem in computer vision with primary applications in surveillance and autonomous systems. Over the years, numerous tracking methods have been developed, each leveraging different principles and architectures to enhance accuracy and robustness. This paper provides an overview of various tracking approaches, highlighting key trends and advancements in the field. Additionally, a comparative analysis is conducted between two prominent trackers from the family of adaptive correlation filters and Siamese neural networks. The discussion covers their general methodologies, advantages, and challenges, offering insights into their relative performance in different tracking scenarios.

Keywords: object tracking, feature extraction, correlation filters, Siamese neural networks

AUI2.5 (#5595)

ROBUST TRAJECTORY TRACKING OF DIFFERENTIAL DRIVE PLATFORMS USING DISCRETE-TIME SLIDING MODE CONTROL

Vladimir Mitić, Anđela Jovanović, Vladimir Sibinovic and Boban Veselić

This paper proposes a control structure suitable for trajectory tracking tasks performed by a differential drive mobile platform, operating under external disturbances. To address these challenges, a discrete-time sliding mode controller (DSMC) is implemented within the inner velocity control loops, offering robust behavior. In addition to enhanced robustness, the proposed controller effectively eliminates wheel slippage. The performance of the proposed system is evaluated through simulations and compared to the control system having conventional digital PI controllers in the velocity control subsystems.

Keywords: Trajectory tracking, Differential drive, Mobile platform, DSMC

AUI2.6 (#2302)

BEARING ONLY TRACKING FOR MANEUVERING TARGET: EKF, UKF AND CKF

Zvonko Radosavljevic, Dejan Ivkovic and Branko Kovacevic

The bearings only tracking (BOT) is non linear estimate process which determine the trajectory of the target based on a time series of bearing measurements from a one, two or more observer. It is assumed that the motion of the target is constrained to straight

line, constant speed segments separated by maneuvers in course and speed. Extended Kalman filter (EKF) is commonly used in BOT and having good computational efficiency, but often leads to unstable estimations. The unscented Kalman filtering (UKF) and cubature Kalman filter (CKF) are recently suggested for stability improvements, and UKF is suggested more suitable for real-time applications than EKF. In this paper a comparative analyzes between the EKF, UKF and CKF implementations is provided.

Keywords: bearings only tracking, Kalman filter, multiple models

НУКЛЕАРНА ТЕХНИКА / NUCLEAR ENGINEERING AND TECHNOLOGY

СЕСИЈА / SESSION (HT1+NTI1)

Уторак, 10. јун / Tuesday, June 10th Сала 2 / Hall 2 15.00-17.15

Председавајући / Chair:
Koviljka Stanković, Univerzitet u Beogradu - Elektrotehnički fakultet, Beograd, Srbija

NTI1.1 (#2005)

THE RELIABILITY OF ELECTRICAL BREAKDOWN OF GAS-FILLED ELECTRONIC COMPONENTS UNDER IMPACT OF GAMMA RADIATION (INVITED PAPER)

Milic Pejovic

With respect to the application involving gas-filled electronic components, they can operate in one of three different modes. The first one is known as non-self sustaining discharge. Components like ionization chambers, proportional counters and Geiger-Muller (GM) counters usually work in this mode. Second mode is so called breakdown mode, i.e. gas transitions from non-self sustaining to self sustaining discharge. Gas-filled surge arresters and gas-switches work in this mode. Self-sustaining discharge is the third mode where display panels and light sources operate. These investigations will be focused on breakdown area for gas-filled components at low pressures for the case when secondary (gamma) processes on the cathode play a dominant role in breakdown initiation. The breakdown voltage is the parameter that defines breakdown in gas-filled component. Its value is usually determined by ramping up the voltage on the gas component until the non-self sustaining discharge is established.

Keywords: electrical breakdown, gas-filled electronic component, gamma radiation

NTI1.2 (#6194)

OVERVIEW AND ANALYSIS OF THE RESULTS OF IAEA INTERCOMPARISONS FOR SIMULATED SURFACE CONTAMINATION SAMPLES

Jelena Krneta Nikolic, Milica Rajačić, Nataša Sarap and Marija Janković

Radiation and Environmental Protection Department of the Vinča Institute readily takes part in various intecomparison measurements, especcially those organized by the International Atomic Energy Agency (IAEA). Within these intercomparison, several years in a row (2019-2024.) one of the requirement was to measure samples simulating surface contamination. The measurement method applied was gamma spectrometry,

gross alpha and gross beta measurements. This paper presents summation and overview of those results and the analysis of the approach implemented in obtaining the values. The valutation of the trueness and accuracy of the results is also presented and analyzed in order to establish whether the measurement method applied is adequate for obtaining acceptable results.

Keywords: surface contamination, proficiency test, gamma spectrometry, gross alpha and gross beta activity

NT1.1 (#8891)

TRENDOVI I IZAZOVI FISIONIH NUKLEARNIH TEHNOLOGIJA

Marija Šljivić-Ivanović, Maja Rajkovic, Kristina Pavicevic, Danica Jovasevic, Ivana Jelic and Marija Janković

Smanjenje karbonskog otiska i imperativ održivog razvoja kao ciljevi „Zelene agende“ se mogu postići samo promenom udela pojedinih izvora energije u energetskom miksu. U skladu sa tim, nuklearna energija zajedno sa hidroenergijom je ključni izvor niskougljične energije za mnoge zemlje širom sveta. Međutim, primena nuklearne energije u proizvodnji električne izuzetno varira jer su brojne one države koje se u velikoj meri oslanjaju na nju, ali nasuprot tome brojne su i one koje je uopšte ne upotrebljavaju. Ključno pitanje je održivost velikih reaktora, koji su se pokazali kao najefikasniji način za proizvodnju energije. Iako su koristi primene nuklearne energije za čovečanstvo neosporne, brojne izazove donose i tržišni trendovi i političke strategije, koje je teško predvideti ili kontrolisati.U ovom radu su sumirani rezultati i dostignuća u razvoju nuklearnih fisionih tehnologija širom sveta.

Keywords: fisija, nuklearne tehnologije, nuklearni reaktori

NT1.2 (#7157)

TRENDOVI U UPRAVLJANJU TOKOVIMA RADIOAKTIVNOG OTPADA: IZAZOVI I PERSPEKTIVE

Maja Rajković, Ivana Jelić, Kristina Pavićević, Danica Jovašević, Marija Janković and Marija Šljivić-Ivanović

Porast proizvodnje električne energije u nuklearnim elektranama, primene radioaktivnih materijala u industriji, medicini, naučnoistraživačkom radu, dovodi do povećanja količina radioaktivnog otpada, što dalje zahteva poboljšanje metoda njegovog upravljanja. Dosadašnja istraživanja fokusirana su na metode procesiranja otpada i načine njegovog zbrinjavanja, sa osvrtom na poštovanje regulatornih propisa. Predmet ovog rada jeste analiziranje savremenih trendova u upravljanju tokovima radioaktivnog otpada, uključujući i inovativne metode skladištenja, tretmana i odlaganja. Poseban osvrt je na unapređenim tehnologijama za separaciju i reciklažu radioaktivnih materijala, novim regulatornim okvirima i integraciji cirkularne ekonomije u ovoj oblasti. Takođe, razmatrani su izazovi prilikom zbrinjavanja visoko radioaktivnog otpada u odgovarajuće geološko skladište, sa osvrtom na potencijal korišćenja digitalizacije i modelovanja u optimizaciji procesa upravljanja.

Keywords: radioaktivni materijal, upravljanje otpadom, nuklearna bezbednost, cirkularna ekonomija, digitalizacija

NTI1.3 (#5988)

NUCLEAR DIPLOMACY BETWEEN INTERNATIONAL SECURITY AND GEOPOLITICAL COMPETITION:

Sanela Veljković, Milica Ćurčić and Marina Dabetić

Nuclear diplomacy is one of the key mechanisms of global security. However, it can also be perceived as an instrument of geopolitical competition among nuclear-armed states. This paper examines its dual nature, exploring how international agreements and institutions contribute to global security while also analyzing how major powers use nuclear capabilities as a means of competition. By assessing the provisions of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), the paper examines both the successes and limitations of diplomatic efforts in preventing nuclear proliferation. Special emphasis is placed on the dynamics of relations between leading nuclear powers and their approach toward regional actors that have acquired nuclear weapons after 1968. The paper concludes that the future of nuclear diplomacy remains uncertain precisely because of its dual nature.

Keywords: nuclear diplomacy, international security, geopolitics, nuclear weapons

NTI1.4 (#8374)

PHASES OF INTEGRATED RISK MANAGEMENT IN CBRN RISK MITIGATION AND RECOVERY

Marina Dabetić, Milica Ćurčić and Sanela Veljković

This paper examines integrated risk management approaches for CBRN (Chemical, Biological, Radiological, and Nuclear) threats, focusing on preparedness, mitigation, response, and recovery phases. It explores the challenges posed by these threats, which can have significant and widespread impacts, and emphasizes the importance of effective planning, training, and cooperation among relevant stakeholders. The role of a modern approach to disaster risk reduction and community resilience in strengthening CBRN management is also discussed. The paper is based on a review of existing literature, which provides insights into current practices and effective approaches for reducing these risks.

Keywords: CBRN risks, integrated risk management, preparedness, mitigation, response, recovery

АКУСТИКА / ACOUSTICS

СЕСИЈА / SESSION (AKI1+AK1)

Понедељак, 9. јун / Monday, June 9th Сала 6 / Hall 6 11.00-14.00

Председавајући / Chair:
Miomir Mijić, Univerzitet u Beogradu - Elektrotehnički fakultet, Beograd, Srbija,
Dejan Ćirić, Univerzitet u Nišu - Elektronski fakultet, Niš, Srbija

AKI1.1 (#0144)

A COMPARATIVE ANALYSIS OF DIFFERENT WAVELET TRANSFORMATIONS ON NORMAL AND WHISPER SPEECH RECOGNITION

Branko R. Marković, Veljko Lončarević and Jovan Galić

Discrete Wavelet Transformation (DWT) is very useful in tasks of signal processing. In this paper, four different types of this transformation (Daubechies, Symlets, Coiflets, and Biorthogonal) are compared in experiments with speech recognition. Two speech modes are investigated: normal and whisper, and two speakers (one female and one male) from the Whi-Spe database are included. For the back-end of the automatic speech recognition (ASR) system, the standard Dynamic Time Warping method was applied. The results are presented in the form of tables and histograms. They suggest which wavelet transformation is the most convenient for this kind of speech recognition.

Keywords: Speech recognition, Discrete Wavelet Transformation, Daubechies, Symlets, Coiflets, Biorthogonal, Whisper, Dynamic Time Warping

AKI1.2 (#6917)

DRONE-BASED ULTRASOUND SYSTEM TOWARDS HIGH FREQUENCY PEST DETERRENCE

Vasilije Kovacevic, Marija Ratković, Tatjana Miljković, Maksim Kostadinov and Miloš Bjelić

Rodents pose a significant threat to agriculture by damaging crops, spreading disease, and contaminating soil. To counter this, farmers often resort to chemical pesticides, which can harm ecosystems, or to non-chemical deterrents that tend to be less effective and subject to rodent adaptation. As a sustainable alternative, the RODENT project, Rodent Obstruction through Drone-Enabled Non-invasive Technology, introduces a drone-mounted ultrasound system designed to emit high-frequency signals that deter rodents without harming the environment. In the initial design phase of the project, the first experiments were conducted in anechoic conditions to evaluate the acoustic performance of low-cost ultrasound speakers driven by a custom signal generator and amplifier. Results showed that both attenuation with distance and speaker directivity were within the expected range for rodent-sensitive frequencies, particularly at 70 kHz. However, the presence of side and rear lobes highlighted the need for improved directionality. Obtained results show that the proposed method effectively generates ultrasound signals within the targeted rodent-sensitive frequency range and validates the idea of using low-cost speakers in drone-mounted deterrence systems.

Keywords: drone-based system, ultrasound deterrence, rodent and pest control, directional speakers

AKI1.3 (#6490)

ENVIRONMENTAL NOISE ASSESSMENT IN OUTDOOR AREAS: A COMPARATIVE REVIEW IN EUROPEAN COUNTRIES

Momir Praščević, Darko Mihajlov and Petar Jovanović

This paper aims to analyze methods for assessing environmentral noise in European countries, with a particular focus on comparing legally prescribed noise limit values with the recommended values of the World Health Organization (WHO), as well as on the elements used for assesssing noise in outdoor areas. Strategic noise maps, developed using common noise indicators and calculation methods defined by Directive 2002/49/EC, form the basis for environmental noise assessment. In addition to the noise indicators defined by the Directive, which are also used for the development of action plans, various other indicators are employed for purposes such as noise reduction, land-use planning, and environmental noise measurement. The Interest Group on Noise Abatement (IGNA) has conducted a comprehensive review of the legislation of Individual European countries, and based on their reports, this paper presents a comparative analysis of the elements used to asssess environmental noise in 18 countries.

Keywords: noise indictors, limit values, reference time intervals, assessment location, corrections

AKI1.4 (#9195)

MEASUREMENT OF THE ABSORTION COEFFICIENT IN AN ANECHOIC CHAMBER BASED ON THE SUBTRACTION METHOD

Marko Janković, Dejan Ćirić, Maro Puljizević and Aleksandar Pantić

This paper presents a novel approach for measuring the sound absorption coefficient of porous materials in an anechoic chamber, motivated by the inconsistencies observed in results obtained from certified reverberation chambers. The proposed method is based on the ISO 13472-1 standard and utilizes a simplified setup consisting of a single microphone and a sound source. The microphone is positioned normal to the sample surface, while the sound source varies its angle of incidence at 0°, 15°, 30°, and 45°. The final absorption coefficient is calculated as the average of the measured values across all angles. The key result of this study is the demonstrated repeatability of the measurements in different anechoic chambers, showing consistent absorption values for the same material.

Keywords: absorption coefficient, subtraction method, subsample optimization

AK1.1 (#0792)

AKUSTIČKI ODZIV FUDBALSKOG STADIONA

Dragana Šumarac Pavlović, Miloš Bjelić, Nikola Jokić, Marija Ratković, Filip Batić, Miodrag Stanojević, Tatjana Miljković and Miomir Mijić

Savremeni fudbalski stadioni moraju imaju adekvatan audio sistem za ozvučavanje koji je, prema pravilima FIFA, obavezan deo šireg sistema za obaveštavanje u slučaju vanrednih okolnosti. Kao takav, sistem se koristi i za emitovanje raznih informacija od značaja za praćenje fudbalske utakmice i za emitovanje muzike u pauzama igre. Sa takvom funkcijom, osnovni parametar kojim se definiše kvalitet audio sistem na stadionu je razumljivost emitovanog govora koja se postiže. Stadion kao fizičko okruženje zadovoljava uslove da se pri pobudi zvukom u njemu generiše specifičan reverberacioni proces koji negativno utiče na tu razumljivost. Zbog toga je poznavanje akustičkog

odziva stadiona značajno za dizajn zvučničkih sistema. Da bi se jasnije sagledao taj inženjerski aspekt organizovana je analiza akustičkog odziva na stadionu „Rajko Mitić“ u Beogradu (poznat kao Stadion Crvene zvezde ili „Marakana“). U ovom radu su prikazani rezultat sprovedene analize i neke akustičke specifičnosti stadiona kao ambijenta za reprodukciju zvuka.

Ključne reči: Fudbalski stadion, impulsni odziv, razumljivost govora, vreme reverberacije

AK1.2 (#4090)

AKUSTIČKE PROMENE TONA HARFE PRI RAZLIČITIM POZICIJAMA I NAČINIMA OKIDANJA

Tatjana Miljković, Dragana Šumarac Pavlovoć and Jelena Ćertić

Ovaj rad istražuje akustičke i perceptivne aspekte tonova harfe kroz analizu četiri karakteristična fenomena: inharmoničnost parcijala, vremenska promena osnovne frekvencije (glide), pojava fantomskih parcijala i njihov vremenski razvoj. Eksperimentalni korpus čine tonski snimci jedne iste žice harfe, pobuđivane u tri različita uslova: (1) višestrukim okidanjima istom jačinom na istoj poziciji, (2) promenom jačine na fiksnoj poziciji, i (3) promenom pozicije okidanja pri približno konstantnoj jačini. Poseban akcenat stavljen je na treći slučaj, kako bi se ispitali efekti mesta pobude na spektralnu strukturu i vremensku stabilnost tona. Analiza obuhvata praćenje amplitudne dinamike osnovnih i fantomskih parcijala kroz vreme, kao i promene osnovne frekvencije, sa ciljem da se utvrdi veza između fizičkih parametara pobude i rezultujućih karakteristika tona.

Ključne reči: ton harfe, inharmoničnost parcijala, fantomski parcijali, vremenska anvelopa tona, pomeranje osnovne frekvencije

AK1.3 (#4372)

PERFORMANSE DEKONVOLUCIONIH ALGORITAMA SA UPOTREBOM GRID REDUCTION METODE

Nebojša Kolarić and Miloš Bjelić

U ovom radu analizirane su performanse tri dekonvoluciona algoritma: DAMAS, FISTA i NNLS sa i bez primene grid reduction metode. Cilj istraživanja bio je da se oceni uticaj ove metode na brzinu izvršavanja, potiskivanje bočnih lobova i širinu glavnog loba u aplikacijama za mapiranje akustičnih izvora pomoću mikrofonskih nizova. Eksperimenti su sprovedeni nad realnim signalima snimljenim u anehoičnoj sobi i učionici. Rezultati pokazuju da primena grid reduction metode značajno ubrzava izvršavanje algoritama (smanjenje vremena obrade i do 70%), ali dovodi do šireg glavnog loba i slabijeg potiskivanja bočnih lobova u poređenju sa originalnim algoritmima. Uprkos tom kompromisu, rezultati ukazuju na to da grid reduction metoda može biti korisna u aplikacijama gde je vreme obrade kritično, poput real-time sistema za detekciju akustičnih izvora. Značaj rada ogleda se u analizi kompromisa između tačnosti i efikasnosti kod primene grid reduction metode u dekonvolucionim algoritmima.

Ključne reči: DAMAS, FISTA, NNLS, grid reduction

AK1.4 (#6309)

POTISKIVANJE BOČNIH LOBOVA ZVUČNIČKOG NIZA U REALNOM VREMENU

Marija Ratković and Miloš Bjelić

U ovom radu je implementirana metoda za potiskivanje bočnih lobova linijskog zvučničkog niza. Metoda koristi Hanovu prozorsku funkciju za projektovanje frekvencijskih odziva filtara kojim se potiskuju bočni lobovi. Projektovanje filtara i njihovo testiranje je realizovano u namenski kreiranom softverskom modelu. Simulacijom predložene metode je pokazano da se pored potiskivanja bočnih lobova, može obezbediti i konstantna širina glavnog loba. Glavni cilj ovog rada je potiskivanje bočnih lobova u realnom vremenu što je realizovano kroz hardversku implementaciju na namenskom procesoru. Korišćenjem predložene metode veliki bočni lobovi su na 1/3 oktavnom opsegu sa centralnom frekvencijom 8 kHz potisnuti do 6 dB, dok je glavni lob znatno sužen. Ovakvi sistemi mogu doprineti formiranju privatnih zona slušanja. Takođe se mogu se koristiti u konferencijskim i razglasnim sistemima gde je potrebno fokusirati zvuk u uskoj zoni.

Ključne reči: Bela hardver, bočni lobovi, filtriranje, Hanov prozor, realno vreme, zvučnički niz

АНТЕНЕ И ПРОСТИРАЊЕ / ANTENNAS AND PROPAGATION

СЕСИЈА / SESSION (АП1+API1)

Понедељак, 9. јун / Monday, June 9th Сала 2 / Hall 2 11.00-12.30

Председавајући / Chair:
Miodrag Tasić, Univerzitet u Beogradu - Elektrotehnički fakultet, Beograd, Srbija,
Branko Kolundžija, Univerzitet u Beogradu - Elektrotehnički fakultet, Beograd, Srbija

API1.1 (#0716)

APPLICATION OF MACHINE LEARNING IN PREDICTING THE FORCE OF RADIAL PASSIVE MAGNETIC BEARING

Isidora Jovanović, Natalija Ivković, Ana Vučković, Mirjana Perić and Nebojša Raičević

This paper investigates the application of machine learning methods for predicting the interaction force between ring-shaped permanent magnets in radial passive magnetic bearings. A semi-numerical approach based on the application of fictitious magnetic charges is used to produce datasets for training three different models: Random Forest, Polynomial regression, and Kernel Ridge regression. The findings highlight the potential of machine learning as an effective alternative to traditional force calculation methods.

Keywords: machine learning, magnetic charges, magnetic force, passive magnetic bearings, permanent magnet

API1.2 (#9062)

FULL-WAVE SOLUTION OF INDOOR PROPAGATION IN TIME DOMAIN USING A 2D SOLVER

Branko Kolundzija and Tomislav Milosevic

This paper demonstrates a successful handling of significant computational challenges for simulating indoor propagation channels in time domain using WIPL-D 2D EM Software. It actually shows the efficiency of two-dimensional (2D) electromagnetic (EM) simulation and modeling of realistic indoor environments. By employing the 2D EM Solver, under certain conditions, a high efficiency in terms of computational resources and simulation time is achieved. The research illustrates that, for specific scenarios, 2D modeling gives expected results and thus can effectively replace 3D simulations, making it an efficient alternative for analyzing time-domain propagation. Moreover, the impact of material properties, such as the difference between concrete and metal pillars, on signal distortion is also highlighted, providing deeper insights into wave behavior in an indoor environment.

Keywords: Indoor, propagation, EM, simulation

AP1.1 (#0908)

PROCEDURE ZA ODREĐIVANJE OTPORNOSTI REŠETKASTE UZEMLJIVAČKE ELEKTRODE TRAFOSTANICE

Dejan Jovanovic, Nenad Cvetkovic, Miodrag Stojanovic and Vladimir Stanković

U radu je izvršena karakterizacija uzemljivača trafostanice realizovanog pomoću rešetkaste elektrode kao glavnog elementa uzemljivačkog sistema. To je učinjeno primenom različitih numeričkih modela, odnosno simulacije koja uključuje korišćenje programskog paketa COMSOL, kao i eksperimentalni metodi. Primenjene procedure opisane u radu uključuju korišćenje Metoda Momenata i različitih empirijskih formula za određivanje otpornosti uzemljivačkih elektroda. Navedeni metodi primenjeni su za određivanje otpornosti rešetkaste uzemljivačke elektrode postrojenja 35/10 kV trafostanice. Pri tome je izvršeno poređenje rezultata dobijenih proračunom, simulacijom i eksperimentalnim procedurama

Ključne reči: Uzemljivač, električni potencijal, otpornost, Metod Momenata

API1.3 (#2633)

THE INFLUENCE OF THE PROXIMITY EFFECT ON THE ACCURACY OF MODELING OF WIRE ANTENNAS BASED ON THIN-WIRE APPROXIMATION

Ilija Kuzman and Branko Kolundžija

Basic method for numerical analysis of thin-wire antennas is method of moments applied to electric field integral equation based on thin-wire approximation, which does not take into account the proximity effect. Influence of this approximation onto analysis accuracy is examined by comparing the results of precise wire and plate models of two antenna types (half-wavelength dipole and Yagi antenna). It is seen from the results that neglecting the proximity effect can in extreme cases lead to the error greater than 50% for admittance, and greater than 10% for the gain. In particular, in the case when distance between wires is greater than $\lambda/10$, the proximity effect practically does not influence on the accuracy if the wire diameter is smaller than $\lambda/50$.

Keywords: thin-wire antennas, method of moments, thin-wire approximation, the proximity effect

API1.4 (#4251)

ON THE QUADRILATERAL MESHING OF THE FRACTURED HUMAN FEMUR BONE IN ELECTROMAGNETIC SIMULATIONS

Branislav Ninković and Miodrag Tasic

3D Computer-Aided Design (CAD) models of the human bones are commonly available in STL format, where the surfaces of the models are represented with dense triangular meshes. Numerical analysis is often performed using quadrilateral meshes, in which case conversion from triangular to quadrilateral mesh is necessary. In this paper we investigate such conversion for a fractured human femur bone, for the purpose of the full wave electromagnetic (EM) analysis using Method of moments (MoM) applied to Surface integral equations (SIEs). The goal is to minimize the number of quadrilaterals in the converted mesh, while preserving accuracy of the EM analysis. It is shown how to choose parameters of the conversion to accomplish this goal.

Keywords: CAD, STL, quadrilateral mesh, femur, MoM

БИОМЕДИЦИНСКА ТЕХНИКА / BIOMEDICAL ENGINEERING

СЕСИЈА / SESSION (BTI1)

Понедељак, 9. јун / Monday, June 9th Сала 6 / Hall 6 15.00-16.45

Председавајући / Chair:
Milica Janković, Univerzitet u Beogradu - Elektrotehnički fakultet, Beograd, Srbija

BTI1.1 (#6030)

BRAIN-COMPUTER INTERFACE: PAST, PRESENT, AND FUTURE (INVITED LECTURE)

Lazar Jovanovic

Over the last 50-60 years, brain-computer interface (BCI) technology has evolved from the realm of science fiction into research laboratories and clinical trials, and is now making its way to the consumer market. This lecture will highlight the use of BCIs in rehabilitation, focusing on the studies of the BCI-controlled functional electrical stimulation therapy as a novel approach for restoring upper-limb motor function after stroke or spinal cord injury. These studies have demonstrated the feasibility and safety of using a non-invasive, single-channel electroencephalography (EEG)-based BCI to trigger electrical stimulation synchronized with the user's intention to move, leading to clinically meaningful improvements in motor function. Beyond the technical achievements and promising clinical results, this work underscores the importance of designing systems that prioritize user accessibility—streamlined setup, intuitive operation, and integration into existing rehabilitation workflows.

Keywords: Brain-computer interface (BCI), Rehabilitation, Electroencephalography (EEG), Functional electrical stimulation (FES), Wearable technology

BTI1.2 (#0835)

DESIGN AND USER VALIDATION OF NOVEL HYBRID ELECTRODES FOR EMG RECORDING AND ELECTROTACTILE STIMULATION

Milica Baljic, Martin Alexander Garenfeld, Alexander Løvig Borg, Filip Budimir, Vladimir Kojić, Strahinja Došen and Matija Strbac

This paper presents the development and validation of a novel stretchable dry hybrid electrode for electrotactile stimulation and EMG recording, designed for integration into prosthetic socket liners. Three electrode prototypes were compared: (1) dry stretchable electrode; (2) electrode with elevated pads via plastic layering beneath; (3) electrode with 3D-printed conductive plastic atop the pads. Six able-bodies subjects were recruited to assess the active stimulation range and subjective comfort and preference. Electrodes 1 and 3 showed comparable sensation and discomfort thresholds (1.1–4.1 mA), while electrode 2 exhibited a reduced dynamic range and higher pad failure rate. Four out of six participants preferred electrode 1. A prolonged 6-hour test with electrode 1 confirmed stable stimulation thresholds over time in a single subject. The initial results support the feasibility of novel dry textile-integrated electrodes for providing feedback in closed-loop applications.

Keywords: human machine interface, electrotactile stimulation, multi-pad electrode, sensory feedback, hand prostheses

BTI1.3 (#7939)

EMG ENVELOPE EXTRACTION FOR MYOELECTRIC PROSTHESIS CONTROL

Andrea Vaštag, Vojin Ilić, Olivera Tomašević, Milovan Medojević and Luka Mejić

This study evaluated the performance of four groups of digital filtering pipelines - simple and complex combinations of rectification, low-pass, and notch filters, for real-time EMG envelope extraction, a common approach in myoelectric control systems. Evaluation metrics used were Root Mean Square Error (RMSE), Coefficient of determination (R2), Kolmogorov-Smirnov (KS) test, and execution time, with the latter analyzed using box plots to assess. The results showed that the first and the third group of filters had the most variable runtime, while the second and the fourth were more consistent. The fourth group of filters showed the lowest RMSE and KS test values, the highest R^2, indicating the best predictive performance, and thus being most adequate for real-time applications due to the balance between its simplicity and the quality of the obtained envelope. The findings emphasize the importance of including execution-time analysis when selecting digital filters.

Keywords: myoelectric control, electromyography, envelope, digital filters, RMSE, R2, KS test, runtime execution, real-time operation

BTI1.4 (#0330)

TIME-OF-FLIGHT SENSING FOR THE RECOGNITION OF OBJECT PROPERTIES IN PROSTHESIS CONTROL

Ksenija Baraković, Nikola Jorgovanović, Filip Gašparić, Bojan Jorgovanović and Strahinja Došen

Myoelectric control of hand prostheses requires users to learn unnatural command sequences, which can be both physically and mentally demanding. Semi-autonomous control seeks to automate some of them by anticipating the user's intentions, but it often

relies on large, data-heavy computer vision systems that limit real-time use. Our approach applies basic geometric processing to depth data gathered by Time-of-Flight (TOF) sensors to extract object dimensions and orientation. We compared VL53L5CX and VL53L7CX sensors in different setups at various distances from the target. The narrow setup with VL53L5CX (45mm between sensors) estimated the primary dimension (width/height) and orientation with 15mm average error and a 66.6% success rate. VL53L7CX performed better in orientation recognition but showed larger dimension errors and variance. Compact TOF sensor layouts, especially with different fields of view, proved effective for sparse point cloud-based recognition of object properties.

Keywords: semi-autonomous control, robotic prosthesis, time of flight sensor, point cloud processing, depth perception, embedded systems

BTI1.5 (#6607)

PERFORMANCE EVALUATION OF A FOUR-MATRIX-BASED METHOD FOR SYNTHESIZING A 12-LEAD ELECTROCARDIOGRAM FROM 3-QUASI-ORTHOGONAL LEADS

Marjan Miletic, Vladimir Atanasoski, Petra P. Beličev, Goran Gligorić, Uroš Ralević, Jelena Kršić, Aleksa Obradović, Aleksandar Lazović, Danka Stojanović, Jovana Petrović and Branislav Vajdić

Mobile ECG devices effectively detect arrhythmias but often miss acute conditions like heart attacks due to the limited data from just 1–2 leads. We have recently proposed a novel method of ECG synthesis for synthesize 12-lead ECG from 3 quasi-orthogonal ECG leads using a 4-matrix (4M) transformation. The approach employs four personalized matrices to reconstruct the P wave, QRS complex, ST segment, and T wave, calibrated from non-simultaneous 3-lead and 12-lead ECG measurements. Here we provide a detailed account on the method testing on the recordings obtained from 64 healthy volunteers. The method outperforms the EASI-based synthesis, achieving a mean cross-correlation (CC) of 0.96 versus 0.89 for EASI. Morphology and cardiac angle agreement, assessed via Pearson R-correlation, is also superior. The 4M method enables reliable diagnostic interpretation, making it suitable for converting mobile 3-lead ECG device data into accurate synthesized 12-lead recordings.

Keywords: ECG synthesis, non-simultaneous measurements, mobile 3-lead ECG device

BT1.1 (#0202)

RITMOVI SRCA: ZNACI SLOŽENOSTI I POREMEĆAJA U ELEKTROKARDIOGRAFSKIM SIGNALIMA

Jelena Kršić, Aleksandra Maluckov, Danka Stojanović, Vladimir Atanasoski, Marija D. Ivanović and Jovana Petrović

U ovom radu istražujemo različite srčane ritmove primenom formalizma i teorije kompleksnih sistema na EKG signale. Rezultati pokazuju da se metrike zasnovane na RR intervalima, varijabilnost srčanog ritma i Šenonova entropija, mogu koristiti za razlikovanje periodičnih od neperiodičnih ritmova, dok se periodični ritmovi dodatno klasifikuju po frekvenciji srčanih otkucaja. Veličine koje u obzir uzimaju i amplitude signala, kao što su parametri Poenkareovih dijagrama i multifraktalnih spektara, daju nove informacije i indikatore kompleksnosti EKG signala, te predstavljalju potencijalne nove biomarkere aritmija. Prikazani rezultati predstavljaju korak ka sistematičnom

povezivanju dinamičkih parametara EKG signala sa biomarkerima korisnim u kliničkoj praksi.

Ključne reči: srčani ritam, Šenonova entropija, Poenkareov presek, multifraktalnost, atrijalni flater, atrijalna fibrilacija

СЕСИЈА / SESSION (BTI2)

Уторак, 10. јун / Tuesday, June 10th Сала 2 / Hall 2 9.00-10.45

Председавајући / Chair:
Jovana Petrović, Univerzitet u Beogradu – Institut za nuklearne nauke „Vinča“, Beograd, Srbija

BTI2.1 (#7267)

MACHINE LEARNING FOR ESTIMATING CHRONOLOGICAL AGE IN CHILDREN USING THE LONDON ATLAS AND DENTAL RADIOGRAPHS

Ana Savić, Marija Marin, Nastasija Malivuk, Filip Mrkić, Lazar Milić and Bojan Petrović

This study aims to evaluate convolutional neural network models for automated estimation of chronological age in children using dental radiographs. A dataset of 28 pediatric dental radiographs were collected from individuals with known chronological ages. Using the London Atlas, dental development stages were annotated. Before training the CNN models, preprocessing and segmentation techniques were applied. For supervised learning models were used: MobileNetV2, DenseNet121, EfficientNet B0 and ResNet34. Performance was evaluated using parameters, such as accuracy, precision, sensitivity and specificity. Among the models, the MobileNetV2 architecture achieved the best performance, with high correlation between predicted and actual age with 95% accuracy. The integration of machine learning with dental radiographic analysis provides a promising tool for accurate, age estimation. This approach may enhance diagnostic workflows in pediatric dentistry and forensic identification practices.

Keywords: Machine Learning, Chronological Age Estimation, Dental Radiography, London Atlas, Pediatric Forensic Dentistry, Convolutional Neural Networks

BTI2.2 (#6707)

CHARACTERIZATION OF COMMERCIAL PHOTOPOLYMERS FOR MICROFLUIDIC APPLICATIONS

Nastasija Malivuk, Lazar Milić, Igor Putnik, Bojan Petrović, Stevan Cvetićanin and Sanja Kojić

This study characterizes five common photopolymers used in lab-on-chip microfluidic devices, focusing on mechanical performance and surface wettability to assess biocompatibility. These factors influence fluid flow, sample interaction, and structural stability. Surface properties were analyzed via the sessile drop technique, while nanoindentation provided hardness and Young’s modulus data. Results show significant differences in mechanical parameters while wetting angle differences are less than 20%. These insights guide material selection for safe, efficient biological sample handling. The findings support ongoing development of advanced microfluidic systems for precise, non-toxic manipulation of living samples.

Keywords: Microfluidics, Photopolymers, Nanoindentation, Wetting, Lab-on-chip

BTI2.3 (#5692)

MIGRAINE PREDICTION: IS IT THE WEATHER?

Đorđe Čikić, Dragan Janković and Aleksandar Milenković

Migraine is recognized as the second most disabling neurological disorder. Taking preventive medication can reduce the pain, but the patient needs to know when the attack will happen. Patients often perceive that the weather is their migraine trigger. This paper focuses on examining the correlation between weather factors and migraine attacks. An extensive dataset with migraine reports gathered over 12 years shows that factors like rainfall, cloud cover and humidity are the factors that potentially trigger migraine. This study also found that factors differ in males and females as the results are more accurate for males. A custom algorithm is developed for analyzing the neural network in order to examine the weather factors that impact the migraine occurrence.

Keywords: migraine, weather factors, neural networks

BTI2.4 (#3895)

DEVELOPMENT OF A CHATBOT FOR SUPPORTING PATIENTS WITH MULTIPLE SCLEROSIS

Marija Mitić, Miloš Jolović, Aleksandar Joksimović, Marijana Despotović-Zrakić and Zorica Bogdanović

Chatbots powered by large language models offer a scalable solution to support multiple sclerosis patients by providing accurate, empathetic, and personalized responses to their questions. The chatbot's functionalities include symptom tracking, assisting patients in formulating relevant questions for neurologists, and differentiating between urgent and non-urgent symptoms. By incorporating retrieval-augmented generation (RAG) and domain-specific medical data, the chatbot can offer up-to-date and evidence-based guidance. Integration of reinforcement learning and fine-tuning techniques can enhance chatbot accuracy and adaptability while maintaining safety. AI-driven healthcare solutions such as a well-optimized chatbot demonstrate how accessible and reliable they can be as tools for MS patients, complementing traditional medical care.

Keywords: multiple sclerosis, large language models, medical AI, healthcare chatbots

BTI2.5 (#9817)

FACIAL EMOTION RECOGNITION: AN EYE-TRACKING APPROACH TO UNDERSTANDING EMOTIONAL PROCESSING

Mihailo Bojat, Vanja Kovic, Milica Đurić-Jovičić, Ivan Vajs and Vladislava Krsmanović

Facial expressions provide a fundamental means for communication, and with an unlimited number of nuances in emotion portrayal, it is important to understand how emotion recognition works. In this paper, 10 participants (5 female and 5 male) were shown 4 blocks of images (each having 36 images) of faces portraying emotions: neutral, happiness, sadness, anger, fear and disgust. The first two blocks displayed regular images of faces, the other two showed upside-down images. Their performance and eye movements were monitored using an eye-tracking device. By analyzing the recognition accuracy, the time spent and the number of fixations for each image, the influence of participant gender, image modifications, and attributes of actors was assessed. The results show an overall recognition accuracy of around 80%, with female participants having an overall higher recognition accuracy. Happiness was shown to be the best-

recognised emotion, with sadness being the one most often misinterpreted. This conclusion was also shown in the eye-tracking metrics, with sadness being the most frequent emotion for the high-valued outliers.

Keywords: emotion recognition, facial processing, eye-tracking, face expression, fixations

BTI2.6 (#0634)

WORKING MEMORY TASK OUTCOME PREDICTION BASED ON EYE-TRACKING ANALYSIS

Tijana Bogdanović, Ljiljana Ranđić, Vanja Ković, Željko Đurović, Milica Jankovic and Ivan Vajs

Working memory is an important part of the complex memory system that enables information flow from short-term to long-term memory. It is responsible for logical thinking, reasoning, and complex cognitive tasks. Eye movements strongly correlate with working memory load. In this study, five participants completed working memory tasks while their eye-tracking data were collected during task performance. Each participant completed a total of 50 working memory tasks, distributed across five levels of difficulty. Seven features were extracted from the eye-tracking data, focusing on those derived from interactions with areas of interest - specifically, the positions of objects described in each task. The extracted features were used to predict the outcome of the performed tasks (correct or incorrect) using a feature selection algorithm and three machine learning algorithms. The best performance was gained with a support vector machine model, giving a total accuracy of 81.67%.

Keywords: working memory, eye-tracking, feature selection, machine learning

ЕЛЕКТРОЕНЕРГЕТИКА / POWER ENGINEERING

СЕСИЈА / SESSION (EEI1)

Понедељак, 9. јун / Monday, June 9th Сала 1 / Hall 1 11.00-14.00

Председавајући / Chair:
Slobodan Vukosavić, University of Belgrade – School of Electrical Engineering, Belgrade, Srbija
Marko Rosić, University of Kragujevac - Faculty of Technical Sciences, Čačak, Serbia

EEI1.1 (#5389)

ADVANCEMENTS IN ELECTRICAL MACHINES FOR E-MOBILITY (INVITED PAPER)

Jan Barta

The growing trend in the electrification of all modes of transportation has led to an increasing demand for electrical machines specifically developed for this sector. This has resulted in advancements in electrical machines over the past few decades, primarily intended for e-mobility applications. This paper presents a review of these machines, with a focus on their applications in the automotive sector. The paper discusses the challenges and requirements for these machines, as well as the main technological themes. Additionally, a brief overview of current technologies is provided, and some real topologies are compared. This work is intended as a reference for researchers and engineers seeking information in this rapidly developing sector.

Keywords: Electric vehicles, Electrical machines, Hybrid vehicles, Induction machines, Permanent-magnet machines

EEI1.2 (#4603)

DESIGN AND OPTIMIZATION OF SMALL INDUCTION MACHINES FOR PUMP APPLICATIONS

Martin Světlík and Jan Bárta

This paper delineates the process of design, modeling, and multi-objective optimization of a compact induction machine tailored for pump drive applications. The primary objective is to enhance critical performance parameters—specifically efficiency and thermal characteristics—while adhering to manufacturability constraints prevalent in industrial settings. A systematic methodology is proposed, encompassing both electromagnetic and thermal modeling, alongside an optimization strategy utilizing the Non-Dominated Sorting Genetic Algorithm II. Furthermore, the study encompasses the development of prototypes and their subsequent experimental validation, ensuring that the final design meets established performance criteria and practical implementation standards. This research underscores the potential for significant energy savings through optimization, even in low-power electrical machines that are often neglected regarding efficiency enhancements.

Keywords: Small induction machine, Machine optimization, NSGA-II algorithm

EEI1.3 (#9821)

ASYMMETRICAL FOUR-PHASE 8/6 SWITCHED RELUCTANCE MOTOR

Mladen Terzic and Dragan Mihic

This paper presents an optimized design and control strategy for an asymmetrical 8/6 switched reluctance motor (SRM) drive, aiming for a wide constant power-speed range with high efficiency. The optimization process selects stator pole widths and coil turns to maximize torque while meeting constraints. A JADE algorithm optimizes design parameters and control variables, including turn-on and turn-off angles. Results show that an asymmetrical configuration extends the constant power-speed range by 25.6%, improving high-speed performance. These findings highlight the advantages of asymmetrical SRM topologies for applications requiring extended high-speed operation, making them a strong alternative to traditional symmetrical designs.

Keywords: switched reluctance motor (SRM), power-speed characteristics, finite element method (FEM)

EEI1.4 (#0201)

TIME-STEPPING FINITE ELEMENT MODELING OF A SYNCHRONOUS TURBO-GENERATOR

Aldin Kajević and Gojko Joksimović

This paper presents methodology for modelling a synchronous turbo-generator using the Finite Element Method (FEM) in Altair Flux software. A detailed workflow is provided, covering geometry creation, material assignment, meshing strategies, boundary condition implementation, and solver configuration. The configured FEM model is solved using a transient magnetic solver, and key simulation results, including current waveforms, developed electromagnetic torque and speed response, are extracted for

analysis. This systematic approach provides an accurate and reliable framework for synchronous machine modeling, enabling performance evaluation and optimization.

Keywords: finite element method (FEM), synchronous turbo-generator, electromagnetic simulation, Altair flux, time-step simulation

EEI1.5 (#2114)

SINGLE-PHASE TRANSFORMER CIRCUIT SOLVING USING HARMONIC INTERPOLATION METHOD

Srđan Divac, Krzysztof Chwastek, Mariusz Najgebauer and Branko Koprivica

The aim of this paper is to present a way of solving in the time domain an electrical circuit with a single-phase transformer. The considered circuit consists of an AC power supply, a ring-shaped transformer and a resistor in the transformer primary and secondary circuit. Three working regimes of the transformer have been considered – when it is loaded and when it is close to no-load and short-circuit working conditions. Calculations have been made at industrial frequency of 50 Hz using an iterative procedure based on Harmonic Interpolation Method (HIM) and Bertotti's Statistical Theory of Losses (STL). The obtained results are compared with the results calculated using an equivalent transformer circuit and well-known RL model. The details regarding the calculation procedures, measurement setup and results, the comparison of the calculated results, as well as their appropriate analysis, are presented in this paper.

Keywords: single-phase transformer, ring-shaped core, Harmonic Interpolation Method, RL model, time domain

EEI1.6 (#1996)

ESTIMATION OF SWITCHING TRANSIENT OVERVOLTAGE MAGNITUDE DURING TRANSMISSION LINE ENERGIZATION USING MULTIRESOLUTION ANALYSIS

Dimitrije Rozgić and Predrag Petrović

Abstract—The energization of an unloaded transmission line generates switching transient overvoltages, the magnitude of which is highly dependent on the point-on-wave at which the switching operation occurs. Multiresolution analysis (MRA) can be employed to extract time-domain information from such transient signals by decomposing them into low-frequency components, referred to as approximations, and high-frequency components, referred to as details. In this paper, an MRA-based algorithm is proposed for the estimation of switching transient overvoltage magnitude. The algorithm utilizes the Haar wavelet and its associated scaling function. Due to its simplicity and computational efficiency, the Haar wavelet serves as a powerful signal processing tool with significant potential for application in power system transient analysis.

Keywords: Switching overvoltages, Line energization, MRA (Multiresolution Analysis), Haar wavelet

EEI1.7 (#7455)

WIND TURBINE PARAMETRIC MODEL WITH CONSIDERATION OF THE INFLECTION POINT

Srđan Milićević, Sulaiman Milad, Vladimir A Katić and Aleksandar M Stanisavljević

This paper gives an extended inflection point parameter p model of the wind turbine power curve. It represents a continuation of the authors´ research on wind turbine models reported in previous papers. The model uses the shape parameter of the Weibull wind-speed distribution, the wind turbine power curve inflection point parameter, and the resolution of the wind turbine power curve. Although it is a three-parameter model, the simplicity is preserved. The model is tested using data from a wind park in Serbia for different wind turbine sizes. The results show improved accuracy in a range suitable for engineers in the field.

Keywords: Wind power, Wind turbine modeling, Weibul, Distribution, Inflection point parameter

СЕСИЈА / SESSION (EEI2)

Уторак, 10. јун / Tuesday, June 10th Сала 1 / Hall 1 9.00-10.45

Председавајући / Chair:
Vladimir Katić, University of Novi Sad – Faculty of Technical Sciences, Srbija
Mladen Banjanin, University of East Sarajevo - Faculty of Electrical Engineering, BiH

EEI2.1 (#8382)

OBJECTIVE COMPARISON OF HARMONIC POWER FLOW RESULTS: METHODS AND SOFTWARE TOOLS

Miloš Milovanović, Jordan Radosavljević, Bojan Perović, Mladen Banjanin, Jovan Vukašinović and Andrijana Jovanović

This paper provides an objective comparison of objectively compares harmonic power flow (HPF) results, focusing on the methods and software tools used for harmonic analysis of distribution networks. Particular emphasis is placed on the influence of system element modeling on the accuracy of HPF results, including the modeling of linear and nonlinear loads, as well as the impact of the skin effect, harmonic phase angles, and Thevenin equivalent impedance of the substation bus. Harmonic analysis was performed using software tools ETAP, DIgSILENT, SINCAL, and PCFLO. Results obtained were compared with those derived using the decoupled HPF method. The testing was conducted on two widely used distribution networks: the IEEE 18- and 33-bus. Results from various software tools demonstrated a high degree of agreement. The models of the tested IEEE systems, applied across different software tools, are available at https://github.com/MilosFTN/Models-of-the-IEEE-18--and-33-bus-test-systems.

Keywords: comparison, distribution system, harmonic power flow (HPF), software tools, system element modeling

EEI2.2 (#8745)

NUMERICAL CALCULATIONS OF THE GROUNDING SYSTEMS OF HIGH VOLTAGE SUBSTATIONS, OVERHEAD LINE TOWERS, AND WIND TURBINE TOWERS

Mladen Banjanin, Adnan Mujezinović and Miloš Milovanović

This paper presents the results of numerical calculations of the grounding resistances, and step and touch voltages, of the high voltage substations, overhead line towers, and wind turbine towers. Calculations are done using a simple mathematical model and considering homogeneous soil. The accuracy of calculated results is verified by analyzing different grounding systems of high voltage substations and overhead line towers and by comparing results with those calculated using commercial FEM-based software. The configurations of grounding systems of wind turbine towers applicable in high resistivity terrain are presented. Important details for the design of the wind turbine tower grounding systems are also discussed.

Keywords: grounding resistance, step voltage, substation, touch voltage, wind turbine tower

EEI2.3 (#6121)

THINGSPEAK PLATFORM FOR IOT SENSOR DATA ACQUISITION AND ANALYSIS IN SHIPBOARD SOLAR PV SYSTEMS

Tahir Mavrić, Ilija Knežević, Martin Ćalasan and Tatijana Dlabač

This paper investigates the application of the ThingSpeak platform for real-time monitoring of shipboard photovoltaic (PV) systems. A simulated environment was created using MATLAB to replicate sensor data for key parameters, including temperature, voltage, current, power and solar irradiation. These values reflect operational conditions typical for a ship in the Boka Bay, Montenegro. Data were uploaded to ThingSpeak at regular intervals and visualized through interactive dashboards. The study demonstrates how ThingSpeak, combined with MATLAB, can be a lightweight, cloud-based monitoring solution for maritime energy systems, allowing data to be collected, visualized, and analyzed remotely without the need for sophisticated on-site infrastructure.

Keywords: ThingSpeak, IoT, MATLAB, PV systems, shipboard monitoring, cloud analytics, energy data

EEI2.4 (#3449)

PARAMETER TUNING AND STRATEGIC PLACEMENT OF PASSIVE HARMONIC FILTERS FOR POWER QUALITY ENHACEMENT IN MODERN DISTRIBUTION NETWORKS

Stevan Rakočević, Martin Ćalasan and Miloš Milovanović

The integration of renewable energy sources (RESs), particularly photovoltaic (PV) systems, presents new challenges for the functioning of distribution systems. The higher harmonics generated by the power converters of RES lead to noticeable issues with electricity quality. This paper introduces a methodology for the optimal placement and parameterization of passive harmonic filters (PHFs) in distribution networks that incorporate PV systems. This approach is based on two key components: the voltage stability index (VSI) for determining location and Particle Swarm Optimization (PSO) used for parameter tuning. The simulation was conducted on an enhanced IEEE 69-bus

test system, which included integrated PV systems and non-linear loads, while also accounting for the uncertainties in both PV production and electrical load. Two optimization scenarios are targeting power quality improvement, power loss reduction and lowering the PHF investment cost.

Keywords: photovoltaic, passive harmonic filters, power quality, distribution network

EEI2.5 (#8051)

THE WIND-SPEED ANALYSIS USING PROBABILITY DISTRIBUTION FUNCTIONS FOR WINDS IN SERBIA

Vladimir A. Katić, Srđan Milićević and Sulaiman Milad

Abstract—Due to the wind´s stochastic nature and dependence on many climate parameters, in-depth analysis is needed. In that sense, the wind speed is the most interesting variable, which can be treated in different ways. The Probability Distribution Function (PDF) is commonly used, and many different techniques have been proposed in the literature. In Serbia, the use of the Weibull function is dominant, while other options have not been considered at all. In the paper, the authors tested and compared fourteen different PDFs for several measurement locations in the northern part of Serbia. Results confirmed the high applicability of the Weibull PDF, but other functions proved to be suitable as well. This is particularly true if seasonal or monthly wind speed measurement results are treated. This study contributes valuable insights into understanding the wind power potential in Serbia, emphasizing the importance of considering multiple distribution functions in the wind data analysis.

Keywords: wind energy, wind speed, probability distribution function, Serbia

EEI2.6 (#5835)

A MACHINE LEARNING-BASED APPROACH FOR EARLY FAULT DETECTION IN INDUCTION MOTOR DRIVES

Andjela Stojiljkovic, Milutin Petronijevic and M. Asim Amin

This study relates to data-driven fault detection and condition monitoring of induction motors (IM) using machine learning (ML) techniques. Fault detection is typically performed through vibration monitoring and analysis to prevent damage to IMs. With this goal in mind, vibration signals from three axes (AccX, AccY, AccZ) were considered and analyzed to detect and classify faults under six different operating conditions. The readings were pre-processed using Fast Fourier Transform (FFT) to extract relevant frequency components, and ML-based models were trained with 260 features obtained from the frequency domain. Various algorithms, such as Support Vector Machine (SVM), K-Nearest Neighbors (KNN), and Artificial Neural Networks (ANN), were evaluated for fault classification in MATLAB. The linear SVM model achieved the highest accuracy of 99% compared to other methods, demonstrating its effectiveness in distinguishing between fault types and operating conditions.

Keywords: Vibration, Induction Motor Faults, FFT, SVM

EEI2.7 (#9884)

AGGREGATION OF RENEWABLE ENERGY SOURCES AND ELECTRIC VEHICLES CHARGING VIA REMOTE TERMINAL IN MARKET CONDITIONS

Jovan Vujasinović, Ilija Batas Bjelić, Goran Savić and Ilija Vujasinović

Aggregation of renewable energy sources and electric vehicles charging via remote terminal in market conditions is presented in this paper. The ability to aggregate a wide range of features into one system helps to optimize the use of several subsystems, including the ones that control electric vehicle chargers remotely, smart electricity meter remote control, and cash register remote control while receiving market information. In this manner, consumers of electric vehicles will have easier access to renewable energy-powered charging stations. This system approach of hardware and software enabling the new feature of aggregation helps to reduce the amount of air pollution by promoting economically driven energy transition in transport sector. Therefore, economic aspects of aggregation vehicle chargers and photovoltaic production are additionally considered. The different scenarios of energy independence of aggregator are also defined.

Keywords: aggregator, electric vehicle charger, remote control system, renewable energy source

СЕСИЈА / SESSION (EEI3+EE1)

Уторак, 10. јун / Tuesday, June 10th Сала 1 / Hall 1 15.00-17.15

Председавајући / Chair:
Miroslav Bjekić, University of Kragujevac - Faculty of Technical Sciences, Čačak, Serbia
Marko Rosić, University of Kragujevac - Faculty of Technical Sciences, Čačak, Serbia

EEI3.1 (#1352)

INDUSTRIAL APPLICATION OF OPEN-LOOP ANTI-SWAY CONTROL FOR BRIDGE CRANE HORIZONTAL MOTION DRIVE

Balša Ćeranić, Milan Bebić and Neša Rašić

Bridge or overhead cranes are widespread in industrial halls, warehouses, shipyards, ports, power plants, and mining, where they provide quick and safe transport of heavy loads. Load sway occurs in the event of horizontal motion in these cranes, which hinders dynamic performance and may cause damage to objects in the direct vicinity of the load as well as the load itself. The paper analyses the sway of the load analytically on a simplified model, to determine the dependence of the rope length and the period of oscillation of the load. The open-loop sway control of the crane's horizontal motion is first tested on a simulation model, then applied to a real industrial crane with 25t loading capability. The experimental results confirm the viability of the proposed open-loop control method in reducing the load sway angle. The manipulation of the load without sway oscillations significantly reduces the load manipulation time with the crane.

Keywords: Crane, Anti-Sway, Electrical Drives, Control

EE1.1 (#0302)

RAZVOJ I ANALIZA MATEMATIČKOG MODELA KRETANJA KOLICA DIZALICE U CILJU SMANJENJA NJIHANJA TERETA

Jovan Radaković, Marko Rosić and Milosav Georgijević

Pogon kolica mosne dizalice sa pripadajućim teretom pripada grupi elastičnih veza između vratila el.motora i „radne mašine“. Zbog toga, kao i dejstva inercijalnih sila, tokom kretanja kolica pojavljuje se njihanje tereta. U cilju minimiziranja njihanja radi tačnog pozicioniranja, kao i u cilju minimiziranja vremenskog trajnja vožnje, primenjuju se indirektne metode za kontrolu njihanja tereta. Ovaj rad prikazuje razvoj matematičkog modela kretanja kolica dizalica u programskom paketu Mathcad i njegovu analizu u cilju smanjenja njihanja tereta pri kretanju. Primenom prikazanog pristupa za rešavanje matematičkog modela i simulacija rada za dva izabrana primera vožnje kolica sa pripadajućim teretom, ukazuju na to da su dobijeni rezultati zadovoljavajući, te da se ovaj model preporučuju za primenu u praksi.

Ključne reči: pogon kolica dizalice, njihanje tereta, anti-sway, frekventni pretvarač, kotrola brzine, Mathcad

EE1.2 (#9381)

DIMENZIONISANJE REZIDENCIJALNE STANICE ZA PUNJENJE ELEKTRIČNIH VOZILA KOJA SE NAPAJA IZ OBNOVLJIVIH IZVORA ENERGIJE

Jovan Vujasinović, Goran Savić, Željko Despotović and Ilija Vujasinović

U ovom radu je opisan postupak dimenzionisanja rezidencijalne stanice za punjenje električnih vozila koja se napaja pomoću obnovljivih izvora energije. Pored toga, opisana je i podela stanica za punjenje električnih vozila, data je kategorizacija punjača električnih vozila, kao i prikaz rezidencijalne stanice za punjenje električnih vozila. Pokazano je da se sa postojećim stanjem tehnologije, rezidencijalna stanica za punjenje električnih vozila može implementirati i jednostavno integrisati u okvir tipičnog domaćinstva, stvarajući održivo i efikasno rešenje.

Ključne reči: stanice za punjenje električnih vozila, punjači električnih vozila, obnovljivi izvori energije

EE1.3 (#9584)

PARCIJALNO ENERGETSKI NEZAVISNA STANICA ZA PUNJENJE ELEKTRIČNIH VOZILA KOJA SE NAPAJA IZ OBNOVLJIVIH IZVORA ENERGIJE

Jovan Vujasinović, Goran Savić, Ilija Batas Bjelić and Ilija Vujasinović

U ovom radu je opisana stanica za punjenje električnih vozila koja se napaja iz obnovljivih izvora energije. Definisana su tri tipa energetske nezavisnosti takve stanice i prikazani su rezultati simulacije rada parcijalno energetski nezavisne stanice za punjenje električnih vozila koja se napaja pomoću obnovljivih izvora energije. Prikazani su i benefiti primene scenarija parcijalne energetske nezavisnosti u situacijama u kojima kupac-proizvođač korišćenjem baterije u potpunosti troši proizvedenu električnu energiju za sopstvene potrebe, što posebno dolazi do izražaja kada se proizvedena električna energija plaća značajno manje nego utrošena električna energija.

Ključne reči: stanice za punjenje električnih vozila, punjači električnih vozila, obnovljivi izvori energije

EE1.4 (#7197)

SISTEM ZA NAPAJANJE POTROSAČA MALE SNAGE PRIKUPLJANJEM ENERGIJE IZ SPOLJAŠNJEG MAGNETSKOG POLJA

Luka Kostić, Bogdan Brković, Milovan Majstorović and Mladen Terzić

U je radu opisan uređaj koji omogućava autonomni rad malih potrošača prikupljanjem energije iz spoljašnjeg magnetskog polja, prevashodno sa idejom prikupljanja rasutog fluksa energetskih transformatora. Ovakvi uređaji korisni su u situacijama gde, osim rasutog magnetskog polja, ne postoji drugi izvor energije iz koga bi se mogli napajati senzori male snage u transformatorskim stanicama. Ovakvi uređaji trebalo bi da budu izvedeni kao slobodnostojeći, jednostavni za rukovanje i robusni prilikom postavljanja, kako bi funkcionisali u različitim okolnostima. Predstavljen je proces idejnog dizajna ovakvog uređaja pomoću proračuna baziranih na metodi konačnih elemenata sa posebim osvrtom na jednostavnost i nisku cenu izrade. Na osnovu dizajna testiranog kroz simulacije, formiran je prototip uređaja koji je potom testiran u laboratorijskim uslovima. Za referentnu merenu vrednost magnetske indukcije, ostvarena je zadovoljavajuća vrednost izlazne snage. Utvrđeno je da bi se primenom ovako projektovanog sistema moglo omogućiti napajanje jednog ili više senzora.

Ključne reči: Energetski transformator, Senzor, Autonomni rad, Rasuti fluks, Prikupljanje energije

EE1.5 (#5121)

DIZAJN I ANALIZA PERFORMANSI REZONANTNOG ENERGETSKOG PRETVARAČA

Lazar Lukić, Bogdan Brković, Milovan Majstorović and Mladen Terzić

U ovom radu se analizira sistem za prenos energije primenom rezonantnog pretvarača sa galvanskom izolacijom. Prikazani su principi funkcionisanja rezonantnih pretvarača i izvedeni su analitički izrazi za analizu njihovih performansi u ustaljenom stanju. Demonstriran je i postupak odredivanja pa- rametara konkretne topologije rezonantnog pretvarača za prenos definisane vrednosti snage pri zadatim vrednostima ulaznog i izlaznog napona. Provera proračunatih parametara izvršena je pomoću simulacija u softverskom alatu za računarsku analizu električnih kola.

Ključne reči: rezonantni pretvarač, dizajn, analiza, ZVS

EE1.6 (#2657)

UNAPREĐENJE PREDIKCIJE SNAGE NA IZLAZU HIDROELEKTRANE PRIMENOM SEZONSKE SEGMENTACIJE I SOM-METODA KLASTERIZACIJE PODATAKA

Stefan Čubonović and Aleksandar Ranković

Ovaj rad predstavlja nastavak prethodnog istraživanja u primeni veštačkih neuronskih mreža (Artificial Neural Networks – ANN) za predikciju snage na izlazu hidroelektrane (HE), korišćenjem dva tipa ANN: veštačke neuronske mreže sa jednosmernim prostiranjem signala (Feedforward Artificial Neural Networks – FF-ANN) i rekurentne neuronske mreže (Recurrent Neural Network – RNN). U novom pristupu povećan je obim podataka za testiranje modela na celu godinu. Godišnji skup podataka podeljen je u četiri sezonske celine po meteorološkom kriterijumu – proleće, leto, jesen i zima – pri

čemu je za svaku sezonu razvijen poseban adaptivni model ANN, sa dodatnom podelom podataka na osnovu dinamike protoka. Kako bi se unapredila preciznost segmentacije radnih režima, u radu je takođe primenjena Self-Organizing Map (SOM) neuronska mreža za klasterizaciju podataka, čime je omogućeno bolje prilagođavanje ANN modela različitim uslovima rada. Cilj rada je dodatno unapređenje preciznosti i robusnosti modela kako bi se omogućila bolja prilagodljivost specifičnim hidrološkim i operativnim uslovima svake sezone. Rezultati testiranja pokazuju da sezonski i SOM modeli nadmašuju model treniran na ograničenom periodu, po pitanju preciznosti predviđanja. Na ovaj način doprinosi se poverenju u kreirane modele i otvaraju se mogućnosti za njihovo unapređenje.

Ključne reči: veštačka neuronska mreža, sezonska podela, SOM, hidroelektrana, protok

ЕЛЕКТРИЧНА КОЛА, ЕЛЕКТРИЧНИ СИСТЕМИ И ОБРАДА СИГНАЛА / ELECTRIC CIRCUITS AND SYSTEMS AND SIGNAL PROCESSING

СЕСИЈА / SESSION (ЕК1+ЕКІ1)

Понедељак, 9. јун / Monday, June 9th Сала 3 / Hall 3 11.00-14.00

Председавајући / Chair:
Milka Potrebić Ivaniš, University of Belgrade – School of Electrical Engineering, Belgrade, Srbija

EKI1.1 (#8391)

MACHINE LEARNING TECHNIQUES FOR SMART AGRICULTURE (INVITED PAPER)

Zoran Stamenkovic

We present the research results that are a basis for integration of hardware devices, databases, machine learning techniques, and related application software. The developed machine learning techniques assist farmers in making data-driven and rule-based decisions to reduce the pesticide use and environmental harm. We merge information coming from the features, variables, and correlations extracted by the machine learning algorithms, together with information generated by the previous knowledge in the existing databases. The final goal is to learn actionable rules that assist the farmer and help the decision-making process. The developed models can be used to simulate the interaction with the environment and estimate rewards and the expected value function. The framework integrates the objective data, ML algorithms and application software which can generate and provide end-user relevant information or control information for actuators.

Keywords: Agriculture, Machine learning, Actionable rules

EKI1.2 (#5280)

COMPARATIVE ANALYSIS OF YOLOV11 AND YOLOV12 FOR AI-POWERED AERIAL PEOPLE DETECTION

Nebojsa Simic and Ana Gavrovska

YOLO (You Only Look Once) is one of the leading and popular object detection approaches to perform object detection. In this paper a comparison between the latest

YOLO models version 11 (YOLOv11) and 12 (YOLOv12) is made for aerial people detection purposes. Here, the experimental analysis is performed in order to observe the main differences and innovations between YOLOv11 and YOLOv12 models delivering state-of-the-art (SOTA) performance. Their performance is assessed using the publicly available VisDrone dataset, specifically designed for visual capturing by drone-mounted cameras. The obtained differences and tradeoffs between CNN (Convolutional Neural Network)-centric architectures and attention-centric architectures are discussed. The goal of this paper is to provide insight into key differences of the training performance and handling of challenging object detection tasks.

Keywords: deep learning, computer vision, YOLO, object detection, drone, feature aggregation, people detection

EKI1.3 (#7456)

ELECTRONIC DEVICES FOR CONNECTING, CONTROLLING AND MONITORING VENDING MACHINES, CAR WASHES, COFFEE MACHINES VIA PC AND POS TERMINAL

Mihajlo Tatović and Predrag B. Petrović

Most of the available vending machines, self-service car washes and coffee machines do not have the option of card payment and most often there is no process for issuing a fiscal receipt. A solution has been proposed in the form of centralized certified software should ensure connectivity with the tax administration and cover the necessary security elements on the one hand and connectivity with the self-service system and devices located within. It is not possible to connect them directly due to different communication interfaces and protocols, so it is necessary to develop a universal electronic device that will provide connection, monitoring and control of various devices. In the following text, a coupled electronic device based on an 8-bit PIC microcontroller and the MAX3100 chip with MDB, ccTALK, MDB edge protocols, a parallel port, and other options required for efficient, stable, and reliable connection to self-service devices with a central management system will be presented.

Keywords: vending machine, self-service car washing, electronic device, 8bit PIC microcontroller, Multi Drop Bus, ccTalk, MDB exe

EKI1.4 (#1472)

ON THE DESIGN OF GENERALIZED COSINE WINDOW FUNCTIONS

Dusan Grujic and Nikola Petrovic

This paper addresses commonly misunderstood properties of window functions, and discusses some important properties of generalized cosine window functions. It is shown how some well-known window functions can be derived from window function properties. New window functions are designed to show how a window function can be tailored for a specific application.

Keywords: Window functions, Generalized Cosine, Flat-top, Design

EK1.1 (#3888)

MEASURING THE FLIGHT PATH OF A DRONE USING AN EXTERNAL GNSS MODULE FOR IOT

Anđela Ninković, Milka Potrebić Ivaniš and Dejan Tošić

This paper presents a compact and cost-effective system for recording drone flight paths using an external GNSS module and Arduino-based platform. The motivation for developing such a system arises from the limitations of commercial drones that restrict access to raw GNSS data. The proposed system, built around the u-blox NEO-6M GPS module, an Arduino Mega 2560 board, a microSD card module, and a step-up voltage converter, operates independently from the drone's internal electronics and records real-time positioning data during flight. The drone used for testing, ZLL SG906 MAX2 BEAST 3E, was manually piloted while the external device collected GPS coordinates, altitude, speed, HDOP, and satellite count. Data analysis included 2D and 3D trajectory reconstruction, flight speed visualization, and the evaluation of GNSS signal quality. The results demonstrate that the system effectively logs accurate flight data and enables post-processing analyses, including the detection of zones with weak GPS reception. This approach is particularly valuable for experimental and educational use in areas where direct access to drone software is not available.

Keywords: GNSS Module, ZLL SG906 MAX2 drone, Arduino platform, navigation accuracy, trajectory analysis

EK1.2 (#9243)

SISTEM ZA PRIJEM PODATAKA SA FMCW RADARSKOG SENZORA PREKO LVDS INTERFEJSA

Nikola Petrović and Dušan Grujić

U ovom radu je prikazan sistem za prijem podataka sa FMCW radarskog sensora pomoću LVDS interfejsa, realizovan na Digilent Nexys Video FPGA platformi. Predloženi sistem omoguća deserijalizaciju podataka primljenih preko LVDS interfejsa, sinhronizaciju podataka, automatsku detekciju širine radarske reči kao i pristiglog CRC podatka. Projektovani sistem vrši CRC proveru kao i adekvatno formatiranje podataka kako bi se omogućila dalja obrada FMCW radarskih podataka.

Ključne reči: Chisel, FPGA, FMCW, LVDS, Radar

EK1.3 (#6464)

IZDVAJANJE OBELEŽJA NA BAZI SPEKTOGRAMA ZA KLASIFIKACIJU RADARSKIH CILJEVA

Đorđe Damnjanović, Mihailo Tomić and Sava Stanišić

U ovom radu analizirani su metodi za izdvajanje obeležja radarskih ciljeva (vozila, osobe, grupe) zasnovanih na teksturi spektrograma. Korišćeni su parametri: entropija, moment trećeg reda raspodele energije i usmerenost spektrograma. Istraživanje je pokazalo da izbor parametara za izračunavanje spektrograma (vrsta prozora, dužina prozora, preklapanje i broj tačaka Furijeove transformacije) značajno utiče na separabilnost klasa. Najbolji rezultati separabilnosti ostvareni su za pravougaoni prozor dužine 512 odmeraka. Obeležja zasnovana na teksturi spektrograma pokazala su potencijal za automatsku klasifikaciju sa tačnošću većom od 90%.

Ključne reči: obeležja, radarski cilj, spektrogram, entropija, prozorska funkcija

EK1.4 (#8085)

ANALIZA RESTAURACIJE SLIKE SNIMLJENE DETEKCIJOM NEŽELJENOG ZRAČENJA MONITORA RAČUNARA JEDNOSTAVNIM ALATIMA

Borko Đaković, Nenad Stojanović, Milena Grdović and Branko Vujatović

U radu je izvršena uporedna analiza jednostavnih i često korišćenih tehnika za restauraciju slike. Ukupno je korišćeno 13 tehnika za restauraciju slike, a njihova uporedna analiza izvršena je pomoću tri mere za objektivnu procenu kvaliteta slike. Za potrebe restauracije, korišćena je slika detektovana sa monitora računara putem neželjenog elektromagnetnog zračenja. Pokazano je da se jednostavnim metodama može dobiti dovoljno kvalitetna slika, sa koje se mogu preuzeti podaci potencijalno važni i poverljivi za korisnika računara, bez njegovog znanja o tome. Ukazano je na važnost primene zaštitnih mera u cilju smanjenja neželjenog zračenja sa računarske i elektronske opreme na kojoj se obrađuju podaci.

Ključne reči: restauracija slike, kvalitet slike, KEMZ, monitor

EK1.5 (#7189)

METOD MODELOVANJA REZONATORA SA DVE BLISKE FREKVENCIJE PRIMENOM NARUŠENJA SIMETRIJE

Pavle Stipsić

U ovom radu ćemo izložiti postupak modelovanja poligonalnih rezonatora sa deformisanom Cnv simetrijom. Rezonatori su oblika jednakostraničnog trougla, kvadrata i kruga, blago izduženih duž određenog pravca. Narušenje simetrije smanjuje dimenziju nekih ireducibilnih podprostora sa dva na jedan i dovodi do razdvajanja frekvencija dvostrukih modova za oscilovanje u spektru. Metod daje predviđanje rezonantnih frekvencija i cepanja spektra u zavisnosti od parametra deformacije.

Ključne reči: rezonator, simetrija, teorija reprezentacija, narušenje simetrije

МЕТРОЛОГИЈА / METROLOGY

СЕСИЈА / SESSION (МЛ1+MLI1)

Понедељак, 9. јун / Monday, June 9th Сала 5 / Hall 5 9.00-10.45

Председавајући / Chair:
Dragan Lazić, Tehnički opitni centar - Ministarstvo odbrane, Beograd, Srbija
Neda Spasojević, Tehnički opitni centar - Ministarstvo odbrane, Beograd, Srbija

ML1.1 (#2361)

ETALONIRANJE CCLD PREDPOJAČAVAČA NAELEKTRISANJA

Dragan Lazic, Slobodan Subotić, Milos Jovanovic and Jelena Jovanovic

U radu je prikazano etaloniranje CCLD predpojačavača naelektrisanja, tip B&K 2647, tj. predpojačavača sa strujnom pobudom. Metoda se realizuje u Tehničkom opitnom centru primenom etalona za vibracije B&K 3629W.

Ključne reči: vibracije, predpojačavač naelektrisanja, merna nesigurnost

ML1.2 (#6888)

MOGUĆNOST ETALONIRANJA BERT METARA U TEHNIČKOM OPITNOM CENTRU

Neda Spasojević, Miša Markuš, Slobodan Subotić, Dragan Lazić, Miloš Jovanović and Aleksandar Atanacković

Ovaj rad opisuje problematiku etaloniranja BERT metara, često zastupljenih merila za testiranje stope bitske greške u digitalnim sistemima. Osnovne prepreke u formiranju metoda etaloniranja vezane su za deficit javno dostupne literature u oblasti BERT metara i specifikacije neophodne za formiranje kriterijuma za ocenu metrološke ispravnosti merila. U radu je predložen metod etaloniranja koji laboratorija ML 02 Tehničkog opitnog centra (TOC) primenjuje uz sva postojeća ograničenja. Metod se oslanja na dostupna uverenja o etaloniranju dva tipa BERT metara izdata od akreditovane laboratorije iz Italije. Međutim, u uslovima ograničenih informacija, obuka iz oblasti etaloniranja BERT metara se nameće kao neophodnost.

Ključne reči: BER, BERT metar, etaloniranje, interfejs

ML1.3 (#2840)

MERENJE PARAMETARA RADIO-NAVIGACIONIH SISTEMA VOR I ILS

Miša Markuš, Neda Spasojevic and Aleksandar Atanacković

U radu je opisan osnovni princip rada radio-navigacionih sistema VOR i ILS. Dat je prikaz merne opreme koja se u Tehničkom opitnom centru koristi za pregled VOR i ILS prijemnika u vazduhoplovima. Razmatrana je mogućnost etaloniranja ove merne opreme u metrološkoj laboratoriji Tehničkog opitnog centra

Ključne reči: Etaloniranje, ILS, Merenje, Navigacija, VOR

MLI1.1 (#9653)

TEMPERATURE EFFECTS ON PRECISION RESISTORS: A REVIEW OF METHODS FOR DETERMINING TEMPERATURE AND LOAD COEFFICIENTS, THEIR ADVANTAGES, LIMITATIONS AND RESULTS

Slobodan Subotić, Jelena Jovanović, Miloš Jovanović, Neda Spasojević, Dragan Lazić and Nikola Jovičić

The electrical resistance of precision resistors is affected by temperature due to two main factors: ambient temperature changes and self-heating from power dissipation. The first factor is quantified by the temperature coefficient of resistance (TCR), which indicates how much the resistance varies with temperature. The second factor, known as the load coefficient or load effect, measures the change in resistance caused by the resistor heating up as it dissipates power due to the current flowing through it. This review examines various methods used to determine temperature and load coefficients, highlighting their advantages, limitations, and the results observed in different studies. Furthermore, the review discusses key findings from past research, comparing the reliability and consistency of different approaches.

Keywords: precision resistor, temperature effect, power loading effect, temperature coefficient, thermal resistance, load coefficient

ML1.4 (#6753)

ETALONIRANJE INFRACRVENIH BESKONTAKTNIH MERILA TEMPERATURE KORŠĆENJEM IC KALIBRATORA SA POSEBNIM OSVRTOM NA UKUPNU MERNU NESIGURNOST

Milos Jovanovic, Dragan Lazic, Slobodan Subotic, Neda Spasojevic, Misa Markus, Nikola Jovicic and Aleksandar Atanackovic

Predstavljeni su osnovni fizički i matematički postulati implementirani kod beskontaktnih merila temperature, njihova primena, osnovne karakteristike i ograničenja. Poseban osvrt u radu, dat je na budžet merne nesigurnosti, glavne elemente budžeta merne nesigurnosti, kao i proračun ukupne merne nesigurnosti tokom etaloniranja.

Ključne reči: beskontaktni način, infracrveni sistem, temperatura, merna nesigursnost

ML1.5 (#9008)

SENZORI KAO DEO DIGITALNIH BLIZANACA KANALIZACIONIH SISTEMA: SPECIFIČNOSTI MERNIH METODA I MOGUĆNOSTI PRIMENE PRISTUPAČNIH REŠENJA

Damjan Ivetic, Robert Ljubičić, Jovana Lakičević, Ljiljana Brajović and Miloš Milašinović

Uloga kanalizacionih sistema je da bezbedno sprovode upotrebljene i atmosferske vode sa urbanih slivova, bez prekida u radu. Jedan od pristupa koji se razvija poslednjih godina, a koji potencijalno može značajno da unapredi rad ovih sistema je primena digitalnih blizanaca. Sastavni element digitalnih blizanaca je i adekvatno prostorno raspoređena senzorska mreža, koja omogućava praćenje merodavnih hidrauličkih veličina u realnom vremenu. Nažalost, imajući u vidu specifičnosti rada ovih sistema i visoku cenu profesionalne merne opreme, najčešće ovakvih senzora nema dovoljno. U ovom radu je dat osvrt na specifičnosti mernih metoda koje se koriste u kanalizacionim sistemima. Analizirana su i alternativna rešenja u vidu pristupačnih senzora, gde je posebno apostrofirano rešenje koje se razvija na Institutu za hidrotehniku koje se bazira na primeni videometrijskih metoda. Taksativno su navedeni i posebni uslovi koja sva merna oprema koja se koristi u kanalizaciji, mora da zadovolji.

Ključne reči: senzori, kanalizacioni sistemi, digitalni blizanci, merenje nivoa vode, merenje protoka vode

ML1.6 (#0031)

ETALONIRANJE MILIVOLTNOG OPSEGA AC KALIBRATORA JF 5200A

Nikola Jovičić and Slobodan Subotić

U ovom radu su opisane metode merenja milivoltnih opsega AC napona kalibratora u metrološkoj laboratoriji za osnovne električne veličine u Tehničkom opitnom centru. Dat je spisak opreme koja se koristi, kao i dobijeni rezultati merenja.

Ključne reči: etaloniranje, AC napon, odnos deljenja

СЕСИЈА / SESSION (MЈI2+MLI2)

Понедељак, 9. јун / Monday, June 9th Сала 5 / Hall 5 11.00-14.00

Председавајући / Chair:
Dragan Denić, University of Niš, Faculty of Electronic Engineering, Serbia
Aleksandar Kovačević, Fakultet tehničkih nauka, Univerzitet u Kragujevcu, Srbija

ML2.1 (#2207)

MERENJE SILE MERNIM TRAKAMA SA POBUDOM NAIZMENIČNIM NAPONOM I PRIMENOM METODE DIGITALNOG LOCK-IN POJAČAVAČA

Milica Stojanović, Dragan Zivanović, Jelena Đorđević Kozarov, Milan Simić and Miroljub Pešić

Prilikom pobude mernog mosta sa mernim trakama jednosmernim naponom, mogu se javiti greške usled termoelektričnih napona u kolu mernog pretvarača, šumova niskih frekvencija, kao i usled ofset napona u mernom kolu, što smanjuje tačnost merenja.Ukoliko se merni most sa mernim trakama pobuđuje naizmeničnim signalom, ove greške se mogu eliminisati. U radu je prikazan princip merenja sile korišćenjem mernih traka povezanih u merni most, koji se pobuđuje naizmeničnim naponom. Primenom metode digitalnog lock-in pojačavača, postiže se poboljšanje tačnosti i osetljivosti merenja.

Ključne reči: merenje sile, merne trake, digitalni pojačavač, lock-in pojačavač

ML2.2 (#7507)

REALIZACIJA I OČITAVANJE STAKLENOG DISKA PSEUDOSLUČAJNOG APSOLUTNOG ENKODERA

Goran Miljković, Ivana Ranđelović, Dragan Denić, Aleksandar Jocić and Jelena Jovanović

U radu je najpre opisan postupak izrade staklenog diska optičkog pseudoslučajnog enkodera. Potom je predstavljen postupak očitavanja koda sa realizovanog diska enkodera. Očitani signali, nakon njihove obrade, se vode na ulaze akvizicione kartice. U LabVIEW softveru je realizovan virtuelni instrument za određivanje ugaone pozicije na osnovu očitanih signala.

Ključne reči: obrtni optički apsolutni enkoder, pseudoslučajna binarna sekvenca, virtuelna instrumentacija

ML2.3 (#0460)

PERFORMANSE DPCM SISTEMA SA LLOYD-MAX KVANTIZEROM I PREDIKTOROM PRVOG REDA PRIMENJENOG NA EKG SIGNAL

Aleksandar Jocić, Milan Dincic, Zoran Peric, Dragan Denic, Goran Miljković and Milica Stojanović

U radu su predstavljene performanse DPCM (Differential Pulse Code Modulation) sistema sa fiksnim Lloyd Max kvantizerom i prediktorom prvog reda. Sistem je primenjen za obradu snimljenog EKG (ElectroCardioGram) signala. Sagledane su mogućnosti korigovanja parametara sistema kao što su opseg kvantizera i vrednosti

koeficijenta prediktora sa ciljem poboljšanja performansi sistema. Uočen je efekat propagacije greške nastale usled kvantizacije i predikcije.

Ključne reči: DPCM sistem, Lloyd-Max kvantizer, EKG signal, koeficijent prediktora

MLI2.1 (#7681)

A SIMPLE VIRTUAL SENSOR APPROACH FOR BLACK CARBON ESTIMATION IN SENSOR NETWORKS

Miloš Davidović, Milena Davidović, Maja Jovanović, Marija Živković, Shahin Tabandeh and Milena Jovašević-Stojanović

This paper presents a simple virtual sensor predictive model based on multiple linear regression for the estimation of the equivalent black carbon concentration in an air quality automatic monitoring sensor network. The predictive model uses selected pollutants concentration and meteorological parameters as predictor variables, and equivalent black carbon concentration as target variable. Virtual sensor model is assessed for several different training/test periods. Dataset for training and validation of the model is derived using a vast dataset collected in WeBaSOOP project on Ada Marina, Belgrade supersite.

Keywords: sensor networks metrology, air pollution, equivalent black carbon, monitoring supersite, machine learning

ML2.4 (#8004)

ODREĐIVANJE EMISIVNOSTI MASKIRNE MREŽE SA ALUMINIJUMSKOM FOLIJOM IC KAMEROM

Milena Jovanović and Marina Tripković

Poznavanje emisivnosti materijala je značajno kako sa stanovišta merenja temperature, tako i sa stanovišta osmatranja i otkrivanja objekta. Podaci o emisivnosti za specijalne materijale, kakvi se koriste u vojnoj tehnici ne mogu se naći u dostupnoj literaturi. Poznato je da emisivnost materijala zavisi od temperature, talasne dužine, ugla zračenja i strukture površine (hrapavost, oksidacija, premazi), materijala i geometrije. Određivanje emisivnosti materijala IC kamerom se vrši u cilju da se pokaže postojanje bitnih razlika u karakteristikama provodnih i izolacionih materijala (dielektrika) i njihova primena u vojne svrhe.

Ključne reči: emisivnost materijala, IC zračenje, merenje temperature, toplotna provodljivost, termovizijska kamera

ML2.5 (#3060)

STRUJNA SONDA ZA OSCILOSKOP NA BAZI STRUJNOG MODULA SA HOLOVIM SENZOROM

Dejan Janjić, Srđan Divac, Aleksandar Kovačević and Branko Koprivica

Cilj ovog rada je da se prikaže način izrade strujne sonde za osciloskop bazirane na komercijalnom strujnom modulu sa Holovim senzorom. Strujna sonda je namenjena za merenje stalne struje u opsegu do 5 A. Osim detalja vezanih za projektovanje i izradu sonde, u radu su prikazani i rezultati njenog ispitivanja, sprovedenog sa ciljem određivanja njene tačnosti. Očitavanja struje sa sonde su upoređena sa očitavanjem sa referentnog univerzalnog mernog instrumenta i izvršena je odgovarajuća analiza rezultata. Dobijeni rezultati, detalji njihove analize i odgovarajući zaključci su dati u radu.

Ključne reči: strujna sonda, osciloskop, stalna struja, tačnost

ML2.6 (#6891)

MERENJE KVALITETA OSVETLJENOSTI RADNE POVRŠINE U KANCELARIJI

Marina Tripković and Milena Jovanović

U svakodnevnom životu se često zanemaruje ili nedovoljno poklanja pažnja u obezbedjivanju pravilnog, odnosno kvalitetnog osvetljenja na radnim površinama u kancelarijama. U Republici Srbiji se koriste različiti standardi za proveru osvetljenosti radnih površina i to u zavisnosti od vremenskog perioda kada je zgrada izgrađena. Razvojem tehnologije novih tipova osvetljenja, kao na primer LED sijalica se javlja potreba definisanja merne metode za ispitivanje novog tipa osvetljenja u skladu sa zahtevima starijih standarda. Predmet ovog rada je upravo prikaz jednog takvog merenja, gde su u kancelariji merene vrednosti osvetljaja radne površine nakon zamene sijalica sa Volframovom niti odgovarajućim LED panelima. Ispitivanje je rađeno u skladu sa zahtevima standarda za dnevno i električno osvetljenje SRPS U.C9.100 iz 1963. godine.

Ključne reči: osvetljenost, ravnomernost osvetljenja, faktor dnevne osvetljenost, luminansija (bleštavost)

ML2.7 (#5114)

ANALIZA ZAGAĐENJA VAZDUHA U GRADOVIMA SRBIJE: SEZONSKA VARIJABILNOST I ZNAČAJ LOKALNE KALIBRACIJE SENZORSKIH MREŽA

Uzahir Ramadani, Slobodan Radojević, Dušan Radivojević, Marija Živković, Viša Tasić and Ivan Lazović

Praćenje kvaliteta vazduha ključno je za razumevanje uticaja zagađenja na ljudsko zdravlje i životnu sredinu. Nacionalna mreža za automatski monitoring kvaliteta vazduha putem automatskih mernih stanica obezbeđuje precizna i metrološki sledljiva merenja koncentracija zagađujućih materija, pružajući pouzdane podatke koji se mogu koristiti za kalibraciju i verifikaciju rezultata merenja senzorskih mreža i uređaja koji koriste jeftine senzore za praćenje kvaliteta vazduha. Ovaj rad prikazuje rezultate analize koncentracija PM2.5, PM10, SO2 i NO2 u odabranim urbanim sredinama u Republici Srbiji u periodu od 2019. do 2023. god. Korišćenjem deskriptivnih i komparativnih statističkih metoda, identifikovane su prostorne razlike u stepenu zagađenja i izražene sezonske promene pojedinih zagađujućih materija, što značajno utiče na interpretaciju vremenskih trendova i procenu izloženosti stanovništva aerozagađenju. Poseban akcenat stavljen je na pouzdanost i stabilnost mernih podataka, kao i na njihovu primenu u podršci metrološki relevantnim analizama. Prikazana analiza predstavlja osnovu za izgradnju sistema za monitoring kvaliteta vazduha utemeljenih na validiranim podacima, čime se omogućava uvođenje lokalno kalibrisanih, sledljivih i efikasnih mreža za monitoring kvaliteta vazduha zasnovanih na primeni jeftinih senzora.

Ključne reči: Kvalitet vazduha, prostorne varijacije, sezonske varijacije, jeftini senzori, lokalna kalibracija

MLI2.2 (#5663)

DESIGN AND VALIDATION OF DIGITAL MEASUREMENT SYSTEM FOR MEASURING MASS BASED ON ANALOG SCALE (STUDENT PAPER)

Jelena Komad, Marjan Urekar and Miodrag Babić

This paper presents a method in which, by measuring a non-electrical quantity such as mass, an electrical quantity like resistance can be obtained, without using complicated and very expensive measurement converters to transform one quantity into another. This measurement system is realized using an analog kitchen scale and a sensor for measuring the liquid level in car reservoirs.

Keywords: measurement of non-electric quantities, measurement of electrical quantities, mass, analog kitchen scale, liquid level sensor, resistance

СЕСИЈА / SESSION (MLI3)

Уторак, 10. јун / Tuesday, June 10th Сала 5 / Hall 5 9.00-10.45

Председавајући / Chair:
Marjan Urekar, University of Novi Sad, Faculty of Technical Sciences, Novi Sad, Serbia
Slobodan Subotić, Tehnički opitni centar - Ministarstvo odbrane, Beograd, Srbija

MLI3.1 (#6179)

CALCULATION OF MEASUREMENT UNCERTAINTY FOR PRESSURE AND FORCE TRANSDUCERS

Katarina Nestorović, Marina Simović Pavlović, Milan Jovanović and Veselin Živanović

In this paper, calculation of the measurement uncertainty was performed. The measurements presented in this paper were carried out in order to test the weapon systems. Pressure and force transducers were used for the measurement process. When measuring a physical quantity and under repeated conditions, different results are obtained. These variations are the result of random processes and measurement uncertainty is used to describe them. Measurement uncertainty can be reduced by repeating the measurement process and presenting an estimated measurand. Statistical and probability theory methods are used to estimate measurement uncertainty.

Keywords: measurement uncertainty, reliability, transducer, method, statistics

MLI3.2 (#0907)

GUI-BASED APPLICATION FOR AUTOMATED CALIBRATION OF K-TYPE THERMOCOUPLES (STUDENT PAPER)

Filip Ivanic and Marjan Urekar

This paper describes implementation of a GUI application which automates the process of calibrating K-type thermocouples. The application was developed using the Python programming language.

Keywords: Python, Application, Graphic User Interface, Calibration, Thermocouple

MLI3.3 (#1622)

USING LABVIEW TO DISPLAY ELECTROPHYSIOLOGICAL SIGNALS, ANALYZE AND SIMULATE EVOKED POTENTIALS (STUDENT PAPER)

Marija Dom and Marjan Urekar

This paper shows the procedure for recording and processing signals from the subject s cortex in the form of evoked potentials, with the addition of electroencephalography, without which this procedure would not be possible. LabVIEW is used as a programming environment for the analysis and simulation of these signals.

Keywords: evoked potentials, electroencephalography, LabVIEW

MLI3.4 (#2816)

AUTOMATED SYSTEM FOR PROTECTING TOMATOES FROM DISEASES IN A GREENHOUSE USING TEMPERATURE AND RELATIVE AIR HUMIDITY REGULATION (STUDENT PAPER)

Miloš Stojanović and Marjan Urekar

This paper shows how, by applying modern technologies belonging to Industry 4.0 and basic methods of growing plants in a greenhouse, to protect tomatoes from popular fungal diseases. In addition to the equipment that will be used to maintain parameters such as temperature and relative humidity, the logic will be explained, i.e. operating principle of the tomato protection system. Also, this paper shows the importance of measuring the basic parameters as the key to the proper functioning of the system. What was taken from the technologies belonging to Industry 4.0 is the long-distance monitoring of measured parameters, which additionally shows how important measurements are for this work. What makes this work unique is the possibility of applying the idea developed here in the real world.

Keywords: Greenhouse, Temperature, Relative humidity, Fungal diseases, Tomatoes, Temperature and relative humidity sensors, Programmable logic controler, Human-Machine interface

MLI3.5 (#4495)

MEASUREMENT AND CONTROL IN WELL AUTOMATION SYSTEMS (STUDENT PAPER)

Teodora Prečanica, Miloš Stojanović and Marjan Urekar

This paper is an example of measuring and control well automation systems. It represents a system that works with the help of a pump at a certain depth. Through the sensors, we have an insight into the current flow and pressure and thus regulate the entire process. There is also a PLC that manages the system, it is programmed so that the system functions without constant human observation. And the speed of the pump and its operation depends on the water level and the desired pressure and flow. All devices in the system are closely related to each other due to the operating conditions of the process.

Keywords: Programmable Logic Controller, Human Machine Interface, sensors, well, pump

MLI3.6 (#0049)

MEASUREMENT OF ELECTRICAL QUANTITIES ON SPECIFIC CONSUMERS IN THE OIL INDUSTRY (STUDENT PAPER)

Milica Mijić and Marjan Urekar

Method of measuring electrical quantities at a gathering and dispatch station, its shortcomings, the proposed improvements, and a comparison of two measurement approaches.

Keywords: Electrical measurements, current transformers, SCADA, oil, pumps, PLC, industry

СЕСИЈА / SESSION (MЛI3+MLI4)

Уторак, 10. јун / Tuesday, June 10th Сала 5 / Hall 5 15.00-17.15

Председавајући / Chair:
Dragan Pejić, Univerzitet u Novom Sadu, Fakultet tehničkih nauka, Novi Sad, Srbija
Đorđe Novaković, Univerzitet u Novom Sadu, Fakultet tehničkih nauka, Novi Sad, Srbija

MLI4.1 (#0445)

ADVANCING ENERGY DIGITALIZATION THROUGH DIGITAL TWINS AND LIVING LABS (INVITED LECTURE)

Živko Kokolanski

The transition toward sustainable and resilient energy systems is a key priority under initiatives such as REPOWER EU, the European Green Deal, and EUSAIR. Energy digitalization plays a crucial role in achieving these goals by enabling efficient management, real-time monitoring, and advanced forecasting of renewable energy sources. Digital twins and living laboratories emerge as a key enabling technologies in this transformation, offering a platform for innovation, experimentation, and optimization of energy systems. Living labs provide real-world environments for testing and validating new energy technologies before large-scale deployment. The INNOFEIT Living Lab in Skopje exemplifies this approach, integrating a solar power plant, battery storage, an electric vehicle charger, a geothermal heat pump, a weather station, and infrastructure automation.

Keywords: Energy Digitalization, Digital Twins, Living Labs

ML3.1 (#1184)

DIGITALNI KALIBRATOR FAZNOG STAVA 90 STEPENI

Sanja Mandić, Dragan Pejić, Đorđe Novaković and Nemanja Gazivoda

U ovom radu dat je prikaz realizacije digitalnog kalibratora faznog stava od 90 stepeni baziranog na binarnom brojaču. Motivacija istraživanja proizilazi iz potrebe za testiranjem prethodno razvijenog sistema za mernje faznog stava, čiji se rad zasniva se na merenju vremenskih intervala smicanja dva signala, upotrebom tajmerskog modula mikrokontrolera. U ovakvom sistemu uočen je niz problema koji uzrokuju sistematske greške u procesu merenje, te pored metode merenja, razvijeni sistem implemetira i novu metodu za potiskivanje nastalih grešaka. Cilj istraživanja predstavljenog u ovom radu jeste razvoj sistema koji na svom izlazu daje signale čiji je fazni stav tačno i precizno realizovanih 90 stepeni, kako bi bilo moguće testiranje i kalibracija sistema za merenje faznog stava i predložene metode potiskivanja sistematskih grešaka.

Ključne reči: Metode merenja, fazni stav, tajmerski modul, binarni brojač, digitalni kalibrator

MLI4.2 (#9409)

EVALUATION OF MEASUREMENT UNCERTAINTY OF A DIGITAL AC VOLTMETER USING THE MONTE CARLO METHOD

Sara Kasapović, Dragan Pejić, Nemanja Gazivoda, Danilo Tamindžija, Marjan Urekar and Platon Sovilj

This paper presents a detailed evaluation of the measurement uncertainty of a digital AC voltage measuring device, using both analytical methods and the Monte Carlo simulation technique. A comprehensive mathematical model was developed, considering the contributions from key device components. The measurement uncertainty budgets were calculated across all operating ranges of the device, with special emphasis placed on identifying and analyzing dominant sources of error. Monte Carlo simulation proved effective for uncertainty estimation. Potential improvements through software-based compensation methods are also discussed.

Keywords: measurement uncertainty, Monte Carlo method, analog-to-digital converter, uncertainty budget

MLI4.3 (#3551)

AUTOTUNING AND MEASUREMENT OF PI CONTROLLERS FOR LOW-POWER DC MOTORS: A MICROCONTROLLER-BASED IMPLEMENTATION USING THE RELAY METHOD AND PYTHON GUI

Ivan Tomić and Marjan Urekar

This paper presents a solution for tuning the parameters of a PI controller for low-power DC motors, integrating an autotuning method based on the relay test. The system provides a practical approach to automatically adjusting control parameters, improving the system's dynamic response and stability. The proposed method was compared with the traditional Ziegler-Nichols closed-loop method, showing superior speed of response but with a higher steady-state error when using the relay test. A custom Graphical User Interface (GUI) was developed in Python for user interaction, enabling real-time tuning and parameter visualization. The system also features an integrated microcontroller-based platform for motor control, with a focus on ease of integration into real-world applications. The results indicate the effectiveness of this system for controlling DC motors, with potential applications in robotics, automation, and other areas requiring precise motor control.

Keywords: Python, autotuning, Graphic User Interface, PID controller, DC motors

MLI4.4 (#2617)

MACHINE LEARNING METHODS IN MEASUREMENTS OF PHOTOVOLTAIC POWER PLANTS

Josif Tomić, Vladimir Pejanović, Zoltan Čorba and Platon Sovilj

Recently, photovoltaic power plants have been producing increasing amounts of energy, and for the stable operation of the entire energy system, it is necessary to predict their production. Because the production levels of this energy source vary, it is increasingly difficult for energy companies to balance production and consumption of electricity. To effectively balance consumption and production, prediction methods based on machine learning algorithms have recently been used. This paper presents several examples of the

application of machine learning to measurements at a photovoltaic power plant. Various predictions of the power of photovoltaic panels are given, as well as predictions of the solar radiation energy on a practically installed photovoltaic panel.

Keywords: machine learning, prediction, photovoltaic panels, random forest, ARIMA

MLI4.5 (#2988)

RETROFITTING LEGACY PHOTO-SENSOR INFRASTRUCTURE FOR HYBRID SMART AGRICULTURE AND INDUSTRY 4.0

Vladimir Pejanović and Marjan Urekar

As a response to Industry 4.0 machine-centric and short-term product usage approach, several concepts of re-use of legacy products and infrastructure, like Retrofitting concept, with sustainability, as well as efficiency in mind, have been developed. Device, designed in this paper, is intended to be used for connecting new sensors (in a combination with the old ones) with legacy infrastructure. Developed device is presented as an element of Retrofitting concept, and is designed to include functions of hybridization of analog-to-analog and analog-to-digital solutions as well as smart agriculture and Industry 4.0.

Keywords: Retrofitting concept, Industry 4.0, Smart Agriculture, photo-sensors, hybridization, sustainability

MLI4.6 (#5535)

APPLIED IMPLEMENTATION OF A BIOMETRIC IDENTIFICATION SYSTEM BASED ON ANTHROPOMETRIC FEATURES

Sara Bratić and Đorđe Novaković

In this paper, the focus is placed on the practical implementation of an identification system that integrates anthropometric principles with dactyloscopy. The goal is to demonstrate how theoretical foundations can be translated into a functional device that utilizes hardware components such as the Fingerprint 2 Click and Fever Click sensors, supported by the STM32 microcontroller platform and software based on FreeRTOS and Python. The system is capable of detecting a live user based on body temperature and matching fingerprint data against a local database, achieving reliable and fast identification.

Keywords: Anthropometry, Dactyloscopy, Fingerprint 2 Click, Fever Click, STM32, FreeRTOS, Python

ML3.2 (#5305)

МЕРЕЊЕ ПОДУЖНЕ ЕЛЕКТРИЧНЕ ОТПОРНОСТИ ЦЕВИ НАФТОВОДА

Rajčević Jovan, Dragan Pejić, Đorđe Novaković, Nemanja Gazivoda and Novica Marković

У овом раду дат је приказ мерења електричне отпорности цеви намењене за транспорт нафте. Мерење је иницирано из потребе стварања електромагнетске и термичке слике приликом експлоатације нафте у чврстом агрегатном стању, ради мењања агрегатног стања и чишћења од феромагнетских честица. Спроведено је четворожично мерење, како би се елиминисао утицај отпорности контаката. Дати су анализа резултата, математички модел резултата мерења и буџет мерне несигурности.

Кључне речи: електрична отпорност, четворожични спој, мерна несигурност

МИКРОЕЛЕКТРОНИКА И ОПТОЕЛЕКТРОНИКА / MICROELECTRONICS AND OPTOELECTRONICS

СЕСИЈА / SESSION (MO1+MOI1)

Уторак, 10. јун / Tuesday, June 10th Сала 6 / Hall 6 9.00-10.45

Председавајући / Chair:
Dana Vasiljević Radović, IHTM-CMTM, Beograd, Srbija

MOI1.1 (#9460)

A HIGHLY LINEAR RAIL-TO-RAIL OPERATIONAL TRANSCONDUCTANCE AMPLIFIER

Razmik Soghomonyan

This paper presents an architecture for a rail-to-rail operational transconductance amplifier (OTA) that substantially improves the linearity of the OTA transconductance. The proposed method uses a simple input voltage scaling technique paired with a five-transistor negative feedback loops for the output stage to apply the scaled differential voltage across a resistor that guarantees linearity. This approach has applications in signal processing environments, such as receiver and transmitter integrated circuits, suppressing heavily system inherent noise generated by deviations from an expected linear behavior. The proposed architecture has been implemented in 14nm FinFET technology. Spice simulations performed for the developed circuit show less than -65dB of total harmonic distortion (THD) of the output current at 1MHz for rail-to-rail input signal in the -40...125°C temperature range considering the supply voltage variation in ±10% range.

Keywords: transconductance, linearity, OTA, THD

MOI1.2 (#7552)

GOLD NANOPARTICLES EMBEDDED IN POLYDIMETHYLSILOXANE (PDMS) MICROREACTORS FOR PLASMONIC ENHANCEMENT OF PHOTOCATALYTIC PROCESSES

Marko Obradov, Ivana Mladenović, Milena Rašljić Rafajilović, Olga Jakšić and Dana Vasiljević Radović

We present an approach to utilize plasmonic (gold) nanoparticles embedded within the polydimethylsiloxane (PDMS) host toped of with a thin semiconductor layer to enhance photocatalytic processes in microfluidic devices. We chose this approach because it is technologically simple, requires minimal changes to the standard microreactor fabrication process, is cost effective and is widely available as PDMS is the most commonly used material to fabricate microfluidic devices. We analyze the influence of particle size and concentration as well as the semiconductor layer material (refractive index) on the plasmonic response of the structure. This allows us to tune the primary and secondary effects of plasmonic resonance, such as light localization, hot carrier generation, heating effect, etc., which are crucial for enhancement of photocatalytic processes.

Keywords: plasmonics, PDMS, photocatalysis, semiconductors, microreactors

MOI1.3 (#4220)

VISUALIZATION OF LATENT FINGERPRINTS ON MOLYBDENUM SUBSTRATE WITH NI ELECTRODEPOSITED AND NI-BASALT CO-ELECTRODEPOSITED COMPOSITE LAYERS

Ivana O. Mladenović, Marija M. Vuksanović, Željko Radovanović, Vladislav Jovanov, Vera Obradović, Jelena S. Lamovec and Nebojša D. Nikolić

The aim of this paper is to use pure Ni and layers based on Ni and particles of basalt (B) for the development and visualization of latent fingerprints on Mo substrate by taking of the marks' topography and mechanical advantages. B was used as reinforcement under co-electrodeposition process of Ni-B layers with the aim to obtain better contrast between ridges. The microstructural and chemical properties were tested using FE-SEM/EDS and AFM. The Ni-sulphamate bath without/with particles were used for synthesizing of layers in the direct current regimes, first on clean substrate, and then on substrate where the fingerprints were placed. The adhesion properties of layers were evaluated using scratch tape adhesion test. All layers were deposited with variations in current densities. An improvement adhesion property was observed for all Ni-B layers. The more visible development of fingerprints was obtained at higher current density, for Ni, and at lower current density, for Ni-B layers.

Keywords: molybdenum, basalt particles, nickel layers, co-electrodeposition, latent fingerprints, adhesion

MOI1.4 (#3392)

EVALUATION OF ADHESION PERFORMANCE OF ELECTRODEPOSITED NICKEL COATINGS ON COPPER AND MOLYBDENUM SUBSTRATES USING DIFFERENT TECHNIQUES

Milica Mušicki, Nikola Mitrović, Sara Rethas, Ivana O. Mladenović, Sara Petković, Vesna Radojević and Jelena S. Lamovec

For analysis of adhesion performance, composite structures consisting of electrodeposited nickel coatings on copper and molybdenum substrates were prepared. The experimentally determined deposition rate for a current density of 35 mA/cm2, 0.7 μm/min, the deposition time was calculated for coating thicknesses of 5, 10 and 20 μm. The adhesion performance of the "hard coating on a soft substrate" composite systems was investigated using three types of adhesion testing: a bidirectional bending test, a cross-hatching method, and a Vickers microindentation method. The morphology of the surfaces of substrates and coatings before and after the adhesion testing was examined using a stereomicroscope and a metallurgical microscope. The adhesion strength of nickel coatings on molybdenum substrate was poor and decreased with increasing coating thickness, but on copper substrates, adhesion strength was excellent for all coating thicknesses. Different adhesion tests gave consistent results.

Keywords: nickel electrodeposition, coating adhesion, bidirectional bending test, cross-hatching test, microindentation, critical reduced depth

MOI1.5 (#1891)

WEARABLE HEART RATE SENSOR BASED ON MXENE-COATED POLYMER MEMBRANE

Ivan Pesic, Marko Spasenović, Milena Rašljić-Rafajilović, Stefan Ilić, Marko V. Boskovic, Jean-Olivier Durand and Marija Pergal

This study introduces an innovative approach by coating PVDF membranes with MXene layers, which act as an electrically conductive channel, facilitating accurate detection of heart rate signals when used in piezoresistive mode, provided the MXene layer was optimized to an appropriate thickness. Structural characterization via XRD, and SEM-EDX confirmed the successful formation of stable, layered MXene structures without signs of oxidation. Heart rate monitoring tests performed with a MXene-PVDF sensor on a pulse simulator and analyzed with the HeartPy software revealed superior sensor performance, characterized by a high signal-to-noise ratio (SNR~26.78 dB) and excellent accuracy in tracking the preset beats per minute (BPM). The obtained results highlight the great potential of MXene-coated polymer sensors for advanced wearable health monitoring applications, particularly in professional sports performance assessment and personalized medical diagnostics.

Keywords: MXene, Polymer, Wearable sensor, Electrical properties, XRD, SEM-EDX, HeartPy

MO1.1 (#2309)

PRIMENA PREDIKTIVNIH TEHNOLOŠKIH MODELA U SPICE SIMULACIJI PRSTENASTOG OSCILATORA

Miloš Marjanović, Aneta Prijić, Danijel Danković and Zoran Prijić

Ovaj rad prikazuje primenu prediktivnih tehnoloških modela u projektovanju prstenastih oscilatora uz korišćenje SPICE simulacija. Razmatran je rad prstenastih oscilatora sa različitim brojem invertora, sa i bez kola za dozvolu rada, implementiranih u CMOS tehnologijama (45, 32, 22, 16 nm). Izvršeno je dimenzionisanje tranzistora, a zatim je analiziran period oscilovanja u funkciji temperature i napona napajanja. Rezultati pokazuju da broj invertora, prisustvo kola za dozvolu rada i izbor naponskih i temperaturnih uslova značajno utiču na performanse oscilatora. Zaključeno je da je važno postići kompromis između frekvencije, potrošnje i složenosti dizajna prstenastog oscilatora, u zavisnosti od specifičnih zahteva primene.

Ključne reči: prstenasti oscilator, SPICE simulacija, PTM

MO1.2 (#2939)

ANALIZA UTICAJA PELTIJEVOG EFEKTA NA EFIKASNOST TERMOELEKTRIČNIH GENERATORA U SAMONAPAJAJUĆIM SISTEMIMA

Aleksandra Stojković, Aneta Prijić, Miloš Marjanović, Jana Vračar Zlatković, Zoran Prijić and Vesna Paunović

Termoelektrični generator (TEG) priključen na električno opterećenje generiše nižu vrednost napona nego kada je u uslovima otvorenog kola usled dejstva Peltijevog efekta. U ovom radu je eksperimentalnim merenjima analiziran uticaj ovog efekta na efikasnost TEG-ova u okviru kompaktnih sklopova sa hladnjakom pri uslovima prirodnog hlađenja.

Sklopove sačinjava minijaturni TEG u kombinaciji sa hladnjacima izrađenim od aluminijuma, keramike alumine, mikroporozne keramike i bakarne pene. Određene su minimalne temperaturne razlike pri kojima sklopovi obezbeđuju kontinualno funkcionisanje integrisanog kola za upravljanje energijom, a posledično i rad samonapajajućeg sistema čiji su sastavni deo. Dodatno, za sve sklopove je određeno relativno smanjenje vrednosti napona predatog opterećenju pri maksimalnoj razmatranoj temperaturnoj razlici između tople strane TEG-a i ambijenta.

Ključne reči: Peltijev efekat, sklop termoelektrični generator-hladnjak, samonapajajući sistem

МИКРОТАЛАСНА ТЕХНИКА, ТЕХНОЛОГИЈЕ И СИСТЕМИ / MICROWAVE TECHNIQUE, TECHNOLOGIES AND SYSTEMS

СЕСИЈА / SESSION (MTI1+MT1)

Понедељак, 9. јун / Monday, June 9th Сала 2 / Hall 2 12.30-14.00

Председавајући / Chair:
Nebojša Dončov, University of Niš, Faculty of Electronic Engineering, Niš, Serbia

MTI1.1 (#0389)

DPD COMPENSATION AND DIGITAL SECOND-ORDER TECHNIQUES TESTING ON DOHERTY PA FOR 5G APPLICATIONS

Aleksandra Đorić, Aleksandar Atanasković and Nataša Maleš Ilić

In this paper, a fifth generation Doherty power amplifier (DA) that operates at 3.5 GHz is linearized by two linearization techniques (one iteration of the DPD Compensation technique-DPD_lin and digital second-order technique-2nd_lin) through simulation tests for the 5G post-OFDM modulation schemes, such as FBMC, UFMC and FOFDM signals. The digital 2nd order technique uses digital nonlinear 2nd order baseband signals adjusted in magnitude and phase that afterward modulate the fundamental carrier's second harmonic. These generated signals are injected at the input and output of the main amplifier in the DA. The tests are performed for both techniques for the same conditions for three input power levels and accomplished results are compared graphically and in table.

Keywords: Doherty power amplifier, 5G application, DPD Compensation technique, second harmonic, baseband component

MTI1.2 (#1201)

EXPERIMENT WITH AN OPEN RING AS AN IDEA FOR MICROWAVE MICROSTRIP PRESSURE SENSORS ON TEXTILES

Dusan Nesic

Preliminary experiments with a coupled open ring and a split ring as pressure sensors are given. The construction was made on a textile (felt), where copper self-adhesive tape was used for metallization. Foam rubber was used to apply pressure to the open part of the ring.

Keywords: microwave, textile, open ring, pressure sensor

MTI1.3 (#8034)

ANN MODEL OF PARABOLIC REFLECTOR ANTENNA WITH VARIABLE FEED POINT POSITION

Ksenija Mladenović, Zoran Stanković, Olivera Pronić Rančić and Nebojša Dončov

In this paper, the influence of the axial displacement of the feeder on the directivity of the parabolic reflector antenna is investigated. Deep neural networks are used to model the directivity of the antenna based on the following parameters: frequency, antenna diameter, focal length to antenna diameter ratio and feed point position along the main lobe axis. The accuracy and computational efficiency of the developed neural model is investigated and compared with that of the conventional EM model.

Keywords: parabolic reflector antenna, directivity, feed point, artificial neural networks

MTI1.4 (#9613)

A 3D-PRINTED STRUCTURE APPROACHING LOW-PASS FILTERS FOR HIGH-FREQUENCY APPLICATIONS

Paolo Esposito, Gianluca Barile, Leonardo Pantoli, Vincenzo Stornelli and Giuseppe Ferri

High-frequency filters play a significant role in microwave applications, enabling effective signal processing, noise reduction, and frequency selection in communication, sensing, and electronic systems. This work proposes a 3D-printed passive structure based on inductive-capacitive passive filters for applications on the edge of the microwave range. The presented structure has a 900 mm2 area. Results show sufficient agreement between theoretical and measured cut-off frequencies in the 500-600 MHz range. Additionally, the 3D-printed structure shows an RC-like behavior, with sufficient impedance matching and an in-band minimum equal to -7 dBs. Finally, Insertion Loss equals -4 dB.

Keywords: 3D-printing, filters, microwave, 3DPCBs, fused deposition modelling

MTI1.5 (#1215)

PRINTED 2D CROSSED SLOT ANTENNA ARRAY WITH HIGH GAIN AND LOW SIDE LOBE LEVEL FOR MM-WAVE APPLICATIONS

Marija Milijić and Branka Jokanovic

The paper presents compact 2D antenna array with 8 x 8 crossed slots designed for the frequency band 24.25–27.5 GHz. The antenna consists of 8 linear subarrays with 8 identical crossed slots that are positioned parallel to each other on the top of the low-loss substrate. The crossed slots in sub-array are series-feed by microstrip line on the bottom side of the substrate. The subarrays are excited with corporate feeding network that provides tapered power distribution with maximum side lobe suppression of 24 dB in the E plane. However, the uniform series feeding along 8 crossed slots in each sub-array causes the side lobe suppression of 13.5 dB in the H plane. The antenna with planar reflector has maximum gain of 25.7 dBi.

Keywords: antenna array, corporate feeding, crossed slot, microstrip line feeding

MT1.1 (#5275)

KOMPAKTNI MULTI-BAND FILTAR SA SPLIT-RING REZONATORIMA NA FR4 SUPSTRATU ZA POBOLJŠANU SELEKTIVNOST U MIKROTALASNIM ANTENAMA

Luka Lazović, Branka Jokanović, Ana Jovanović and Vesna Rubežić

U ovom radu predstavljen je kompaktni multi-band filtar zasnovan na split-ring rezonatorima (SRR), izrađen na FR4 supstratu. Filtar je dizajniran za primjenu u mikrotalasnim antenama sa ciljem poboljšanja frekventne selektivnosti i smanjenja ukupnih dimenzija sistema. Poseban akcenat stavljen je na upotrebu jeftinog FR4 supstrata kako bi se omogućila integracija u low-cost mikrotalasne antene i uređaje. Korišćenjem SRR struktura postignuta je multi-band karakteristika sa jasno definisanim propusnim opsezima i visokom selektivnošću između njih. Filtar je modelovan i optimizovan pomoću CST softwera. Dobijeni rezultati potvrđuju pogodnost predloženog rešenja za integraciju u kompaktnim i niskobudžetnim mikrotalasnim sistemima i antenama.

Keywords: split-ring rezonatorima, filteri, mikrotalasne antene, FR4

НОВИ МАТЕРИЈАЛИ / NEW MATERIALS IN ELECTRICAL AND ELECTRONIC ENGINEERING

СЕСИЈА / SESSION (HM1+NMI1)

Понедељак, 9. јун / Monday, June 9th Сала 5 / Hall 5 15.00-16.45

Председавајући / Chair:
Vesna Paunović, University of Niš, Faculty of Electronic Engineering, Niš, Serbia
Nebojša Mitrović, University of Kragujevac, Faculty of Technical Sciences, Čačak, Serbia

NMI1.1 (#3931)

ADVANTAGES OF SIMULTANEOUS USE OF IS/DS SPECTROSCOPY ANALYSIS IN CHARACTERIZATION OF TRANSPORT PROPERTIES OF CERAMICS AND CHALCOGENIDE GLASSES (INVITED PAPER)

Mirjana Šiljegović, Milica Kisić, Stevan Jankov and Stevan Armaković

Impedance spectroscopy (IS) is an established measurement method used for studying the electrical properties of a wide range of materials. The greatest advantage of this technique lies in collecting information about the materials' bulk phase (conductivity, dielectric permittivity) and their inner and outer interfaces simultaneously. Since it considers both the real and the imaginary part of the complex impedance, this approach is experimentally efficient and provides more information at the same time. This paper presents relevant practical aspects of the interpretation and analysis of the electrical and dielectric behavior of three different classes of materials based on IS and DS modelling. The first class of materials refers to metal doped chalcogenide glasses (Bi-As-S system and Cu-As-Se system) for which IS/DS analysis was crucial in detection of different structural units and phases and characterization of their contribution in impedance response.

Keywords: impedance spectroscopy, dielectric spectroscopy, chalcogenide glasses, photocatalyst, ferrites

NMI1.2 (#1791)

A PHENOMENOLOGICAL MODEL TO ACCOUNT ANISOTROPIC MAGNETIC PROPERTIES OF ELECTRICAL STEELS

Krzysztof Chwastek, Mariusz Najgebauer, Łukasz Mruk, Branko Koprivica, Marko Rosić and Stan Zurek

Anisotropy is an intrinsic and persistent feature of crystalline materials. The paper considers its effect on magnetic properties of electrical steels (non-oriented and grain-oriented). In particular the angular dependence of coercive field strength is discussed. A simple phenomenological model derived from texture analysis in materials science is adapted for the aforementioned dependence. The paper proves that the approach offers a straightforward way to describe the angular dependence of important quantities used for characterization of electrical steels, thus it might be interesting and useful to the designers of magnetic circuits in electrical machines.

Keywords: anisotropy, soft magnetic materials, electrical steels, magnetic properties, modeling

NMI1.3 (#3296)

APPLICATION OF STEINMETZ-TYPE POWER LAWS TO THE LOSS DESCRIPTION IN NiFe ALLOYS

Mariusz Najgebauer, Krzysztof Chwastek, Branko Koprivica and Srđjan Divac

The paper discusses the application of Steinmetz-like power laws to the description of energy losses in Ni-Fe alloys (permalloys). Two types of permalloys with different nickel contents (50 and 79%) were analyzed. A phenomenological two-term formula for the dependence of loss density on frequency and magnetic induction is proposed. For the examined samples the formula yields the averaged errors below 12.3%.

Keywords: permalloys, loss density, modeling

NMI1.4 (#6763)

APPLICATIONS OF NVIDIA JETSON NANO: A COMPREHENSIVE REVIEW

Ahmad Youssef and Dejan Jokic

This study looks at how the NVIDIA Jetson Nano is essential to enable edge AI applications in a variety of industries, including autonomous systems, healthcare, agriculture, and rehabilitation. The review examines studies from 2020 to 2024 using a methodical approach based on the PRISMA framework and Zotero for reference management. It emphasizes the platform's advantages in providing real-time AI solutions for complex tasks like computer vision and deep learning, as well as its small size and energy efficiency. It assesses the uses, advantages, and difficulties of the Jetson Nano, paying special attention to its contributions to autonomous systems, precision farming, healthcare advancements, and rehabilitation technologies. Critical insights into the revolutionary effect of the Jetson Nano and its potential to propel future developments in edge computing are provided by this thorough examination.

Keywords: NVIDIA Jetson Nano, Edge AI applications, Edge Autonomous systems, Healthcare, Agriculture, Rehabilitation, Real-time AI solutions

NMI1.5 (#4861)

PENETRATION DEPTH AND MAGNETOIMPEDANCE EFFECT IN CoFeSiB AND FeNbCuSiB AMORPHOUS WIRES

Nebojsa Mitrovic, Jelena Orelj, Radoslav Surla, Borivoje Nedeljkovic and Vladimir Pavlovic

The magnetoimpedance (MI) elements prepared on amorphous cobalt-based $Co_{68.15}Fe_{4.35}Si_{12.5}B_{15}$ and iron-based $Fe_{73.5}Nb_3Cu_1Si_{13.5}B_9$ wires prepared by the melt-spinning technique were studied. In addition to the investigation of the MI-effect by MI-modulus Z (Hex, f), an analysis of penetration depth δm (Hex, f), which is a crucial MI-parameter, was performed by exploiting MI-element magnetoresistance MR (Hex, f). Comparative studies of the dependence of the skin depth on the magnetic field and frequency δm (Hex, f) have shown that the cobalt-based amorphous wires attain an order of magnitude lower penetration depth values.

Keywords: CoFeSiB and FeNbCuSiB amorphous wires, magnetoimpedance (MI) effect, MI-element, penetration depth

NMI1.6 (#2609)

MICROWAVE CHARACTERIZATION OF AMORPHOUS $Fe_{72}Cu_1V_4Si_{15}B_8$ RIBBONS: DE-EMBEDDING ANALYSIS

Vedran Ibrahimović and Nebojša Mitrović

This study presents a combined theoretical, simulation-based, and experimental approach for high-frequency characterization of amorphous ferromagnetic materials using microwave techniques. A custom de-embedding algorithm was applied to remove systematic errors introduced by the conductive lines of the test fixture, with supporting electromagnetic simulations performed in CST Studio Suite and measurements on $Fe_{72}Cu_1V_4Si_{15}B_8$ ribbons using a Vector Network Analyzer (VNA). In addition to the giant magnetoimpedance (GMI) effect of about 228% under high magnetic excitation, a negative magnetoresistance around 1500 MHz was observed.

Keywords: $Fe_{72}Cu_1V_4Si_{15}B_8$ amorphous ribbons, giant magnetoimpedance, S-parameters T-parameters, de-embedding

NM1.1 (#1658)

UTICAJ Er^{3+} JONA NA SPECIFIČNU ELEKTRIČNU PROVODNOST DOPIRANE $BaTiO_3$ KERAMIKE

Miloš Đorđević, Vesna Paunović, Aneta Prijić and Zoran Prijić

U ovom radu ispitivana je specifična električna provodnost $BaTiO_3$ keramike dopirane erbijumom u koncentraciji od 0.01 at% do 1.0 at%. Uzorci su dobijeni konvencionalnom metodom i sinterovani od 1320°C do 1380°C. Na nižim koncentracijama veličina zrna kretala se u opsegu od 10 μm do 50 μm. Sa povećanjem koncentracije, veličina zrna je opadala i na koncentraciji od 1.0 at%, kretala se od 2 μm do 20 μm. Za sve ispitivane uzorke određivana je specifična električna provodnost u temperaturnom intervalu od 30°C do 170°C i u frekventnom opsegu od 100Hz do 1MHz. Porast temperature uticao je na promene vrednosti specifične električne provodnosti i njeno smanjenje. Za vrednost specifične električne provodnosti je karakteristična velika promena u vidu pada provodnosti u intervalu od sobne temperature do 100°C, nakon čega dolazi do neznatne promene vrednosti. Povećanjem frekvencije zabeležen je rast vrednosti električne provodnosti pri čemu se na frekvencijama iznad 50 kHz javlja nagli skok

Ključne reči: mikrostruktura, $BaTiO_3$ keramika, specifična električna provodnost

РОБОТИКА И ФЛЕКСИБИЛНА АУТОМАТИЗАЦИЈА / ROBOTICS AND FLEXIBLE AUTOMATION

СЕСИЈА / SESSION (ROI1)

Понедељак, 9. јун / Monday, June 9th Сала 3 / Hall 3 9.00-10.45

Председавајући / Chair:
Kosta Jovanović, University of Belgrade – School of Electrical Engineering, Belgrade, Serbia

ROI1.1 (#2736)

REUSABLE SOFTWARE COMPONENTS FOR ADOPTION OF ROBOTICS IN SMES

Zavisa Gordic, Nikola Knežević and Kosta Jovanović

This paper aims to present an application example of an efficient approach to the introduction of innovative and agile solutions into manufacturing small and medium enterprises (SMEs). It relies on common open platform reference architecture to develop a set of reusable and modular software components for different manufacturing applications. Designed to be versatile and reusable, these components are intended to serve as building blocks for introduction of agile and intelligent solutions into manufacturing environments. Their open-source nature enables companies to reuse previously developed functionalities, rather than starting from scratch, reducing implementation speed and related costs. The paper presents a real-world example of deployment of such reusable components in a typical scenario commonly found in manufacturing SMEs. The example examines the benefits to the company along with adoption challenges and explores the potential new use cases for the deployment of developed components.

Keywords: Robotics, Industry 4.0, Agile Manufacturing, Small and Medium Enterprises (SMEs)

ROI1.2 (#2868)

REAL-TIME OBJECT DETECTION FOR MOBILE ROBOT MANIPULATION TRAINED ON SYNTHETIC DATA FROM UNREAL ENGINE

Jovan Vasić, Lazar Milić and Mirko Rakovic

Autonomous mobile robots operating in dynamic environments, such as those encountered in robot competitions, require robust and high-speed object detection capabilities to interact effectively with their surroundings. This paper presents a system for real-time object detection for the Eurobot 2025 competition. The core of our perception system is the YOLO neural network model, selected for its proven performance in achieving a balance between speed and accuracy. A significant challenge is acquiring large, diverse, and precisely labeled datasets representative of the competition environment. To address this, we created a virtual environment in Unreal Engine to generate a synthetic labeled dataset. This allows for automated dataset generation under a wide range of controlled conditions, including varied lighting, object

poses, and environmental configurations specific to the Eurobot game table. The trained YOLO model enables the robot to reliably detect specific game objects necessary for manipulation tasks and scoring points within the competition rules. We demonstrate the viability and effectiveness of training a state-of-the-art object detection model primarily on synthetic data for a demanding real-world robotic application, highlighting the potential of high-fidelity simulation environments to accelerate the development of autonomous robot perception systems.

Keywords: Object detection, Synthetic Data, Mobile robot, Robot perception

ROI1.3 (#1380)

ADVANCING HUMAN-ROBOT COLLABORATION THROUGH EXTENDED REALITY - ASSEMBLY USE CASE

Marko Skakun, Vojislav Vujicic, Veljko Todic, Zavisa Gordic, Nikola Knezevic and Kosta Jovanovic

The evolution of Industry 5.0 promotes human-centric automation by integrating advanced technologies with user well-being and adaptability. In this context, the XR4Human-SERVE 5.0 was presented with a simplified neuroergonomic workstation that reduces the complex architecture of the SHOP4CF platform into a unified system combining an XR headset (HTC XR Elite) and a collaborative robot. The proposed solution replaces traditional multi-device setups (including PCs, EEG systems, external screens, and gesture sensors) with a single XR-based interface, preserving essential functionalities such as task guidance, human-robot interaction (HRI), and mental focus assessment (MFA). The methodology involves the functional decomposition of SHOP4CF components and their reintegration into an immersive XR environment using Unity for interface design and ROS for robot control. After virtual prototyping and validation through simulation, the system was physically implemented and tested in a laboratory setting using a Franka Emika Panda robot. The main contribution of this paper is the first functional prototype of a VR and cobot-supported neuroergonomic workstation. This paper demonstrates a viable path toward lightweight, human-centred, and scalable industrial solutions aligned with the principles of Industry 5.0.

Keywords: Industry 5.0, Extended Reality (XR), collaborative robotics, human-centered automation

ROI1.4 (#5447)

THE METHODOLOGY FOR THE DESIGN OF UNDERACTUATED ADAPTIVE ROBOTIC FINGER FOR PRECISION GRASPING TASKS

Lazar Matijašević, Živana Jakovljević, Dušan Nedeljković and Živojin Suvajac

Robotic grippers are essential components in modern automation. While traditional designs excel in the manipulation of identical objects in structured environments, they often lack the adaptability required for handling various objects in unstructured settings. This limitation has led to increased focus on adaptive solutions, with underactuated robotic hands emerging as a promising alternative that combines dexterity, mechanical simplicity, and cost efficiency. Underactuated designs use fewer actuators than degrees of freedom and rely on passive elements such as springs and mechanical limits for adaptation to object's shape. This work shows the design of a two-phalanges underactuated robotic finger actuated by a four-bar linkage and gear mechanism. The finger is intended for robotic hand used for precision grasping tasks. A methodology for

calculating optimal linkage dimensions and mechanism for adaptability are also described, as well as the method for the analysis of grasping force.

Keywords: four-bar linkage, underactuated robotic hands, precision grasping

ROI1.5 (#6794)

VISION-BASED ROBOTIC SYSTEM FOR PACKAGING LOOSE MATERIALS IN FOOD INDUSTRY - USE CASE DESIGN

Veljko Todic, Nikola Ružić, Miloš Petrović, Nikola Knežević and Kosta Jovanović

The food industry is increasingly adopting automation to enhance efficiency, reduce costs, and ensure food safety. Despite advancements, challenges such as labor shortages, food variability, and stringent hygiene standards hinder widespread robotic integration, particularly in packaging and handling tasks. This paper reviews key obstacles in automating food processing, including the need for adaptable robotic manipulators, advanced vision systems for object recognition, and specialized end-effectors capable of handling diverse food textures and shapes. We propose a vision-based robotic system for packaging loose materials, featuring the Franka Emika Panda collaborative robot, a custom-designed gripper, and a 3D depth-sensing camera for real-time object detection and manipulation. The system architecture integrates user-friendly control interfaces, modular design, and scalable automation to optimize portioning and packaging tasks. Additionally, we discuss future research directions, such as improving random bin-picking algorithms, IoT-enabled robotic systems, and cost-effective end-effector designs. Our work aims to inspire further innovation in food industry automation, bridging the gap between research and practical implementation.

Keywords: food packaging, food robotics, collaborative robots, end-effectors, vision system

ROI1.6 (#8384)

COMBINING OBJECT DETECTION AND REINFORCEMENT LEARNING FOR VISION-GUIDED ROBOTIC MINI-GOLF

Viktor Salaj, Lazar Milić and Mirko Rakovic

This paper addresses the problem of robotic arm manipulation inside a simulated mini-golf environment to successfully put the golf ball into the hole. The position of the golf ball and hole is estimated from an RGB image using a trained YOLOv8 object detection model, introducing noise in the parameters used for neural network training. A custom simulation environment is developed using PyBullet, where a robot arm based on the xArm model learns to control the position and orientation of the end-effector. The agent is trained using a Soft Actor-Critic (SAC) reinforcement learning algorithm, with the addition of a Hindsight Experience Replay (HER) to improve learning efficiency. The processing of the visual input is done in real time, and the raw image data is not stored during training. The goal of this research is to enable precise control of the robot for accurate ball striking in real-life conditions, with the broader aim of demonstrating how the combination of reinforcement learning and visual feedback can be combined to solve complex manipulation tasks.

Keywords: Reinforcement learning, robotic arm manipulation, YOLO-v8, Object detection

СЕСИЈА / SESSION (PO1+ROI2)

Понедељак, 9. јун / Monday, June 9th Сала 3 / Hall 3 15.00-16.45

Председавајући / Chair:
Aleksandar Rodić, University of Belgrade – Institute Mihajlo Pupin, Belgrade, Serbia

ROI2.1 (#5011)

ADDITIVE TECHNOLOGIES IN THE SERVICE OF ADVANCED ROBOTICS AND VICE VERSA (INVITED PAPER)

Miloš Pjević

For decades, since the introduction of the first industrial robot, Unimate, achieving a harmonious balance between performance and feasible robotic design has been essential. Manufacturing limitations, material availability, and sensor and actuator systems have significantly influenced robotic system design. However, since their commercial debut in 1986, additive manufacturing (AM) technologies have been revolutionizing how once-unimaginable ideas are designed, presented, and ultimately produced. This paper explores the achievements in additive manufacturing with a special focus on its application in advanced robotics. A detailed classification of existing additive technologies is presented, along with a comprehensive review of their advantages in specific robotic applications. The growing role of additive technologies in expanding robotics across industries is also discussed...

Keywords: Additive Technologies, Advanced Robotics, 3D printing, Manufacturing

ROI2.2 (#5953)

MULTI BODY DYNAMICS SIMULATION OF THE OFF-ROAD ROBOTIZED VEHICLE IN THE ROBOSHEPHERD SYSTEM

Miša Tomić, Miloš Simonović, Vukašin Pavlović, Miloš Milošević, Nikola Vitković and Milan Banić

The progress of modern technology can make robots more useful, more efficient and applicable in different areas. Swarm robots, which are autonomous, cooperative, self-organized, and coordinated groups of robots, are one of the rapidly expanding areas of robotics. There are many different swarm robots examples in the industry, as well as in scientific research, and every robotic unit in most of these examples is not physically connected to other robotic units. There are much fewer examples of a group of robots where there is some physical connection in the form of a rope or tow link between two robots. Connecting several robots by wire or rope, where a wire is maintained to be tightened, can form moving fence. This system can be used as an autonomous system for herd keeping and breeding - RoboShepherd. Dynamics of such robotic system can be complex. This paper presents multi body dynamics simulation of the off-road robotized vehicle in the RoboShepherd system.

Keywords: mobile robot, multi body dynamics, simulation

ROI2.3 (#3957)

USE OF A GENETIC ALGORITHM TO DETERMINE THE OPTIMAL PATH FOR THE AUTONOMOUS MOBILE ROBOT

Nastasija Nikolić, Carlo Caiazzo, Ivan Mačužić, Osmo Kauppila, Arso Vukićević and Marko Djapan

Up to 60 percentages of realized costs in warehouses can be attributed to the collection of ordered products. As the use of robots expands, the research aims to reduce operating costs and make robots more efficient in warehouses. In this regard, it is necessary to optimize the robot's path in the warehouse. The emphasis is on Autonomous Mobile agents, a type of intelligent vehicle that can perceive its environment. Autonomous Mobile Robot path planning is formulated as a Travelling Salesman Problem. In the paper, the goal of Travelling Salesman Problem is to minimize travel distance. Due to the problem's complexity, the robot's path was planned using a Genetic Algorithm. The optimal path is determined in the warehouse where certain products need to be loaded and delivered for further transport.

Keywords: Autonomous Mobile Robot, Genetic Algorithm (GA), Travelling Salesman Problem (TSP)

RO1.1 (#2194)

KAKO NAUČITI ROBOTA DA REŠAVA IGRU SLAGALICA

Jelena Ilić, Natalija Dimitrijević and Aleksandar Rodić

Sve veća složenost industrijskih procesa i pomeranje ka automatizaciji zahtevaju inteligentne, adaptivne robotske sisteme sposobne da obavljaju kognitivne i vizuomotorne zadatke u dinamičnom okruženju. Ovaj rad predstavlja zadatak sklapanja slagalice-puzli kao ilustrativnu paradigmu za implementaciju ovakvih sistema u industriji. Sklapanje slagalica, koje se često smatra kognitivnom igrom, oponaša mnoge karakteristike koje se nalaze u industrijskim zadacima: velika varijabilnost, nestrukturirana okruženja, potreba za vizuelnim prepoznavanjem, donošenjem odluka, finom manipulacijom i planiranjem putanje. U radu se istražuje kako se veštačka inteligencija, računarski vid, mašinsko učenje, sistemi zaključivanja i planiranje kretanja robota konvergiraju da bi stvorili sisteme koji su sposobni da se nose sa zadacima sa sličnim kognitivnim i manipulativnim izazovima u industrijskim okruženjima

Ključne reči: kognitivni roboti, vizuelno-motorna maniplacija, veštačka inteligencija

RO1.2 (#4198)

SINTEZA KOLABORATIVNE SVESTI KOD ROBOTA

Aleksandar Rodić

Rad se bavi uvođenjem veštačke inteligencije u upravljačku arhitekturu kolaborativnih robota (kobotova) kako bi se poboljšala interakcija čoveka i robota u industriji, posebno u proizvodnim okruženjima sa niskim obimom i visokom prilagodljivošću. Sistem koristi višemodalni interfejs sa dubinskim kamerama, senzorima pokreta i fiziološkim indikatorima za stalno praćenje psihofizičkog stanja radnika - umora, stresa, dekoncentracije ili zdravstvenih problema. Fazi sistem zaključivanja analizira te podatke i određuje stanje radnika na skali od 0 (bezbedno) do 1 (kritično), omogućavajući kobotu da u realnom vremenu prilagodi ponašanje: upozori radnika, smanji brzinu izvršavanja zadatka ili preuzme deo kognitivno-fizičkog opterećenja. Kobot je umrežen sa digitalnim radnim okruženjem i ima pristup proizvodnim planovima, tehničkoj dokumentaciji i

operativnim podacima. Prikazan sistem povećava bezbednost, efikasnost i produktivnost u fleksibilnoj proizvodnji.

Ključne reči: kolaborativni roboti, AI, veštačka svest

ВЕШТАЧКА ИНТЕЛИГЕНЦИЈА / ARTIFICIAL INTELLIGENCE

СЕСИЈА / SESSION (ВИ1+VII1)

Уторак, 10. јун / Tuesday, June 10th Сала 3 / Hall 3 9.00-10.45

Председавајући / Chair:
Miljan Vučetić, Vlatacom Institute of High Technology, Belgrade, Serbia
Nemanja Ilić, Vlatacom Institute of High Technology, Belgrade, Serbia

VII1.1 (#4235)

APPLIED METAHEURISTIC OPTIMIZATION: TUNING LIGHT GRADIENT-BOOSTING MACHINE FOR INSIDER THREAT DETECTION

Vuk Kostic, Luka Jovanovic, Sasa Adamovic, Vico Zeljkovic, Miodrag Zivkovic and Nebojsa Bacanin

This work investigates the fusion of NLP and the LightGBM classifier to build a resilient insider-threat detection framework, with a particular emphasis on inspecting HTTP traffic in organizational networks. HTTP payloads are transformed into numerical vectors via the TF-IDF method using an openly accessible insider-threat corpus. To optimize LightGBM's hyperparameters, an NP-hard challenge, a range of modern metaheuristic measures is compared, culminating in the adoption of the WOA variant, specially adapted for this application. The optimized LightGBM model surpasses 97.62 classification accuracy, underscoring its viability for deployment in real-world cybersecurity contexts. Beyond overcoming existing shortcomings in insider-threat analytics, this study establishes a foundation for future enhancements and suggests that the customized WOA approach can be extended to other critical security problems.

Keywords: Cybersecurity, Insider threat, Optimization, Hyperparameter Tuning, Whale optimization algorithm

VII1.2 (#4297)

COMPARATIVE ANALYSIS OF FEATURE SELECTION TECHNIQUES FOR DETECTING LOW-RATE DDOS ATTACKS IN IOT NETWORK

Dušan Drinić, Marija Novičić and Goran Kvaščev

With the rapid development of modern technologies and devices, there has been an expansion in the application of Internet of Things (IoT) networks across various domains. As the presence of these networks increases, so do the associated security risks. Given that the devices constituting these networks are vulnerable in terms of resource usage, a significant threat arises from attacks such as Low-Rate Distributed Denial of Service (LR-DDoS), which often go undetected by traditional security systems. This paper presents and analyzes a method for detecting LR-DDoS attacks within IoT networks, utilizing the advanced Extreme Gradient Boosting (XGBoost) algorithm and optimizing parameter selection through different feature selection techniques. The results

show no significant decrease in classification performance on reduced dataset comparing to the full dataset.

Keywords: low-rate DDoS, XGBoost, IoT, feature-selection

VII1.3 (#5077)

ML-DRIVEN PREDICTION OF OPTIMAL CONTROL FLOW GRAPH TRAVERSAL ALGORITHM IN MODERN APPLICATIONS

Milan Čugurović, Ivan Ristović, Strahinja Stanojević, Marko Spasić, Vesna Marinković and Milena Vujošević Janičić

Control flow graph models program execution paths and is essential for program analysis and compiler optimizations. Compilers traverse thousands of graphs during compilation, thus, efficient control flow graph traversal is crucial. Prior work shows that breadth-first and depth-first search algorithms can perform differently depending on the graph structure, but the impact of graph features on the choice of the traversal algorithm remained underexplored. In this paper, we construct a dataset of over 200,000 control flow graphs extracted from modern JVM-based applications and train an ensemble-based machine learning model to predict the optimal graph traversal algorithm using only a set of lightweight graph features. Our model identifies the key features that drive accurate predictions, and we demonstrate that these informative features can be efficiently extracted during control flow graph construction.

Keywords: compilers, machine learning, control flow graphs, graph traversals, GraalVM

VII1.4 (#7206)

CLASSIFICATION OF EMPLOYEE PROMOTION DATASET USING NAÏVE BAYES, J48, AND RANDOM FOREST ALGORITHMS

Ljubica Plazinić, Vanja Lukovic and Sanja Antic

This paper focuses on analyzing employee promotion in organizations using machine learning, with a particular emphasis on the Naïve Bayes, J48, and Random Forest algorithms. The research aims to compare the performance of these algorithms in the context of predicting employee promotions. The experiments were conducted in the Weka software environment, and the results were evaluated using accuracy, precision, and recall metrics. The paper also examines the characteristics of the selected algorithms and their ability to interpret data.

Keywords: Machine learning, data classification, employee promotion, Weka, Naïve Bayes, J48, Random Forest

VII1.5 (#2551)

DEVELOPMENT OF A SYSTEM BASED ON DEEP LEARNING FOR FACE AND HAND GESTURE RECOGNITION

Branislav Ristic, Dinu Dragan, Veljko Petrović and Dusan Gajić

This paper presents an implementation of an inte-grated face and hand gesture recognition system. The presentedsystem is developed using Python and employs the MediaPipelibrary for robust hand gesture detection and leverages theDeepFace library for facial recognition and sentiment analysis.The proposed solution is designed to enable natural, nonverbalhuman-machine interaction through gesture-based and visualsignal inputs. We first discuss some necessary fundamentalsof machine learning and neural networks and then offer ashort overview of the technologies used for implementation.We

describe data processing workflows, memory managementstrategies, and algorithmic optimizations. We show that theproposed solution offers flexibility, accuracy, adaptability, anduser privacy, also leaving some room for future enhancements.

Keywords: deep learning, computer vision, face recognition, gesture recognition, sentiment analysis

VII1.6 (#7006)

MACHINE LEARNING-BASED VISUAL LOCALIZATION OF A MOVING OBJECT, TRAJECTORY CONSTRUCTION, AND DEVELOPMENT OF FORECASTING HARDWARE AND SOFTWARE

Vazgen Melikyan, Mushegh Grigoryan, Tigran Khachatryan, Eduard Harutyunyan, Arthur Mkhitaryan and Sargis Azizbekyan

This paper explores the application of ML techniques for visual localization, trajectory prediction, and development of FPGA-based forecasting hardware and software. Integrating computer vision with real-time data processing, the proposed system addresses challenges in dynamic environments, enhancing accuracy and efficiency. The proposed methodology leverages dual-modality drone detection using parallel RGB and infrared processing pipelines, providing a comprehensive framework that combines robust YOLO models, efficient FPGA implementations, and scalable architectures for real-world applications. By integrating two specialized YOLO models - one for RGB and one for IR imagery the system achieves high accuracy and performance even in challenging scenarios such as occluded or GPS-denied environments.

Keywords: Visual localization, trajectory prediction, machine learning, FPGA, forecasting, hardware, real-time systems, dual-modality drone detection

VII1.7 (#9096)

COMPARATIVE ANALYSIS OF MACHINE LEARNING AND FEDERATED LEARNING IN HEALTHCARE

Stevan Stankovic, Pavle Vuletic and Drazen Draskovic

With the rapid development of artificial intelligence in healthcare, machine learning and federated learning have emerged as critical technologies for improving decision-making, diagnostics and personalized treatments. This paper presents a comprehensive comparison between traditional machine learning and a newer federated approach, focusing on their applications in healthcare. Even though machine learning provides great efficiency in resolving complex tasks in healthcare, it faces significant challenges such as data privacy, security and communication cost. In contrast, federated learning offers a decentralised approach which resolves these limitations and allows healthcare institutions to collaboratively train models across multiple devices and locations without sharing sensitive patient data. The experiment conducted in this study utilized a medical dataset to predict whether an individual is an alcohol consumer or not. A range of metrics, including loss, accuracy, precision, recall, AUC, and F1 score, were employed to evaluate and compare the performances of both approaches. By leveraging this technique, federated learning addresses privacy concerns, while maintaining high model performance across distributed datasets. Experiments conducted on healthcare datasets highlight the strengths, challenges and limitations of both machine and federated learning in practical, real-world scenarios.

Keywords: Federated Learning, Machine Learning, Healthcare

VII1.8 (#8422)

APPLICATION OF ARTIFICIAL INTELLIGENCE IN PERSONALIZED LEARNING

Andrijana Gaborović, Marija Nikolić and Vesna Ružičić

Artificial Intelligence (AI) is playing a key role in transforming education, enabling personalized learning tailored to students' individual needs. This paper explores how AI technologies, such as machine learning, data analytics, and adaptive systems, enable the adaptation of teaching content, pace of learning, and teaching methods. Through intelligent tutoring systems, recommended algorithms, and learning analytics, AI can improve student engagement, identify weaknesses, and optimize educational strategies. Apart from the advantages, the paper also analyzes the challenges of applying AI in education, including ethical dilemmas, data protection and the need for pedagogical adaptation. It is concluded that the application of AI in personalized learning brings significant benefits, but requires careful planning and integration into educational systems

Keywords: artificial intelligence, personalized learning, machine learning, adaptive systems, educational technology

СЕСИЈА / SESSION (VII2+VI1)

Уторак, 10. јун / Tuesday, June 10th Сала 3 / Hall 3 15.00-17.15

Председавајући / Chair:
Miljan Vučetić, Vlatacom Institute of High Technology, Belgrade, Serbia
Nemanja Ilić, Vlatacom Institute of High Technology, Belgrade, Serbia

VII2.1 (#0086)

EXPLORING N-SHOT LEARNING APPROACHES IN GENERATIVE LARGE LANGUAGE MODELS FOR THE SERBIAN LANGUAGE

Nikola Djordjevic and Suzana Stojkovic

Fine-tuning large language models for a specific task requires a lot of resources and time. Also, to successfully fine-tune the model, we need to have a high-quality dataset. The lack of fine-tuning datasets is particularly present in low-resource languages, such as Serbian. Therefore, there is a need to examine other approaches for adapting a large language model to a specific task. In this paper, we investigated the N-shot learning capabilities of generative models for sentiment analysis of reviews in the Serbian language. We used two models for N-shot learning - the non-open-source GPT-4o and the open-source Mistral model. We fine-tuned the BERTić model and tested it on the same test set for comparison purposes. The GPT-4o model achieved excellent results, slightly better than the BERTić model. It turned out that the Mistral model lags behind the GPT-4o model and the standard BERTić fine-tuning.

Keywords: Large Language Models, N-shot learning, Fine-tuning, Sentiment analysis

VII2.2 (#3289)

A COMPARISON OF NAMED ENTITY RECOGNITION EVALUATION FRAMEWORKS

Aleksandra Todorović, Vuk Batanović and Lenka Bajčetić

Although the task of Named Entity Recognition is a popular one in Natural Language Processing, there is no universally accepted evaluation framework for it, making it difficult to analyze and compare the results of different models. This paper presents a comparison between the most common Python libraries for Named Entity Recognition performance evaluation: scikit-learn, seqeval, and nervaluate. We design a set of error probes based on common Named Entity Recognition error types and use it to compare the features and analyze the evaluation outputs of the three frameworks. Our findings highlight that framework selection is use-case dependent: seqeval is preferable when strict boundary adherence is critical, nervaluate offers more leniency towards boundary errors and provides better reporting of error types, and scikit-learn, while useful for the overall metrics, provides less detailed feedback on errors involving multi-token entities.

Keywords: Named Entity Recognition, evaluation, scikit-learn, seqeval, nervaluate

VII2.3 (#3821)

BERT-BASED IMPLEMENTATION OF THE SERBIAN LANGUAGE POS TAGGER

Nikola Vukotić and Suzana Stojković

This paper presents a BERT-based POS tagger for the Serbian language. It compares three transformer models: BERTić—pre-trained on South Slavic corpora—and two Jerteh models (Jerteh-81 and Jerteh-355), both based on RoBERTa, a refined version of BERT. The models were fine-tuned on a simplified, corrected version of the SrWaC corpus using 96 POS tags. Over 20 experiments explored different hyperparameter configurations. Jerteh-355 achieved the best results with 95.88% accuracy and an F1 score of 0.959, while Jerteh-81 offered a good trade-off for low-resource environments. The findings confirm the effectiveness of transformer-based approaches for Serbian and suggest directions for future work, including full tagset integration and post-processing techniques.

Keywords: Serbian language POS tagger, BERT, BERTić, Jerteh-81, Jerteh-355

VII2.4 (#0390)

ROUTE-BASED GEOSPATIAL CLUSTERING WITH UNSUPERVISED MACHINE LEARNING

Veljko Lončarević and Željko Jovanović

Smartphones equipped with GPS and accelerometer sensors enable large-scale collection of spatiotemporal data, which can be leveraged for transportation research and urban analysis. In this study, the clustering of geospatial data collected along the route from Čačak to Kragujevac, Serbia, using an Android-based mobile application is investigated. The dataset comprises longitude, latitude, time, and speed attributes, enabling the identification of movement patterns through clustering techniques. DBSCAN and K-Means algorithms are applied to group data points based on location and visualize the resulting clusters using Folium maps. The findings provide insights into travel behavior and variations in movement dynamics.

Keywords: geospatial data, clustering, DBSCAN, K-Means, transportation research

VII2.5 (#0542)

DATA-DRIVEN FORECASTING OF PV MAXIMUM POWER POINT BASED ON ENVIRONMENTAL PARAMETERS USING MACHINE LEARNING

Nemanja Pudar, Ivana Radonjić, Ilija Knežević and Milutin Petronijević

In this paper the prediction of maximum power output (Pmpp) from photovoltaic (PV) panels using machine learning techniques, based on data collected at the Faculty of Sciences and Mathematics, University of Niš is presented. The experimental setup consist of three monocrystalline PV panels mounted at three different tilt angles (0°, 32°, and 90°). Meteorological data such as irradiance, temperature, wind speed, and wind direction were used as inputs, while the maximum power (Pmmp) was predicted. Support Vector Regression (SVR) and Artificial Neural Network (ANN) were trained and tested using this dataset. Both models performed well, while the SVR model achieved slightly higher prediction accuracy, particularly in capturing rapid fluctuations in power output, as confirmed by multiple regression metrics.

Keywords: Photovoltaics, maximum power output, Support Vector Regression, Artificial Neural Network

VI1.1 (#5550)

PRIMENA FEDERATIVNOG UČENJA U PREDIKCIJI AKTIVNOSTI STUDENATA NA E-LEARNING KURSEVIMA

Marko Živanović and Danijela Milošević

Ovaj rad istražuje primenu federativnog učenja (Federated Learning, FL) u predikciji poseta kursevima na osnovu log zapisa interakcija studenata. FL omogućava treniranje modela na distribuiranim podacima bez njihove centralizacije, čime se poboljšava privatnost i sigurnost. Istraživanje obuhvata tri klijenta koji predstavljaju različite kurseve (Veštačka inteligencija, Operativni sistemi i Računarski hardver) i koristi LSTM neuronske mreže za vremensku predikciju broja poseta. Modeli se treniraju lokalno na svakom klijentu, dok se agregacija parametara vrši na centralnom serveru pomoću FedAvg algoritma. Performanse FL modela upoređene su sa centralizovanim modelima koristeći R^2 Score. Rezultati pokazuju da FL može postići konkurentne rezultate uz značajne prednosti u zaštiti privatnosti podataka. Ovaj rad doprinosi analitici učenja i otvara mogućnosti za dalja istraživanja primene FL u obrazovanju.

Ključne reči: Federativno učenje, Predikcija poseta kursevima, LSTM, Analitika učenja, Zaštita privatnosti

VI1.2 (#1801)

MODEL RASPLINUTE EVALUACIJE KVALITETA SOFTVERSKOG SISTEMA ZASNOVAN NA FUZZY LOGICI

Marko Živanović and Olga Ristić

Abstract— U ovom radu predstavljena je metodologija za evaluaciju kvaliteta veb sajtova akademskih i državnih institucija iz svih šest republika bivše SFRJ korišćenjem alata iz oblasti veštačke inteligencije, konkretno fuzzy logike. Razvijen je sistem za automatsku procenu performansi sajtova na osnovu tri ključna parametra: vreme učitavanja stranice, veličina stranice i broj HTTP zahteva. Na osnovu ovih ulaznih vrednosti, fuzzy kontrolni sistem generiše ocenu kvaliteta sajta na skali od 0 do 10, uz proces defazifikacije. U evaluaciju su uključeni sajtovi univerziteta, ministarstava,

naučnih instituta i agencija, čime se pruža sveobuhvatan uvid u tehnički kvalitet javno dostupnih digitalnih resursa u regionu. Pored numeričke ocene, sistem omogućava i vizualizaciju pripadnosti ulaznih vrednosti fuzzy skupovima, čime se dodatno objašnjavaju uticaji pojedinačnih faktora na ukupnu ocenu. Rezultati ukazuju na značajne razlike u tehničkoj optimizaciji analiziranih sajtova, čime se otvara prostor za buduća unapređenja u dizajnu i implementaciji veb prezentacija institucija od javnog značaja.

Ključne reči: fuzzy logika, evaluacija sajta, AI, optimizacija, državne institucije, performanse sajta, SEO, HTTP

AKTUELNOSTI U OBRAZOVANJU U ELEKTROTEHNIČKOM I RAČUNARSKOM INŽENJERSTVU / EDUCATION

СЕСИЈА / SESSION (ЕДУ1+EDUI1)

Понедељак, 9. јун / Monday, June 9th Сала 6 / Hall 6 9.00-10.45

Председавајући / Chair:
Jelica Protić, Univerzitet u Beogradu – Elektrotehnički fakultet, Beograd, Srbija

EDU1.1 (#0176)

TRANSFERZALNE KOMPETENCIJE INŽENJERA ELEKTROTEHNIKE: DOPRINOSI UNIVERZITETSKOG OBRAZOVANJA

Dragana Bjekić, Milica Stojkovic and Milena Damnjanović

Za uspešno poslovno delovanje inženjerima elektrotehnike i računarstva su potrebne kompetencije van okvira stručnih kompetencija. Komunikacione kompetencije i preduzetničke kompetencije, kao posebno važne transferzalne kompetencije, pregledno su prikazane u radu, a potom je izvršena analiza koliko su studijski programi u ovom području formativni za razvoj ovih kompetencija. Za izabranih 10 (od 49) studijskih programa u ovoj oblasti koji se realizuju u četiri EU države u susedstvu, i za 12 studijskih programa u ovoj oblasti na šest fakulteta u Srbiji, utvrđeno je da se na 20 programa realizuju, uglavnom kao izborni, predmeti iz oblasti poslovne komunikacije i preduzetničkog menadžmenta. Na osnovu zastupljenosti ovih predmeta, i potreba budućih inženjera, naglašeno je da u studijskim programima treba da se predvide ishodi, predmeti i aktivosti koji će da osnaže transferzalne kompetencije studenata potrebne za efikasnost u poslovnom okruženju.

Ključne reči: Transferzalne kompetencije, komunikacione kompetencije, preduzetničke kompetencije, inženjeri elektrotehnike i računarstva

EDU1.2 (#0384)

MASTER STUDIJSKI PROGRAMI IZ BIOINFORMATIKE U SRBIJI I SVETU

Lazar Smiljković, Marko Misic and Jelica Protic

U poslednje dve decenije, bioinformatika se razvila u važnu naučnu oblast koja spaja biološke podatke i informacione tehnologije kako bi rešavala složene biološke i medicinske probleme. U vezi sa tim postoji značajan rast potražnja za stručnjacima u ovoj oblasti. Prateći taj trend, akademski institucije širom sveta prilagođavaju svoje

kurikulume zahtevima tržišta rada, nastojeći da usklade osnovna znanja, računarske veštine i interdisciplinarni pristup. U okviru ovog rada se ispituju master programi bioinformatike na univerzitetima širom sveta, analizirajući kompetencije, strukturu kurikuluma, nastavne metode i praktičan rad. Rezultati pokazuju značajne razlike među postojećim programima, s posebnim naglaskom na projektno učenje, praktičnu primenu i povezivanje sa industrijom i kliničkom praksom. Ovi nalazi predstavljaju temelj za kreiranje novog master programa bioinformatike u Srbiji, koji bi kombinovao najbolje globalne prakse sa specifičnim lokalnim potrebama.

Ključne reči: bioinformatika, edukacija, master studije

EDUI1.1 (#3039)

APPLIED AI, TEAMWORK, AND LEARNING IN STUDENT HACKATHONS: CASE STUDY FROM SERBIA

Vanja Milutinović, Jelica Cincović, Vladimir Jocović and Dražen Drašković

Student hackathons have emerged as a dynamic educational mechanism for fostering creativity and accelerating the adoption of new technologies among Computer Science and Software Engineering students. First introduced in university settings in the early 2000s, hackathons have evolved into highly engaging events where students compete to develop innovative software or hardware solutions within a limited time frame. The competitive spirit inherent to hackathons resonates strongly with today's engineering students, motivating them to push boundaries, solve real-world problems, and collaborate effectively under pressure. Participation in hackathons enhances students' technical skills, promotes teamwork, and deepens their understanding of modern tools, frameworks, and platforms not always covered in formal curricula. Over the past five years, hackathons have gained remarkable popularity in Serbia, especially at state faculties and through active student organizations. Many of these events are organized in partnership with recognized ICT companies, providing students with valuable exposure to industry standards and expectations. At the University of Belgrade, the students' programmers' club, within the Google Developer Group network, has successfully hosted numerous hackathons that have become key platforms for skill development and innovation. These events not only contribute to academic growth but also significantly enhance students' employability and entrepreneurial thinking.

Keywords: student hackathon, programming competition, teamwork, innovation, creativity

EDUI1.2 (#7912)

EXPLORING AI TOOLS IN EDUCATION: ANALYZING BENEFITS, CHALLENGES, AND STUDENT ENGAGEMENT

Nikola Stanic, Andrijana Gaborović, Katarina Karić and Jelena Plašić

Artificial Intelligence (AI) tools are transforming education by enhancing learning, improving efficiency, and supporting educators. This paper explores AI-powered educational tools, analyzing their benefits, challenges, and impact on learning. Key applications, such as personalized learning platforms, intelligent tutoring systems, automated grading, and content generation, are evaluated for effectiveness and limitations. A survey of Information Technology students at the Faculty of Technical Sciences in Čačak shows a high level of familiarity and use of AI tools, with most students viewing them as beneficial. However, concerns about misinformation, over-reliance, and ethics highlight the need for responsible AI integration. The paper suggests strategies for incorporating AI into education, emphasizing transparency, ethics, and

guidance. By ensuring a structured approach, AI can complement education without replacing critical thinking and problem-solving skills.

Keywords: AI tools, education, critical thinking, artificial intelligence

EDUI1.3 (#7185)

DC MACHINE WINDING GEOGEBRA APPLICATION

Miroslav Bjekić, Marko Rosić and Darko Miljojković

The paper describes a GeoGebra application that demonstrates the winding configuration of a DC motor armature. The application calculates winding steps, generates winding tables and developed winding diagrams, as well as the number, position, and width of brushes for eight distinct winding types (Lap or Wave, Two-layer or One-layer, Progresive-right or Retrogressive-left). It also offers the visualization of simplex and multiplex windings. The application improves the understanding of the DC machine winding design and construction process, aiding students in more effectively mastering electrical machines course material.

Keywords: GeoGebra, DC machine, Armature winding, Educational software

EDUI1.4 (#0004)

ABSTRACTS AS ACCEPTANCE CRITERIA IN SCIENTIFIC RESEARCH: A STUDY OF THE 68TH ETRAN CONFERENCE PROCEEDINGS

Marina Katic, Jelisaveta Šafranj and Jelena Zivlak

This paper aims to examine whether the authors of abstracts from Proceedings of the 68th ETRAN conference adhered to Hyland's model when composing their abstracts. It employs both quantitative and qualitative analyses of the abstracts to identify and evaluate the presence of each of the five "moves" in Hyland's model—Introduction, Goal, Methodology, Product, and Conclusions—across 21 sections of the Proceedings. The results of this research indicate that two-thirds of the analyzed abstracts demonstrated average (1 section) or above-average (13 sections) compliance with the established criteria within the Serbian language community. In contrast, one-third of the abstracts (7 sections) fell below the average compliance level. In conclusion, this research offers recommendations for future authors to improve the quality of their abstracts and contribute to better visibility and impact of their scientific works.

Keywords: conference abstract moves, Hyland's model, Proceedings of the 68th ETRAN conference

EDUI1.5 (#7520)

THE IMPORTANCE OF ELECTIVE COURSES FOR IT STUDENTS IN THE FUNCTION OF PROFESSIONAL GUIDANCE

Ana Veljić, Srđan Maričić and Goran Jocić

Contemporary higher education is developing on the basis of Bologna declaration and the concept of „lifelong learning“. Characteristics of the previously mentioned are visible in the joint efforts of all the participants involved (teaching staff and students) to improve quality of education and create content adequate for the needs of the market. Burgeoning usage of technology in day-to-day life increased demand for Information Technology (IT) engineers, which resulted in many universities accrediting IT study programs. Versatile usage of technology initiated the development of multidisciplinary programs

so that engineers could apply their field of studies to any area, moreover, they become competitive experts in the labor market. Provided numerous directions of business and diverse needs and aspirations of students, universities introduced elective courses.

Keywords: Bologna declaration, lifelong education, elective classes, IT engineer

EDUI1.6 (#4660)

AN OVERVIEW OF SUPERVISED LEARNING TECHNIQUES IN CONTEMPORARY EDUCATIONAL TECHNOLOGIES

Veljko Aleksić

The rapid advancement of artificial intelligence has catalyzed significant transformations in educational technology, enabling more personalized, adaptive, and data-driven approaches to teaching and learning. The paper examines the theoretical foundations and practical applications of various supervised learning algorithms. The analysis reveals that these techniques offer powerful tools for predicting student performance, automating assessment processes, identifying at-risk students, and personalizing learning. However, their implementation faces challenges related to data quality, model interpretability, and algorithmic bias. The review contributes to the growing body of knowledge on AI in education by synthesizing current research, identifying implementation challenges, and proposing pathways for responsible and effective integration of supervised learning techniques in educational contexts.

Keywords: supervised learning, educational technology, artificial intelligence, algorithms, students

PRIDRUŽENA SESIJA – FORENZIKA

СЕСИЈА / SESSION (FO1)

Среда, 11. јун / Wednesday, June 11th Сала 1 / Hall 1 9.00-10.45

Председавајући / Chair:
Radovan Radovanović, Kriminalističko-policijski univerzitet, Beograd, Srbija

PS-FO1.1 (#7643)

DIGITALNA FORENZIKA U SAVREMENOM SVETU: OD SAJBER NAPADA DO SUDNICE (POZVANO PREDAVANJE)

Slađana Pantelić

U digitalno doba, kada se veliki deo našeg privatnog i poslovnog života odvija putem tehnologije, digitalna forenzika postaje ključna alatka u borbi protiv sajber kriminala. Ovo predavanje osvetljava ulogu digitalne forenzike u savremenom društvu – od prvih koraka u otkrivanju i analizi sajber napada, pa sve do upotrebe digitalnih dokaza u pravnim postupcima. Biće reči o osnovnim principima digitalne forenzike, vrstama digitalnih tragova, tehnikama prikupljanja i očuvanja dokaza, ali i izazovima sa kojima se forenzičari suočavaju u okruženju koje se brzo menja. Poseban akcenat biće stavljen na aktuelne pretnje, forenziku u cloud i mobilnim sistemima, kao i na značaj zakonodavnog okvira i etike u forenzičkoj praksi.

Ključne reči: digitalna forenzika, sajber napadi, digitalni dokazi, forenzička analiza, prikupljanje i očuvanje dokaza, pravni postupci, etika, zakonodavni okvir

PS-FO1.2 (#4548)

ADAPTATION OF SAMPLE RADIATION TO ENVIRONMENTAL CONDITIONS

Dragan Knežević, Milja Knežević and Milesa Srećković

Based on the analysis of the mimicry properties found in natural organisms, an experimental model was developed to adapt to the immediate environment with respect to thermal radiation. This paper presents the results obtained from a simplified reference surface model and corresponding covers composed of various materials, tested against different background samples.

Keywords: mimicry, temperature, radiation, suppression, attenuation, background, cover

PS-FO1.3 (#6153)

NON-INVASIVE RECORDING OF CIRCULATORY SYSTEM

Milja Knežević, Dragan Knežević and Milesa Srećković

In this review, methods for noninvasive in vivo imaging of the circulatory system including both blood and lymphatic flow are presented. Given that many diseases impact the circulatory system, this paper outlines recent advances in preclinical imaging, with a focus on the development of novel tracers, innovative tracer delivery techniques, and emerging imaging modalities.

Keywords: noninvasive imaging, in vivo, blood flow, lymph flow, laser, ultrasound, magnetic resonance, positron emission, diffuse correlation spectroscopy

PS-FO1.4 (#9486)

INTERNET INTELIGENTIH UREĐAJA TEHNIČKE BEZBEDNOSTI U KAZNENO-POPRAVNIM USTANOVAMA U PODRŠCI PROCESU ODLUČIVANJA U BEZBEDNOSNO INCIDENTNIM SITUACIJAMA

Kristijan Đujić, Martin Matijašević, Radovan Radovanovic and Saša Milić

U radu se analizira internet inteligentnih uređaja tehničke bezbednosti u ustanovama za izvršenje krivičnih sankcija u podrški procesu odlučivanja u bezbednosno incidentnim situacijama. Ustanove za izvršenje krivičnih sankcija po svojoj funkciji su mesta sa visokim rizikom od bezbednosno incidentnih situacija. Inteligentni uređaji tehničke bezbednosti su strukturisani u uređaje za video nadzor i perimetrijsku zaštitu, uređaje za održavanje veze, uređaje za otkrivanje i prepoznavanje nedozvoljenih metalnih predmeta, sisteme za kontrolu pristupa i idetifikaciju, sisteme detekcije požara i sisteme mehaničke zaštite, čijom integracijom sistem tehničke bezbednosti čini funkionalnu celinu. Integracija ovih sistema treba da pomogne strategijskom i top nivou bezbednosnog menadžmenta u procesu odlučivanja u uslovima bezbednosno incidentnih situacija.

Ključne reči: zavodi, tehnički, bezbednost, inteligentni, sistem, incidenti

PS-FO1.5 (#5523)

ПРОЦЕНА БАЛИСТИЧКЕ ЗАШТИТЕ ВИШЕСЛОЈНОГ КОМПОЗИТНОГ ПАНЕЛА

Селена Срећковић, Радован Радовановић and Невена Пуач

Испитане су балистичке перформансе композитних материјала кроз две студије случаја у циљу избора материјала у погледу балистичке заштите. У првој,

процењене су балистичке перформансе вишеслојног композитног панела (MAC) са предњом керамичком плочицом, праћеном ламинатом који садржи 50 % епоксидне матрице ојачане тканином и легуром алуминијума. Резултати указују на то да је композитни панел који садржи 40 % епоксидне матрице ојачане тканином и легуром алуминијума, боља алтернатива у односу на кевлар. У другој, испитана је балистичка ефикасност ламинарног композита, сендвич форме два панела композитног материјала и међуслој арамидне тканине. Резултати су показали да произведени панцир спречава продор пројектила калибра 9 mm и омогућава његову потенцијалну употребу, а након испитивања оружјем дуге цеви долази до трајног деформисања панела (оружје 5,56 mm и зрно 7,62 mm), због чега се примена истог у војним операцијама не препоручује.

Кључне речи: балистичке перформансе, дубина пенетрације, композитни материјали

PS-FO1.6 (#7736)

UTICAJ ČAURA, ZRNA I BARUTNIH ČESTICA NA TLO ZEMLJIŠTA

Sara Petković, Radovan Radovanović and Zoran Milanović

This paper presents an overview of the most modern methods in soil sample analysis: an X-ray fluorescence spectrometer for lead detection and an X-ray diffraction device for the detection of hydrocerussite minerals. The basic parameters related to shells, projectiles, powder particles and soil are briefly explained. Then, the impact of cartridges, projectiles and powder particles on the soil due to their decomposition and deposition is stated. The aim of this research paper is to point out the importance of finding new methods for comparative forensic analysis of traces. The analyses will show how the results contribute to more efficient work of forensic scientists in solving crimes.

Кључне речи: чауре cartridges, пројектили projectiles, барутне честице gunpowder particles, олово lead, хидроцерусит hydrocellusite, земљиште soil, анализе analysis

PRIDRUŽENA SESIJA - HERITOLOGIJA

СЕСИЈА / SESSION (HE1)

Уторак, 10. јун / Tuesday, June 10th Сала 6 / Hall 6 16.00-17.15

Председавајући / Chair:
Magdalena Dragović, Univerzitet u Beogradu – Građevinski fakultet, Beograd, Srbija

PS-HE1.1 (#9912)

SRPSKI SREDNJEVEKOVNI MANASTIR SOPOĆANI: GEOMETRIJSKE PROPORCIJSKE ANALIZE U DIGITALNOM OKRUŽENJU (POZVANI RAD)

Magdalena Dragović

Katolikon manastira Sopoćani je jedan od najznačajnih objekata graditeljske kulturne baštine Srbije iz doba vladavine Nemanjićke dinastije. U arhitektonskom smislu crkva nosi nosi obležja Raške arhitektonske škole, sa karakterističnim postupnim izmena prostorne koncepcije kroz vreme, čiji je vrhunac ovde dosegnut. Ovo istraživanje se odnosi na “skrivenu” geometriju koja prati prostornu koncepciju i oblik građevine:u planu-osnovi i u poprečnom preseku kroz kupolu, kao i položaj osnovnih elelmenata spoljašnjosti – fasada sa otvorima. U istraživanju su korišćeni principi proporcionisanja

spoljašnjosti i unutrašnjosti objekta, metodom upisivanja i opisivanja geometrijskih figura jednakostraničnog trougla i kvadrata i izvedenih geometrijskih konstrukcija. Postupak je sproveden na oblaku tačaka, dobijenom terestričkim laserskim skeniranjem crkve. Prostorne karakteristike unutrašnjosti crkve su prikazane kroz 3D modele pojedinačnih strukturnih elemenata u enterijeru.

Ključne reči: Srednjevekovna manastirska crkva, Manastir Sopoćani, Geometrijske proporcije, Geometrijske sheme, 3D model unutrašnjeg prostora crkve

PS-HE1.2 (#7035)

ИСТОРИЈСКИ ПРИКАЗ ГРАЂЕВИНСКИХ РАДОВА НА ХРАМОВНОЈ ГОРИ У ЈЕРУСАЛИМУ У ПЕРИОДУ ОД ПРВЕ ПОЛОВИНЕ ЧЕТВРТОГ ВЕКА ДО ПРВЕ ПОЛОВИНЕ ОСМОГ ВЕКА

Dragan Petrović

Храмовна гора у Јерусалиму представља једно од најважнијих места у историји монотеистичких религија. За јудеизам најзначајније је место порушеног Храма, где је приношена старозаветна жртва Богу. За хришћане је то место у непосредној близини јеврејског Храма, у Преторијуму, или Антонијевом утврђењу, где се одржало суђење Господу Исусу Христу. За ислам, треће место по важности, после Меке и Медине је место где је Мухамед, по учењу Курана, слетео током свог ноћног путовања. Све ово условило је различите грађевинске подухвате на овом месту, нарочито у периоду од установљења хришћанства, као званичне религије Римског царства, до освајања Јерусалима од стране Арапа, као носиоца нове вере - ислама. Аутор у свом раду покушава да изврши хронолошку реконструкцију изградње одређених цркава и манастира, у поменутом периоду, на подручију Храмовне горе и у њеној непосредној близини, као и каснију, највероватнију, промену намена ових објеката, по освајању Јерусалима од стране Арапа.

Кључне речи: Храм, Преторијум, Брдо, Морија, Мозаик, Стена

PS-HE1.3 (#7811)

DIGITALIZATION OF MEDIEVAL ROMANESQUE CHURCH PORTALS IN SERBIA: FROM UNDERLYING GEOMETRY TO THE REASEMBLABBLE 3D-PRINTED MODELS

Tijana Filić, Magdalena Dragović, Ana Urošević, Vladimir Vuković, Jovana Jovanović, Sanja Pušičić and Srđan Milanović

Contemporary technological advancements have brought new approaches in the area of cultural heritage protection and education. The aim of this research is to deepen the understanding of architectural designs, construction technique and underlying geometry for medieval portals in the Studenica and Dečani monasteries through the digitalization: 3D computer modeling and printing. Based on reliable data collection from both classical architectural documentation and digital sources, geometric analyses were conducted, and 3D digital models were created and printed in adequate scales for the two selected portals. 3D-printed models are decomposed on structural elements allowing for observation of mutual correlations and their incorporation in the wall thickness. This approach delivers new educational tool for cultural heritage knowledge gaining.

Keywords: Serbian medieval architectural heritage, Romanesque church portal, Underlying geometry, Geometric model, 3D printed model

PS-HE1.4 (#8170)

POLIPANTOGRAF: PRONALAZAK LJUBOMIRA KLERIĆA

Snežana Šarboh, Bratislav Stojiljković, Miloš Lazarević, Svetislav Marković and Zoran Pajić

Ljubomir Klerić – inženjer rudarstva, konstruktor, pronalazač, univerzitetski profesor, akademik, ali i ministar prosvete, privrede i državni savetnik, jedan je od najznačajnijih naučnika Kraljevine Srbije sa kraja 19. i početka 20. veka. Tokom bogatog konstruktorskog i izumiteljskog delovanja zaštitio je ukupno 46 patenata u devet zemalja. Pronalazak kojim se naročito ponosio bio je polipantograf – mehanička naprava pomoću koje se istovremeno moglo pisati ili crtati sa tri ili pet pera. Cilj rada jeste da osvetli ovaj Klerićev izum, sagleda istoriju njegove patentne zaštite, ali i da realizuje i predstavi trodimenzionalne modele zasnovane na originalnim fotografijama i prikupljenoj patentnoj dokumentaciji.

Ključne reči: Ljubomir Kleric, polipantograf, patenti, Zaostavstina Nikole Tesle, fotografije

PRIDRUŽENA SESIJA - MULTIDISCIPLINARNA

СЕСИЈА / SESSION (MD1)

Среда, 11. јун / Wednesday, June 11th Сала 3 / Hall 3 9.00-10.45

Председавајући / Chair:
Milesa Srećković, Univerzitet u Beogradu – Elektrotehnički fakultet, Beograd, Srbija

PS-MD1.1 (#7409)

PLENTY OF ROOM AT THE BOTTOM, COMPLEXITY TO THE TOP (INVITED PAPER)

Olga Jakšić

In his visionary 1959 lecture "Plenty of Room at the Bottom", Richard Feynman laid the conceptual groundwork for what would become nanotechnology. Sixty-four years later, we live in a time where nano- and micro-engineered structures—such as photonic crystals and metamaterials—have moved from speculation to sophisticated design and practical application. This talk offers a condensed, multidisciplinary review of nanotechnologies, with a particular focus on optoelectronic structures and inverse design methodologies. It highlights contemporary scientific research at the nano-scale as inherently complex due to the integration of mathematical modeling, multiscale simulations, machine learning, and domain-specific databases. These tools are addressed as a support for innovations relevant for solving problems framed by the UN Sustainable Development Goals, with special concern on how we teach and communicate cutting-edge science in engineering curricula.

Keywords: artificial intelligence, inverse design, metamaterials, multiscale modeling, nanotechnologies, photonic crystals, Richard Feynman, UN Sustainable Development Goals (SDGs)

PS-MD1.2 (#2198)

CITIZEN SCIENCE AND ASTROINFORMATICS

Miodrag Malović, Nemanja Rakić and Milanka Pećanac

Citizen science plays an important role in modern astroinformatics, enabling the public to collaborate with professional scientists in large-scale projects like Galaxy Zoo and Planet Hunters. Volunteers classify astronomical objects, detect exoplanets (the planets that orbit stars outside our solar system), and monitor transient events, contributing to major discoveries. With the rise of big data, AI, and machine learning, the integration of automated systems and human input creates a powerful synergy that improves data analysis. Despite the challenges in data quality and ethical issues, citizen science continues to thrive, providing a platform for global participation and encouraging public interest in scientific discovery.

Keywords: citizen science, big data, astronomy, astrophysics, astroinformatics

PS-MD1.3 (#1192)

PROTOKOLI REAGOVANJA U SLUČAJU POJAVE VANREDNIH SITUACIJA NA VOZILIMA NA ELEKTRO POGON

Lazar Miladinović, Radovan Radovanović, Mihajlo Milošević and Vojkan Zorić

Globalni trend razvoja u automobilskoj industriji jeste uvođenje vozila na elektro pogon, koja pored pozitivnih efekata na životnu sredinu, utiču na pojavu novih bezbednosnih rizika za sve učesnike u saobraćaju. Kako nisu jasno definisani normativni zahtevi, niti procedure reagovanja u slučaju ancidenta na vozilima na elektro pogon, u praksi se javljaju i bezbednosni rizici po sve učesnike u saobraćajnom udesu i vatrogasce spasioce koji reaguju na navedene vanredne situacije. Ako se uzme u obzir i veliki broj različitih modela vozila na elektro pogon koji se mogu javiti na tržištu, navedeni bezbednosni rizici su još izraženiji, tako da se u narednom periodu mora jasno definisati protokol delovanja vatrogasaca spasioca prilikom pojave vanrednih situacija u kojima učestvuju vozila na elektro pogon, a kasnije i način obuke. U radu su dati pregledi aktuelnih saznanja o bezbednosnim rizicima, predlozi protokola reagovanja u slučaju pojave vanredne situacije i edukacije vatrogasaca spasioca.

Ključne reči: protokol reagovanja, edukacija vatrogasaca, vozila na elektro pogon, saobraćajne nesreće, požar

PS-MD1.4 (#1350)

REALIZACIJA MERENJA I SPROVOĐENJE MERA U CILJU SMANJENJA RIZIKA OD IZLAGANJA NEJONIZUJUĆEM ZRAČENJU U POLJIMA MREŽNIH FREKVENCIJA

Marija Nikolić, Aleksandra Janićijević, Fathya Shabek and Aco Janićijević

Ispitivanje intenziteta el. polja u frekvencijskom opsegu od 27MHz do 6GHz je važno radi procene nivoa izloženosti ljudi elektromagnetnom(EM) zračenju, koje može da utiče na zdravlje. Ispitivanja su izvršena u zoni gde je potencijalna izloženost nivoima EM polja najveća. Ispitivane su karakteristične pozicije: viši spratovi i mesta gde je povećana frekventnost ljudi ali i neposredan dvorišni i okolni prostor do najbližeg autobuskog stajališta. Ispitivanje je izvršeno u skladu sa rasporedom postavljene opreme predmetnog izvora ispitivanja, potencijalnih relevantnih izvora i potencijalnih uzroka perturbacije prema standardnoj akreditovanoj metodologiji ispitivanja EM polja radio telekomunikacione opreme i sistema. Merna sonda postavljena je u planiranoj geometriji

u datom prostoru na distanci od 1,7m. Tokom merenja, osobe koje čine merni tim, udaljene su od merne sonde bar na distanci od 1,5m. Ovaj pristup osigurava pouzdanost i tačnost merenja bez nepotrebnih rizika po zdravlje. Na predmetnoj lokaciji instalirana je četvorosektorska bazna stanica koja podržava mobilne tehnologije: GSM 900, LTE 800, LTE 1800 i LTE 2100. Na osnovu izvršenih merenja i proračuna se pokazalo da su intenziteti električnog polja za LTE 800, LTE 1800 i UMTS sisteme manji od 15,5V/m, 23,4V/m i 24,4V/m, što su referentni granični nivoi za ove sisteme. Vrednosti faktora izloženosti u razmatranom slučaju manje su od 1 u svim zonama, što ukazuje na nizak nivo izloženosti u odnosu na dozvoljene granice.

Ključne reči: nejonizujuće zračenje, bazne stanice i efekti na zdravlje, karakteristike EM polja mrežnih frekvencija, frekvencijski-selektivna „spot" merenja

PS-MD1.5 (#2374)

VISOKOKVALITETNA ULTRATANKA MIKROMINIJATURNA KVARCNA KRISTALNA JEDINKA AT-REZA OSNOVNE UČESTANOSTI FREKVENCIJE 63MHZ

Dragi Dujković, Ana Gavrovska, Ivan Popović, Lenkica Grubišić and Aleksandar Rakić

U radu je opisan postupak razvoja jedinki kristala kvarca namenjenih za upotrebu u visokostabilnim filtrima, koji rade na frekvenciji od 63 MHz. Prilikom projektovanja filtra, naročita pažnja se posvećuje izboru kristalnih jedinki koje se koriste u rezonatorima. Ektremno visoki zahtevi koji se postavljaju pred filtre, u pogledu propusnog opsega, podešenosti frekvencije i u pogledu neželjenih rezonancija, mogu se ostvariti jedino primenom kristalnih jedinki najvišeg kvaliteta. Dodatni zahtevi se postavljaju pred tehnologiju mehaničke obrade kristalne jedinke, uključujući sečenje, izbor materijala za elektrode, način nanošenja elektroda i način postavljanja jedinke u kućište. Svi ovi zahtevi imaju pretežan uticaj na elektromehaničke karakteristike kristalne jedinke, što definiše njen kvalitet kao komponente za primenu u oscilatorima i filtrima.

Ključne reči: Kristali, filtriranje, neželjene rezonancije, frekvencija

PS-MD1.6 (#5571)

PAMETNE NANOČESTICE KAO NOSAČI LIJEKOVA U MEDICINI

Svetlana Pelemiš, Srđan Vuković and Danijela Rajić

Biološka i medicinska istraživanja danas su usmjerena na pronalaženje materijala pogodnih za primjenu u liječenju različitih bolesti i nedostataka, s po¬sebnim naglaskom na karcinom. Nanočestice se mogu napraviti od širokog spektra materijala, kao što su metali (zlato, srebro), metalni oksidi (npr. titan dioksid (TiO2), silicijum diok¬sid (SiO2)), anorganski materijali (ugljenikove nanocjevčice, kvantne tačke), polimerni materijali i lipidi. Područje nanomedicine uključuje dizajn i razvoj novih nanomaterijala kao što su multifunkcionalne liposomalne nanočestice, funkcionalni fulereni, nanocjevčice, na¬nočestice željeznog oksida, polimerne micele, dendrimeri, polimerne mikrosfereKontrolisana isporuka lijekova ima za cilj postizanje najveće moguće te¬rapijske aktivnosti uz minimiziranje mogućih negativnih nuspojava lijeka. U dizajniranju arhitekture različitih tipova blok kopolimera uvedeni su od¬go-varajući nanotehnološki pristupi, procjenom njihovog efekta u kontrolisanoj isporuci lijekova i metodama dijagnostikovanja.

Ključne reči: nanoparticles, nanomaterial design, drug delivery

PS-MD1.7 (#6795)

MODERNI PRISTUP ZAŠTITI I SPAŠAVANJU LJUDI IZ RUŠEVINA

Mihajlo Milošević, Lazar Miladinović and Radovan Radovanović

Moderni pristupi spasavanju integrišu naprednu tehnologiju, specijalizovanu obuku i međunarodnu saradnju kako bi povećali efikasnost i smanjili rizike za spasioca. Ključne tehnologije uključuju dronove, robote opremljene senzorima, termalne kamere i softver za analizu stabilnosti ruševina. Obuka spasilaca obuhvata tehničke veštine, rad sa psima tragačima i pružanje osnovne psihološke podrške. Međunarodni standardi, kao što su INSARAG, omogućavaju bolju koordinaciju i interoperabilnost između timova. Prevencija se postiže kroz obrazovanje građana, poboljšanje sistema za rano upozoravanje i promociju gradnje otporne na zemljotrese. Veštačka inteligencija dodatno pomaže u analizi podataka i prepoznavanju obrazaca kako bi se identifikovala prisutnost preživelih. Ovi pristupi ne samo da ubrzavaju proces spašavanja, već i značajno doprinose bezbednosti i pripravnosti zajednica za potencijalne prirodne katastrofe.

Ključne reči: prirodna katastrofa, spasavanje, rizici, obuka

PS-MD1.8 (#7282)

AKTUELNI PROBLEMI SA DETEKCIJOM U REALNIM ATMOSFERSKIM USLOVIMA

Ljiljana Konjević, Damjan Sudimac, Katarina Jevtić, Milesa Srećković and Bratislav Iričanin

Za odabrane zagađene atmosferske sredine, izvršena je analiza modelovanja relevantnih optičkih konstanti/parametara, u zavisnosti od koncentracije zagađivača u vazduhu. Za određivanje potrebnih parametara, korišćene su, između ostalih, bazične klasične relacije i aproksimacije (Gladstone–Dale, Maxwell–Garnett). Promena parametara izabranog nosećeg snopa(nekoherentnog/koherentnog, nepolarizovanog/polarizovanog) elektromagnetskog zračenja u atmosferi sa izabranim parametrima, analizirana je u odnosu na referentne vrednosti u vakuumu. U ovom radu, uticaj masene koncentracije zagađivača je posebno razmatran na zabeležene podatke u lokalnoj atmosferi, radi jasnije analize njihovog odnosa, sa posebnim fokusom na vidljivi i daleki infracrveni deo spektra. Istraživanjem je sprovedena detaljna analiza pojava nastalih od ovog faktora i validnost dobijenih podataka, u cilju konkretnih interpretacija primene osnovnih zakona, dostupnih savremenih softverskih paketa i baza podataka.

Ključne reči: Zagađenost vazduha, Indeks prelamanja, Gladstone-Dale relacija, Maxwell-Garnett aproksimacija

PS-MD1.9 (#7282)

ČESTICA VIĐENA PUTEM RAZNIH FORMALIZAMA, APLIKACIJE, NEKAD I SAD U ERI EEE:ENERGIJA, EKOLOGIJA, EKONOMIJA

Milesa Srećković, Željka Tomić and Stanko Ostojić

Čestica shvaćena kao tačka, sa gledišta skupa i njenih glavnih izabranih karakteristika predstavlja u oblastu materijala: polazni kamen temeljac do čvrstog stanja sa prilazom preko kritičnih parametara u drugo, stanje, generalizovanih predstava. Čestica u biologiji, s obzirom na deskripciju (bakterije, virusi, krvna zrnca, može da se posmatra jezikom biologije, daje svoje nove značajne gradivne tvorevine koje dovode do tkiva preko organela. U ovom svetu dosadašnjih podela koje i dalje važe, ali kroz jezik hemije i fizike postavlja pitanje šta se može striktno metodički potvrditi. Današnje tehnologije

sa primenom koherentnih funkcija omogućuju kroz igru: objekt, detekcija, izvor, stalan splet odgovora koji se može postići samo tehničkim nivoom vezanom za ekstremno male intervale vremena u kome se prati prenos enegije fotona u naelektrisanja i poboljašanje karakteristika materijala ne isključujući biološke jedinke ili u mikroskopske delove ćelije i njenih elemenata. U radu se retrospektivno daje akcenat sa posmatranjem simulacija potpomognutih razvojem algoritmima do mernih tehnika koje uključuju najmanji interval vremena koje je stvorilo današnji stepen tehnike uz svestranu pomoć teorijskih bazičnih i novorazvijenih nauka.

Ključne reči: rasejanje čestica, primena, elastično rasejanje, neelastično rasejanje, nelinearna optika

PRIDRUŽENA SESIJA - DIGITALIZACIJA U NAUCI

СЕСИЈА / SESSION (DIG1)

Уторак, 10. јун / Tuesday, June 10th Сала 6 / Hall 6 15.00-16.00

Председавајући / Chair:
Danica Mamula Tartalja, Akademija tehničko-umetničkih strukovnih studija Beograd, Srbija

PS-DIG1.1 (#9172)

CONTEXTUAL SENTIMENT ANALYSIS TRANSFORMS THE INTERPRETATION OF BIG DATA IN HEALTHCARE

Gordana Jelić, Danica Mamula Tartalja and Enis Osmani

The widespread adoption of digital communication in healthcare, along with the growing number of mHealth applications, is generating vast amounts of data. Big data analytics can potentially transform the healthcare sector by analyzing diverse online medical texts. As a specialized NLP task, sentiment analysis aims to identify and extract sentiment from textual data using various techniques, such as machine learning and lexicon-based approaches. This paper explores sentiment polarity in online medical discourse, examining how contextual factors, such as inferred sentiment, sarcasm, irony, and negation affect sentiment interpretation. The research highlights the importance of pragmatic and semantic analysis in medical sentiment classification and proposes improved approaches for handling sentiment polarity in nuanced medical discourse. Insights gained from sentiment analysis can improve patient outcomes and satisfaction, support personalized care, and reduce healthcare costs.

Keywords: mHealth, big data analytics, NLP, sentiment analysis, online communication

PS-DIG1.2 (#4953)

ENERGETSKA EFIKASNOST U OBLASTI ZELENE GRADNJE

Ana Stosovic

Zelena gradnja i energetska efikasnost, kao ključni aspekti održivog razvoja u građevinskoj industriji, imaju za cilj smanjenje negativnog uticaja na životnu sredinu, očuvanje prirodnih resursa i poboljšanje kvaliteta života . Zelene zgrade nude niz prednosti uključujući smanjenu upotrebu materijala, energije i emisije ugljen dioksida, tako da bi trebalo da nastavi da raste iz dana u dan. Efikasnost izvora energije se može ostvariti kroz energetski efikasno osvetljenje, efikasnu ventilaciju, kao i proizvodnju obnovljive energije preko solarnih sistema koji koriste mehaničku opremu poput solarnih

kolektora ili fotonaponskih ćelija za pretvaranje energije u toplotnu ili električnu, koja se kasnije koristi za grejanje. U radu se analiziraju inicajlni troškovi ugradnje aktivnih solarnih sistema i njihova isplativost tokom godina, pre svega smanjenjem potrošnje električne energije. Saradnja između projektanata, investitora i zakonodavaca, omogućiće da zelena gradnja postane pristupačnija.

Ključne reči: odrzivi razvoj, zelena gradnja, energetska efikasnost, ekologija

PS-DIG1.3 (#7395)

ADVANCED SENTENCE GENERATION IN SERBIAN: A RULE-BASED NLP FRAMEWORK WITH MORPHOSYNTACTIC ENHANCEMENTS

Mirjana Tomic and Dejan Djukic

This paper presents an enhanced model for automatic sentence generation in the Serbian language, based on a rule-driven approach with a focus on precise morphosyntactic processing. Compared to earlier versions of the system, substantial improvements have been introduced, enabling the use of verbs in the past tense, nouns and adjectives in various grammatical cases (dative, accusative, locative), as well as dynamic alignment with appropriate prepositions. Special attention is given to the integration of personal pronouns in the role of the subject, allowing for the generation of personalized sentences with correct verb conjugation. Semantic validation is achieved by introducing constraints that define allowable combinations of subjects, verbs, and objects, effectively eliminating illogical or unnatural constructions. Based on these mechanisms, the system successfully produces sentences that are not only grammatically correct but also semantically coherent. The proposed model holds promising applications in education, language tools, and natural language processing systems aimed at morphologically rich languages such as Serbian.

Keywords: Asentence generation, Serbian language, NLP, morphology semantics, rule based, algorithms

PS-DIG1.4 (#8431)

RAZVOJ I PRIMENA ENERGIJE VETRA U SVETU I KOD NAS

Jovo Jelić

U ovom radu dat je prikaz razvoja obnovljivih izvora energije u svetu i kod nas, sa posebnim akcentom na primeni i iskorišćenju energije vetra. Ubrzani napredak civilizacije, tehnologije i industrije, postavlja velike ciljeve u vezi sa održivim razvojem i korišćenjem čistih energija. Poslednjih godina Republika Srbija ulaže velike napore i sredstva u projekte implementacije alternativnih izvora energije kroz izgradnju solarnih elektrana i elektrana na vetar. U energetskom sektoru, razvoj obnovljivih izvora energije i povećanje njihovog učešća u ukupnoj potrošnji energije nalazi se visoko na energetskoj agendi Srbije. Eksploatacija vetroelektrana može doneti brojne koristi našoj zemlji, pre svega obezbeđenjem dodatnih izvora energije neophodnih za razvoj, ali i smanjenjem emisija gasova staklene bašte, doprinoseći tako borbi protiv klimatskih promena. Cilj ovog rada je predstavljanje značaja razvoja i primene energije vetra na primeru aktuelne izgradnje vetroelektrane „Kostolac“.

Ključne reči: čista energija, energija vetra, održivi razvoj, vetropark „Kostolac“

PRIDRUŽENA SESIJA - TOPLOTNE PERFORMANSE SLOŽENIH STRUKTURA. MODELOVANJE I PRIMENA

СЕСИЈА / SESSION (TP1)

Среда, 11. јун / Wednesday, June 11th Сала 2 / Hall 2 9.00-10.45

Председавајући / Chair:
Goran Todorović, Univerzitet u Beogradu – Građevinski fakultet, Beograd, Srbija
Radovan Gospavić, Univerzitet u Beogradu – Građevinski fakultet, Beograd, Srbija

PS-TP1.1 (#8875)

MODELOVANJE TRANSPORTA TOPLOTE KROZ VIŠESLOJNE PLANARNE STRUKTURE KORIŠĆENJEM ELEKTRIČNIH ANALOGIJA I ANALITIČKIH MEOTODA U VREMENSKOM I KOMPLEKSNOM DOMENU (POZVANI RAD)

Radovan Gospavić

Razmatran je transport toplote kroz višeslojne planarne strukture sa proizvoljnim brojem slojeva u nestacionarnom slučaju. Pri analizi su korišćeni pristupi bazirani na električnim analogijama odnosno ekvivalentnom RC kolu i analitički metod baziran na Green-ovim funkcijama. U vremenskom domenu je razmatran impulsni odziv na Dirac-ovu temperatursku pobudi na spoljašnjim površinama strukture. Rezultati dobijeni korišćenjem dva različita metoda su poređeni u vremenskom i kompleksnom domenu. U kompleksnom domenu su korišćeni kružni dijagrami odnosno hodogrami prenosne funkcije sistema dobijeni korišćenjem ekvivalentnog RC kola i odgovarajućeg analitičkog metoda dok su u vremenskom domenu predstavljene odgovarajuće Green-ove funkcije. Analiziran je uticaj različitog broja RC segmenata na kondicioni broj odgovarajuće matrice sistema kao i na ostupanje od analitičkog rešenja.

Ključne reči: Transport toplote, električne analogije, Green-ova funkcija

PS-TP1.2 (#0441)

MELTING TEMPERATURES AND ELECTRICAL CONDUCTIVITY OF LEAD-FREE SOLDERING ALLOYS FOR FILLER MATERIALS

Zoran Karastojković, Milesa Srećković, Radiša Perić, Miša Stević, Nada Ratković Kovačević and Miodrag Malović

Lead-based filler metals were used for soldering for many years, but they are now being gradually replaced by lead-free materials, usually alloys. Contemporary alloys commonly contain metals such as antimony, bismuth, copper, indium, tin, zinc, silver, and gallium. Some of their properties still need to be studied in more detail. A good solder joint must create a reliable electrical connection with high conductivity, having suitable thermal properties at the same time. In addition, soldering materials must meet other requirements such as good fluidity and resistance to corrosion. Mechanical strength is usually not a top priority, except in portable or handheld devices, where the joints need to withstand impacts from drops and shocks. Pure metals are seldom used as filler materials in soldering, as alloys are generally preferred due to their broader range of beneficial properties. In this paper, we take a closer look at several key properties of the soldering alloys.

Keywords: soldering, lead-free alloys, melting temperatures, electrical conductivity

PS-TP1.3 (#6486)

ANALYTICAL DETERMINATION OF TEMPERATURE DISTRIBUTION USING GREEN FUNCTION IN PASSIVE COOLING HEATSINKS FOR POWER CONVERTERS

Dragan Pavlović, Nikola Zivković and Milan Ponjavić

Abstract — The dissipation of high temperatures is a critical challenge in developing power converters, as elevated temperatures degrade system performance and significantly shorten lifespan. This paper introduces an analytical method based on Green's functions for determining the temperature distribution within a finned aluminum heatsink employed for passive cooling of power converters. A square-shaped heat source, characterized by uniform power density, is centrally positioned on the top surface of the heatsink. Key parameters, such as aluminum thermal conductivity, convection coefficients, and ambient conditions, are integrated into the analysis. The analytical results, achieved in less than 5 seconds, show minimal deviation from numerical simulations performed using SolidWorks 2023, which required 2 minutes. These findings provide valuable insights into heatsink efficiency and pave the way for optimizing passive cooling processes in industrial applications.

Keywords: temperature, analytical method, Green function, heatsink, power converter

PS-TP1.4 (#1818)

PASOŠ ZA RENOVIRANJE ZGRADA U CILJU DOSTIZANJA NULTE EMISIJE GASOVA DO 2050. GODINE – STUDIJA SLUČAJA VIŠEPORODIČNE STAMBENE ZGRADE U SRBIJI

Zorana Petojević, Olga Obradović, Nevena Simić, Bojana Zeković, Radovan Gospavić and Goran Todorović

Abstract—Transformacija fonda zgrada ka nultoj emisiji gasova do 2050. godine jedan je od ključnih ciljeva Evropskog zelenog dogovora i nove EPBD direktive. Zgrade, kao najveći potrošači energije, zahtevaju sistemsku i dubinsku obnovu. Pasoš za renoviranje zgrada (Building Renovation Passport – BRP) uveden je kao alat koji omogućava fazni i strateški pristup unapređenju energetske efikasnosti i dekarbonizaciji izgrađenog okruženja. Ovaj rad prikazuje metodologiju razvoja BRP-a kroz studiju slučaja tipične višeporodične stambene zgrade iz 1980-ih u urbanom delu Srbije. Renoviranje je podeljeno u tri faze: poboljšanje omotača zgrade, optimizacija tehničkih sistema i integracija obnovljivih izvora energije. Kroz analizu troškova, koristi i prepreka, rad pokazuje kako BRP može doprineti postepenoj i održivoj obnovi, omogućavajući vlasnicima dugoročno planiranje i informisano donošenje odluka u pravcu zgrada bez emisija.

Ključne reči: Pasoš za renoviranje zgrada, Višeporodične stambene zgrade, Unapređenju energetske efikasnosti, Dekarbonizaciji izgrađenog okruženja, Nulte emisije gasova do 2050.

PS-TP1.5 (#4103)

TEMPERATURSKI IMPULSNI ODZIV DVOSLOJNE GRAĐEVINSKE PREGRADE

Goran Todorović, Radovan Gospavić, Zorana Petojević and Milica Mirković Marjanović

Abstract—U radu je analizirana dvoslojna građevinska pregrada poznatih toplotnih i fizičkih karakteristika i određen je temperaturski impulsni odziv na zadate granične uslove na spoljašnjoj i unutrašnjoj površini. Odziv je određen rešavanjem Fourier-ove jednačine za zadati problem u frekventnom domenu. Temperaturski odziv u vremenskom domenu je dobijen određivanjem polova prenosne funkcije u frekventnom domenu.

Ključne reči: dvoslojna građevinska pregrada, temperaturski impulsni odziv, granični uslovi, frekventni domen

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	Награђени студенти - HUAWEI ICT Competition Grand Prize						**12:45 - 13:00**
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МЕЂУНАРОДНА конференција ИцЕТРАН (12 ; 2025 ; Чачак)

Програм и зборник апстраката LXIX конференције ЕТРАН и 12. међународне конференције ИцЕТРАН, Чачак, 9 - 12. јун 2025. године : електроника, телекомуникације, рачунарство, аутоматика, нуклеарна техника = [Program and Book of Abstracts LXIX Conference ETRAN and 12th International Conference IcETRAN 2025, Čačak, June 9 - 12, 2025.] / [главни уредник Владимир Катић = editor in charge Vladimir Katić]. - Београд : Друштво за ЕТРАН : Академска мисао = Belgrade : ETRAN Society : Academic Mind, 2025 (Београд : Академска мисао = Belgrade : Academic Mind). - XXVIII, 114 str. ; 24 cm

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a) Електротехника -- Апстракти b) Акустика -- Апстракти v) Рачунарска технологија -- Апстракти g) Системи аутоматског управљања -- Апстракти d) Нуклеарна техника -- Апстракти đ) Технички материјали -- Апстракти e) Биомедицина -- Апстракти ž) Метрологија -- Апстракти z) Вештачка интелигенција -- Апстракти

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