The Third Serbian International Conference on Applied Artificial Intelligence, Kragujevac – Book of Abstracts

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with the support of
- **Ministry of Science, Technological Development and Innovation of the Republic of Serbia**
- **Tecnalia Serbia DOO**

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CONTENTS

WELCOME MESSAGE

Dear colleagues and students,

On behalf of the Organizing Committee, it is a pleasure to welcome you at the Third Serbian International Conference on Applied Artificial Intelligence AAI2024 which takes place in Kragujevac, Serbia, on May 23rd-24th, 2024 at the University of Kragujevac.

AAI2024 provides an exceptional Serbian and international forum to share the state-of-the-art research knowledge and results on the innovative theories, methodology and applications of artificial intelligence and its sub-domain like deep learning, machine learning in different areas such as medicine, economy, education, law, smart city, government, industry etc. Moreover, the conference aims to provide a platform for researchers and practitioners for both academia and industry to share the information about cutting-edge developments in the field of artificial intelligence.

It also aims to:

- provide early-stage researchers with an inspiring event allowing them to connect to relevant experts in related fields;
- provide an exciting venue for researchers to network and establish national and international collaborations;
- bring together leading experts from all relevant scientific domains to enhance the understanding of *Artificial Intelligence*;

Topics cover the following:

AI IN DOMAIN-SPECIFIC APPLICATIONS

- AI in Computational Biology, Medicine and Biomedical Applications
- AI in WWW, Communication, Social Networking, Recommender Systems, Games and E-Commerce
- AI in Finance and Risk Management

AI IN DATA ANALYTICS AND BIG DATA

- Visual Analytics for Big Data
- Computational Modeling for Big Data
- Large-scale Recommendation and Social Media Systems
- Cloud/Grid/Stream Data Mining for Big Velocity Data
- Semantic-based Big Data Mining

MACHINE LEARNING AND DATA MINING

- Pre-processing, Dimension Reduction and Feature Selection Computing, Bayesian and Neural Networks
- Learning Graphical Models and Complex Networks
- Active, Cost-Sensitive, Semi-Supervised, Multi-Instance, Multi-Label and Multi-Task Learning
- Transfer/Adaptive, Rational and Structured Learning

There are seven different mini-symposiums:

- **MS1: AI in Energy and Environmental Science**
  Organizers: **Boban Stojanović**, Faculty of Science, University of Kragujevac, Kragujevac, Serbia; **Nikola Milivojević**, Water Institute Jaroslav Cerni, Belgrade, Serbia; **Milan Stojković**, The Institute for Artificial Intelligence R&D of Serbia, Novi Sad, Serbia.
- **MS2: AI & IOT for Smart Industry**
  Organizers: **Milovan Medojević**, The Institute for Artificial Intelligence R&D of Serbia, EnergyPulse DOO, Novi Sad, Serbia.
- **MS3: AI in Computer Vision and Remote Sensing**
  Organizers: **Marko Pavlović**, The Institute for Artificial Intelligence R&D of Serbia, Novi Sad, Serbia; **Slobodan Ilić**, The Institute for Artificial Intelligence R&D of Serbia, Novi Sad, Serbia; **Dubravko Ćulibrk**, The Institute for Artificial Intelligence R&D of Serbia, Faculty of Technical Sciences, University of Novi Sad, Novi Sad, Serbia.
- **MS4: AI and Social Wellbeing**
  Organizers: **Ljubiša Bojić**, The Institute for Artificial Intelligence R&D of Serbia, Novi Sad, Serbia; **Milan Čabarkapa**, Faculty of Engineering, University of Kragujevac, Serbia; **Igor Pantić**, Faculty of Medicine, University of Belgrade, Serbia.
- **MS5: Future of Workforce**
  Organizers: **Jelena Ćulibrk**, The Institute for Artificial Intelligence R&D of Serbia, Novi Sad, Serbia; **Bojana Jokanović**, The Faculty of Technical Sciences, University of Novi Sad, Serbia; **Dunja Bošković**, The Faculty of Technical Sciences, University of Novi Sad, Serbia.
- **MS6: Delivering on The Promise of AI to Improve Health Outcomes**
  Organizers: **Tijana Geroski**, Faculty of Engineering, University of Kragujevac, Serbia; **Nenad Filipović**, Faculty of Engineering, University of Kragujevac, Serbia.
- **MS7: Heritage Mining: Theory and Examples**
  Organizers: **Veljko Milutinović**, Guest Lecturer and Former Faculty, Purdue University, USA Adjunct Professor, University of Indiana in Bloomington, USA, Adjunct Professor, Technical University of Graz, Austria Visiting Professor, University of Kragujevac Visiting Professor, University of Belgrade Visiting Professor, University of Montenegro.

As well as seven world renowned plenary speakers in the area of applied artificial intelligence:

- **Prof. Amir A. Amini** – University of Louisville, Louisville, Kentucky, USA; **Title: 4D Flow MRI: Efficient Acquisition and Deep Learning Strategies for Assessment of Hemodynamics**
- **Prof. Borko Furht** – Florida Atlantic University, Boca Raton, Florida, USA; **Title: Successful Engineering Education Requires Applied Industry Projects**
- **Prof. Themis Exarchos** – Ionian University, Corfu, Greece; **Title: Using Explainable AI (xAI) to Predict the Conversion from Mild Cognitive Impairment to Alzheimer's Disease**
- **Prof. Emil Jovanov** – University of Alabama at Huntsville, USA; **Title: Integrating AI and IoT for Personalized Healthcare**
- **Prof. Dubravko Ćulibrk** – University of Novi Sad, Novi Sad, Serbia; **Title: AI-disrupted Medicine and How to Apply it in Serbia**
- **Prof. Israel Koren** – University of Massachusetts in Amherst, USA; **Title: Protecting Vehicle Privacy against AI-Enhanced Attackers in Intelligent Transportation Systems**
- **Prof. Zoran Obradović** – Temple University, Philadelphia, Pennsylvania, USA; **Title: Characterizing Disruptive Events by Modeling Dynamics in Multiplex Networks**

We have received more than 180 high-quality research papers. As a result of the strict review process and evaluation, the committee selected over 100 papers as extended abstracts.

After the review, full papers from the AAI2024 conference will be published by Springer Verlag in the series "Learning and Analytics in Intelligent Systems" under the title "Applied Artificial Intelligence".

We must also admit that the conference certainly would not have been so successful without the efforts of many people who were actively engaged in organization of such a major academic event. We express gratitude to the members of the program and scientific review committee as well as to all the chairs, organizers and committee members for their dedication and support.

On behalf of the Organizing Committee, we wish you all a pleasant stay in Kragujevac and a productive conference.

Prof. Nenad Filipović*,* Conference Program Chair

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- **Vladimir Ranković,** University of Kragujevac

Keynote Speakers

"4D Flow MRI: Efficient Acquisition and Deep Learning Strategies for Assessment of Hemodynamics"

Prof. Amir A. Amini

Professor and Endowed Chair in Bioimaging Director

Medical Imaging Laboratory

University of Louisville, Louisville, Kentucky, USA

Abstract

4D Flow MRI is a non-invasive method for imaging flow velocities, which provide time-resolved three directional blood flow velocities in a 3D volume. This provides an unprecedented opportunity for detailed mapping of hemodynamic biomarkers. However, the data collection is time consuming, and data usage is hampered by low resolution, noise and artifacts. In this talk, we will describe a unique in-vitro flow testbed to study stenotic flows which we have developed over the last few years which allows for validation of MR-based flow and velocity measurements. We will also describe k-space spiral read-out sequences and deep learning-based image reconstruction which lead to efficient collection of data. Finally, convolutional neural networks will be described for assessment of hemodynamics including intravascular pressures.

"Successful Engineering Education Requires Applied Industry Projects"

Prof. Borko Furht

Professor of Computer Science and Engineering

Director of the NSF Industry/University Cooperative

Research Center Florida Atlantic University, Boca Raton, Florida, USA

Abstract

In this talk we present non-traditional, radical university arrangements that we implemented in the College of Engineering and Computer Science at FAU to create an Entrepreneurial University. To produce successful engineers our thesis is that they should be involved in the applied industry projects. This "re-conceptualization" involves non-traditional, often radical university arrangements. We will present our entrepreneurial, research, and innovation strategy. The backbone of our new concept is the NSF-sponsored Industry/University Cooperative Research Center for Advanced Knowledge Enablement with 45 industry members, a more than 50 applied research projects. The university has created a Research Park with more than 20 high-tech companies and an incubator with more than 30 start-up companies. We also present several successful projects by our faculty and students that resulted in creating start-up companies, patent inventions, and successful products and services.

"Using Explainable AI (xAI) to Predict the Conversion from Mild Cognitive Impairment to Alzheimer's Disease"

Prof. Themis Exarchos

Associate Professor of Data Modeling and

Decision Support Systems in the Department of Informatics, Ionian University, Corfu, Greece and the Director of the Technology Transfer Office of Ionian University

Abstract

Mild Cognitive Impairment (MCI) is a cognitive state frequently observed in older adults, characterized by significant alterations in memory, thinking, and reasoning abilities that extend beyond typical cognitive decline. It is worth noting that around 10%-15% of individuals with MCI are projected to develop Alzheimer's disease, effectively positioning MCI as an early stage of Alzheimer's. We present a novel approach involving the utilization of eXtreme Gradient Boosting to predict the onset of Alzheimer's disease during the MCI stage. The methodology entails utilizing data from the Alzheimer's Disease Neuroimaging Initiative (ADNI). Through the analysis of longitudinal data spanning from the baseline visit to the 12-month follow-up, a predictive model is constructed. The proposed model calculates, over a 36-month period, the likelihood of progression from MCI to Alzheimer's disease, achieving an accuracy rate of 85%. To further enhance the precision of the model, the study implements feature selection using the recursive feature elimination technique. Additionally, Shapley method is employed to provide insights into the model's decision-making process, thereby augmenting the transparency and interpretability of the predictions.

"Integrating AI and IoT for Personalized Healthcare"

Prof. Emil Jovanov

Professor in the Electrical and

Computer Engineering Department at the University of Alabama in Huntsville, USA

Abstract

Traditional healthcare is going through a massive change from reactive, disease focused, to predictive, preventive, personalized, and participatory (P4) healthcare. Massive deployment of IoT devices, both wearable and embedded in our environment, facilitates collection of continuous streams of health-related big data. This data, when processed by AI algorithms, converts big data into smart data and enables the prediction of health trends, early detection of potential health issues, and actionable insights to both users and healthcare providers. This paper outlines current opportunities and challenges, and addresses the technical, ethical, and privacy challenges. As examples, we present health monitoring using standard video cameras, WiFi signal based deep learning network for human activity recognition during activities of daily living, and embedded on-sensor AI models for detection of abnormal heart activity.

"AI-disrupted Medicine and How to Apply it in Serbia"

Prof. Dubravko Ćulibrk

Director of The Institute for Artificial Intelligence Research and Development of Serbia

Professor of Information Systems, Engineering Department of Industrial Engineering and Management, University of Novi Sad, Serbia

University Ambassador and Certified Instructor, Nvidia Deep Learning Institute

Abstract

In recent years, the integration of Artificial Intelligence (AI) in the field of medicine has brought about a significant transformation in healthcare delivery. This talk will delve into the disruptive potential of AI in revolutionizing various aspects of medicine, from diagnosis and treatment to personalized medicine and patient care. By leveraging machine learning algorithms, big data analytics, and advanced technologies, AI is reshaping the landscape of healthcare by enabling faster and more accurate diagnoses, optimizing treatment plans, and improving patient outcomes. The Institute for Artificial Intelligence Research and Development of Serbia is implementing several projects in this domain and finds itself at a forefront of the effort to apply AI to transform healthcare in Serbia to the benefit of all its citizens.

This talk will explore the ethical considerations, challenges, and opportunities that arise with the widespread adoption of AI in medicine, but will also present practical limitations that need to be overcome to achieve the optimal effect of this transformation within the Serbian ecosystem. Join our speaker as we navigate through the exciting realm of AI-disrupted medicine and envision a future where technology plays a pivotal role in enhancing healthcare for the people of Serbia and beyond.

"Protecting Vehicle Privacy against AI-Enhanced Attackers in Intelligent Transportation Systems"

Prof. Israel Koren

Department of Electrical and Computer Engineering,

University of Massachusetts in Amherst, USA

Abstract

Connected and autonomous vehicles in Intelligent Transportation Systems (ITS) rely on vehicle-to-vehicle (V2V) communication to maintain safe inter-vehicle spacing. However, such communications, which frequently update the vehicle's position, threaten privacy by allowing an eavesdropper to potentially track vehicles through their journey.

Mix-zones, which are zones of radio silence where vehicles can change their pseudonyms and thus attempt to throw off potential trackers, have been proposed to deal with this problem. Mix-zones are most effective when placed in high traffic intersections but may cause traffic throughput reduction. We present a mix-zone placement algorithm that allows controlling the tradeoff between vehicle anonymity and a reduced traffic throughput. We then present a new traffic management algorithm within mix-zones that enhances vehicles' privacy. We analyze the effectiveness of the proposed algorithm against a sophisticated attacker that, unlike prior publications, is making use of a powerful supervised machine learning algorithm. Finally, to deal with traffic patterns changes (with time-of-day, day-of-week, and season) we present an approach to place mix-zones dynamically to match the prevailing traffic pattern. Extensive simulations, based on New York City and Boston traffic, are presented to validate the advantages of our algorithms.

"Characterizing Disruptive Events by Modeling Dynamics in Multiplex Networks"

Prof. Zoran Obradović

Laura H. Carnell Professor of Data Analytics

Data Analytics and Biomedical Informatics Center,

Computer and Information Sciences Department, Statistics Department, Temple University

Abstract

This presentation will delve into effective machine learning-based approaches for identifying, categorizing, and forecasting disruptive weather events, even when data is limited and labels are imprecise. We'll showcase some of our latest techniques, which address this challenge by leveraging multiplex evolving networks to jointly analyze structured and unstructured data sources. Our findings demonstrate that by utilizing deep learning and transfer learning techniques, the accuracy and efficacy of diagnostics and risk monitoring for weather events can be greatly enhanced. Specifically, integrating information from weather, geophysical, and social media sources of varying quality and resolutions can yield significant improvements in predicting and managing weather-related disruptive events.

Technical Program

09:00 - 09:30	Opening Ceremony - Day I: **Jelena Begović,** Minister of Science, Technological Development and Innovation, Republic of Serbia **Nikola Dašić**, Mayor of the City of Kragujevac **Prof. Nenad Filipović**, Rector of the University of Kragujevac

09:30 - 10:30	Keynote speakers: **4D Flow MRI: Efficient Acquisition and Deep Learning Strategies for Assessment of Hemodynamics** **Prof. Amir A. Amini** **Successful Engineering Education Requires Applied Industry Projects** **Prof. Borko Furht** Chair: Nenad Filipović

10:30 - 11:00	Coffee Break

11:00 - 12:00	Keynote speakers: **Protecting Vehicle Privacy against AI-Enhanced Attackers in Intelligent Transportation Systems** **Prof. Israel Koren** **Characterizing Disruptive Events by Modeling Dynamics in Multiplex Networks** **Prof. Zoran Obradović** Chair: Veljko Milutinović

Session T.1A 12:00-14:00
Mini-Symposium I – AI in Energy and Environmental Science
Chair: Boban Stojanović

T.1A.1 Deep neural network models for dynamic resilience estimation of a complex water system under hazards - Vukašin Ćirović, Milan Stojković, Vladimir Milivojević

T.1A.2 Temperature as a factor shaping dissolved oxygen in the Danube river - Irena Todorović, Branislav Kisačanin, Milan Stojković

T.1A.3 Recurrent Neural Networks for Energy Management Systems: A Case Study - Jelena Joksimović, Jure Kos, Krištof Debeljak, Janez Povh

T.1A.4 Evaluating Bayesian Approaches for Water Quality Classification: A Comparative Study - Ana Dodig, Tatjana Lutovac

T.1A.5 Exploring machine learning approaches for predicting the resilience of water resources system under hazardous events - Aleksandra Z. Kazaković, Višnja M. Simić and Vukašin B.

Ćirović

T.1A.6 Application of artificial intelligence in approximating 2D hydraulic calculations - Boško Laković, Dušan Stefanović, Uroš Stanković, Luka Stojadinović, Boban Stojanović

T.1A.7 A comparative study of automl libraries and hyperparameter tuning techniques - Radovan Drašković, Marija Jolović, Miloš Ivanović, Boban Stojanović

T.1A.8 Treatment of non-physical Solutions of the Oxygen Diffusion in Soil by Physics-Informed Neural Network - Miloš Ivanović, Ljubica Kuzmanović, Andreja Živić, Milan Kovačević, Svetislav Savović

Session T.1B 12:00-14:00

Mini-Symposium III – AI in Computer Vision and Remote Sensing

Chair: Marko Pavlović

T.1B.1 Efficient sequential detection: enhancing cancer detection in sequential MRI sequences - Aleksandar Cvetković, Veljko Papić

T.1B.2 Improving velocity estimation in GPR recordings using machine learning approach - Daniel Štifanić, Jelena Štifanić, Sandi Baressi Šegota, Nikola Anđelić and Zlatan Car

T.1B.3 Evaluating GDPR and HIPAA in the integration of ML/AI for future-proofing healthcare - Saso Nikolovski, Anita Petreska

T.1B.4 Application of remote sensing indices in vegetation monitoring - Marko Pavlović, Karlo Bala

T.1B.5 Multi-class birads categorization of mammographs using neural networks - Vanja Švenda, Nikola Jovišić, Milica Škipina, Slobodan Ilić

T.1B.6 AI-Driven Soil Property Estimation - Karlo Bala, Marko Pavlović

T.1B.7 The impact of artificial intelligence on digital marketing - Ana Spasojević, Stefan Zdravković, Aleksandar Milovanović

T.1B.8 Human right to artificial intelligence: an alternative regulatory framework - Dragan Dakić

Workshop C 12:00-18:00

Artificial Intelligence for Improved Diagnosis of Heart Failure – The INTELHEART Project

Chair: Smiljana Tomašević

- The aim and vision of INTELHEART project
- The INTELHEART clinical study and data usage following FAIR principles
- The latest advancements in AI-driven diagnosis of heart failure
- Introducing the concept of INTELHEART platform and integration of machine learning, computational modeling, and vocal biomarkers
- Utilization of voice characteristics to assess emotional disturbance and psychological resilience in cardiovascular diseases
- Networking with leading experts, clinicians, researchers, and stakeholders in the field

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14:00 - 15:00	Buffet Lunch

Session T.2A 15:00-17:00

Mini-Symposium II –AI & IoT for Smart Industry and Big Data

Chair: **Milovan Medojević**

T.2A.1 The future of Manufacturing: Generative AI and Beyond - Aleksandar Rikalović, Bojana Bajić, Miloš Jovičić, Milovan Medojević

T.2A.2 Symbolic AI in verifiable design of financial exchanges - Dragisa Žunić, Milovan Medojević, Miloš Jovičić

T.2A.3 **Evaluation of using balanced and unbalanced data for smart city solution based on IoT using classification and adaboostm1 -** Valerij Grašič

T.2A.4 **Edge Intelligence for Cybersecurity: AI-Powered Threat Detection in Hardware Infrastructure -** Milovan Medojević, Velibor Ilić, Dragiša Žunić, Aleksandar Rikalović

T.2A.5 **Dataflow Hardware Advancements for Supporting Artificial Intelligence Algorithms -** Nenad Korolija

T.2A.6 **AI-Powered Prior Art Search: Towards Enriching Intellectual Property Management? -** Ana Hafner, Dolores Modic, Nadja Damij, Andrej Furlan

T.2A.7 **The evaluation of retrieval augmented generation tasks for different large language models fine-tuned for the Serbian language -** Mina Nikolić, Aleksandar Stanimirović, Leonid Stoimenov

T.2A.8 **Graph Neural Networks and Transformer Embeddings: A Hybrid Approach to Improving Recommender Systems -** Marko Njegomir, Matija Matović

Session T.2B 15:00-17:00
Machine Learning and Data Mining
Chair: Vladimir Ranković

T.2B.1 **Sustainable Concrete Mix Designs by Machine Learning Approaches -** Ayman Karaki, Ahmad Hammoud, Bekassyl Battalgazy and Miloš Dujović*

T.2B.2 **Advanced risk management practices – the application of the exact solutions   methods for resilience factors improvement -** Aleksandar V. Aleksić, Michael Huber*, Danijela P. Tadić and Snežana B. Nestić

T.2B.3 **Scaling methodology and phase portraits analysis -** Alina Fedorova, Kipelkin Ivan, Ivana Krtolica, Max Talanov

T.2B.4 **Processing of big data after transcriptome sequencing at single cell resolution -** Nevena Milivojević Dimitrijević, Biljana Ljujić, Marina Gazdić Janković, Ana Mirić, Marko Živanović, Nenad Filipović

T.2B.5 **Local Execution of Large Language Models: Democratizing AI through On-Device Optimization -** Kristina Jovanović, Milan Bjelica

T.2B.6 **Community event discovery using x datastream -** Adedotun Ogundare, Stevan Gostojić, Abdullahi Saleh, James Orban

T.2B.7 **Design of new potential inhibitor of the GABAa receptor assisted by artificial intelligence -** Tamara Mladenović, Dusica Simijonović, Dejan Milenković, Marko Antonijević, Edina Avdović, Sandra Milić, Zoran Marković

T.2B.8 **Multi-layer spectral clustering algorithm based on an adjustment of Laplacian matrix -** Aleksandar Trokičić, Milan Bašić

T.2B.9 **Comparing different approaches for modelling soil properties from Near infrared spectroscopy data -** Ognjen Antonijević, Branislav Bajat, Milan Kilibarda, Dragutin Protić, Aleksandar Sekulić, Petar Bursać, Milutin Pejović, Slobodan Jelić

17:00 - 17:30	Coffee Break

	Keynote speakers:
17:30 - 18:00	**Integrating AI and IoT for Personalized Healthcare** **Prof. Emil Jovanov** Chair: Amir Amini

Session T.3A: 18:00-20:15
Mini-Symposium VII: Heritage Mining: Theory and Examples
Chair: Veljko Milutinović

T.3A.1 Modeling user behavior in big systems - Milan Bradonjić

T.3A.2 Heritage Mining: Theory and Examples - Veljko Milutinović

T.3A.3 Correlation-Based Dimensionality Reduction for Multi-Source Samples - Saša Malkov, Vladimir Brusić, Nenad Mitić

T.3A.4 Text-to-SQL translation: Application of deep learning approach for Serbian language - Zoran Babović

T.3A.5 Can ChatGPT write parallel code? - Marko Mišić, Matija Dodović

T.3A.6 Applied Artificial Intelligence in detecting Hate Speech - Jelica Cincović, Uroš Radenković, Marko Mićović, Adrian Milaković, Vladimir Jocović and Dražen Drašković

T.3A.7 Data analysis techniques and detection of propaganda in Serbian online media in 2023 - Dražen Drašković, Mihajlo Ogrizović, Matija Dodović, Miloš Obradović

T.3A.8 Scientific production and collaboration patterns of medical researchers: a case study in epidemiology and infectious diseases - Iva Potkonjak, Predrag Obradović and Marko Mišić

T.3A.9 Transforming learning: adapting to generative AI technologies in Serbian educational paradigm - Nebojša Stanojević, Ranka Popovac, Tijana Čomić, Uroš Milićević, Dragan Vukmirović

T.3A.10 Physics-Informed Neural Networks for Streamlined Snap-Through Instability Analysis of Shallow Truss - Filip Đorđević, Marko Marinković

Session T.3B: 18:00-20:15
AI in Domain-specific application
Chair: Aleksandra Vulović

T.3B.1 Analysis of association between social media signals and stock return on Asian markets - Milan Zdravković, Pavel Dudko

T.3B.2 Influence of Dimensionality Reduction Approaches on Various Machine Learning Models for a Biomedical High-Dimension Dataset - Sandi Baressi Šegota, Nikola Anđelić Jelena Štifanić, Daniel Štifanić, Zlatan Car

T.3B.3 Fuzzy-based characterization of ovarian tumors - Marija Branković, Ana Mirić, Tijana Geroski, Marko Živanović, Nenad Filipović

T.3B.4 Machine learning-based prediction of immunomodulatory properties of polymers: towards a faster and easier development of anti-inflammatory biomaterials - Aghilas Akkachea, Lisa Clavier, Oleh Mezhenskyid, Kateryna Andriienkova, Thibaut Soubriéd, Philippe Lavalle, Nihal Engin, Varvara Gribova

T.3B.5 Comparing Vision Transformers and Convolutional Neural Networks for Fungi Microscopic Image Classification - Mina Milanović, Aleksandar Milosavljević, Dragan Janković and Marina Ranđelović

T.3B.6 Turbojet engine control with neural network-based feedforward - Luka Miličić, Vladimir Kuzmanović, Ivana Todić

25

T.3B.7 Application of recurrent neural networks in Assessing Drivers' Oscillatory Comfort during fore-and-aft vibrations - Igor Saveljić, Slavica Mačužić Saveljić, Tijana Đukić, Branko Arsić, Nenad Filipović

T.3B.8 Parameter Sensitivity Analysis in Multiscale Agent-Based Modeling of Atherosclerotic plaque progression - Lemana Spahić, Leo Benolic, Safi Ur-Rehman Qamar, Nenad Filipović

T.3B.9 Deep learning segmentation of the porcine superficial femoral arteries oct images - Miloš Anić, Sotiris Nikopoulos, Siaravas Konstantinos, Christos Katsouras, Vassiliki Potsika, Nenad Filipović, Dimitrios Fotiadis

20:30 - 24:00	Gala Dinner

Friday 24 May 2024

9:00 - 9:30	Keynote speaker: **AI-disrupted Medicine and How to Apply it in Serbia** **Prof. Dubravko Ćulibrk** Chair: Tijana Geroski

9:30 - 10:00	Coffee Break

Session F.1A: 10:00-11:30
Mini-Symposium IV: AI and Social Wellbeing
Chair: Ljubiša Bojić

F.1A.1 **A novel model for diversifying ai based recommender systems for societal well-being -** Zorica Dodevska, Ljubiša Bojić, Boris Delibašić

F.1A.2 **Benchmarking GPT-4 in sentiment analysis and bias detection: an evaluation of advanced large language models in textual understanding -** Ljubiša Bojić, Nenad Pantelić, Milan Čabarkapa

F.1A.3 **Adapting all-optical activation functions for predicting stock prices on the Frankfurt stock exchange -** Mladen Banović, Mihailo Todorović, Marko Barjaktarović, Lidija Barjaktarović, Jasna Crnjanski, Marko Krstić, Dejan Gvozdić

F.1A.4 **Unmanned Vehicles - Technical perspective of AI applications and social impact -** Vladimir Đapić, Isidora Grujić, Marijana Gavrilović Božović, Mina Vasković Jovanović, Jasna Radulović, Milan Čabarkapa

F.1A.5 **Application of the AHP method to the investment management of local municipalities and countries -** Aleksandar Kemiveš, Jelena Mišić

Session F.1B: 10:00-11:30
AI in Domain-specific application
Chair: Emil Jovanov

F.1B.1 **Artificial intelligence anxiety among young adults in Montenegro -** Irina Stamatović, Hakile Resulbegoviq

F.1B.2 **Can artificial intelligence mitigate intra-organizational moral outrage? A theory-based model -** Marko Selaković, Nikolina Ljepava, Marija Gačić, Nenad Filipović

F.1B.3 **AI-generated softfakes as disruptors of politician-citizen interaction: ethical considerations -** Nikolina Ljepava, Marko Selaković, Marija Gačić, Nenad Filipović

F.1B.4 **Predicting electrospun PCL/PEG nanofiber diameter using artificial neural network -** Jana Baščarević, Katarina Virijević, Leo Benolić, Marko Živanović, Nenad Filipović

F.1B.5 **Factors influencing ai prediction of socially undesirable behaviors of foster care children -** Ana Miletić Vučković, Marko Selaković, Nikolina Ljepava, Marija Gačić, Nenad Filipović

F.1B.6 **Feature selection for lying posture classification -** Đorđe Nešković, Ilija Tanasković, Nadica Miljković

11:30 - 12:00	Keynote speaker: **Using Explainable AI (xAI) to Predict the Conversion from Mild Cognitive Impairment to Alzheimer's Disease** **Prof. Themis Exarchos** Chair: Smiljana Tomašević

Session F.2A: 12:00-13:30
Mini-Symposium V: Future of Workforce
Chair: Jelena Ćulibrk

F.2A.1 AI as a Catalyst for Research Talent Development: Elevating Employer Branding to Forge a Cutting-Edge Workforce - Milica Brković, Jelena Ćulibrk, Jelena Spajić, Nemanja Tasić

F.2A.2 The role of artificial intelligence in transforming hotels in developing countries, with a special focus on the republic of Serbia - Tamara Gajić, Andrea Ivanišević

F.2A.3 How artificial intelligence is transforming human resource management? - Gala Šikoparija, Jelena Ćulibrk, Bojana Jokanović, Nenad Medić

F.2A.4 Enhanced Biomarker Detection and Health Monitoring Using AI-Driven Multi-Sensor Integration - Matija Štrbac, Miloš Kostić, Goran Bijelić

F.2A.5 DeepTech2M search API for Research Funding - Luka Todorović, Jelena Tomić, Ana Kaplarević Mališić, Nenad Grujović, Fatima Živić

Session F.2B: 12:00-13:30
AI in Domain-specific application
Chair: Igor Saveljić

F.2B.1 Automatization of 3D reconstruction of coronary arteries from angiography projections using AI-enhanced segmentation techniques - Tijana Đukić, Ognjen Pavić, Lazar Dašić, Tijana Geroski, Nenad Filipović

F.2B.2 Artificial intelligence-based anomaly detection with identifying and mitigating abnormal traffic patterns associated with the ddos attack in software–defined networking - Stefan Biševac, Aleksandar Atanasijević, Aleksandar Jokić, Marko Šarac

F.2B.3 Machine learning approach for predicting judicial case outcome - Adedotun Ogundare, Stevan Gostojic, Augustine Tarawali, David Soumano

F.2B.4 Impact of the development of artificial intelligence on the stock market – Nemanja Lojanica, Dragan Stojković, Milica Kaplarević

F.2B.5 Exploring Word2Vec Models for Capturing the Similarity of Codon Embeddings - Anđa Denić, Jelena Pejić, Aleksandar Trokičić

F.2B.6 On Semantic Association Capabilities of GPT LLMs in a Game of Word Associations - Aleksandar Kondić, Vladimir Milovanović

13:30 - 14:30	Buffet Lunch

Session F.3A: 14:30-16:00
Mini-Symposium VI_1: Delivering on the Promise of AI to Improve Health Outcomes
Chair: Tijana Geroski

F.3A.1 **Multilabel classification process optimization through the utilization of transfer learning approaches supported by decision postprocessing techniques -** Ognjen Pavic, Tijana Geroski, Lazar Dašić, Nenad Filipović

F.3A.2 **Pixels to Prognosis: A Data-Driven Deep Learning Approach for Gastric Cancer diagnosis -** Đorđe Karisic, Tijana Geroski, Vesna Ranković, Nenad Filipović

F.3A.3 **Development of convolutional neural network for classification of heart sounds utilizing mel-frequency cepstral coefficients -** Lazar Dašić, Tijana Geroski, Ognjen Pavić, Nenad Filipović

F.3A.4 **AI- and Computer-Based Module for 3D Reconstruction of Patient-specific Carotid Arteries and Plaque Progression Simulation -** Smiljana Tomašević, Tijana Đukić, Miloš Anić, Branko Arsić, Igor Saveljić, Branko Gakovic, Igor Končar, Nenad Filipović

F.3A.5 **Folder design optimization with genetic algorithm for drug coated balloon folding -** Leo Benolić, Stratakos Efstathios, Elisabetta Stretti, Giancarlo Pennati, Spyridon Psarras, Vassilis Kostopoulos, Nenad Filipović

F.3A.6 **Development of a platform for displaying medical results -** Jelena Živković, Đorđe Ilić, Ognjen Pavić, Lazar Dašić, Tijana Geroski, Tijana Đukić, Nenad Filipović

F.3A.7 **Predicting absorbance for different concentration of AgNPs using artificial neural network -** Leo Benolić, Safi Ur Rehman Qamar, Lemana Spahić, Nenad Filipović

F.3A.8 **Identification of Potential Biomarkers and Pathways in Dilated Cardiomyopathy Using Bioinformatics Analysis -** Tamara Mladenović, Sanja Matić, Jelena Pavić, Katarina Virijević, Nenad Filipović

Session F.3B: 14:30-15:30
AI in Domain-specific application
Chair: Dubravko Ćulibrk

F.3B.1 **A brief survey of ai-based methods in astrodynamic problems with disturbances, noises and uncertainties -** Natalia Amelina, Oleg Granichin, Yury Ivanskiy, Kseniia Kopylova, Margarita Maksimenko, Vadim Sakharov and Aleksei Tikhonov

F.3B.2 **AI-based intelligence versus individual intelligence: Regarding designing better environmental policies -** Petraq Papajorgji, Howard Moskovitz

16:00 - 16:30	Coffee Break

Session F.4A: 16:30-18:30
Mini-Symposium VI_2: Delivering on the Promise of AI to Improve Health Outcomes
Chair: Marko Živanović

F.4A.1 **The use of artificial intelligence in predicting the significance of markers related to cell movement -** Dragana Šeklić, Dalibor Nikolić, Milena Jovanović, Katarina Virijević, Marko Živanović, Biljana Ljujić, Igor Saveljić, Nenad Filipović

F.4A.2 **AI-Enhanced Extended Reality in Medicine -** Filip Filipović, Tijana Geroski, Aleksandra Vulović, Nenad Filipović

29

F.4A.3 **Utilization of Augmented reality for improvement of balance disorders -** Đorđe Ilić, Aleksandra Vulović, Nenad Filipović

F.4A.4 **Overview of the Integration of Genetic Algorithms and Reinforcement Learning Techniques -** Bogdan Milićević, Vladimir Milovanović, Miljan Milošević, Nenad Filipović

F.4A.5 **Cardiac segmentation using unetr: a transformer based deep learning approach on the acdc dataset -** Tijana Geroski, Ognjen Pavić, Lazar Dašić, Amir Amini, Nenad Filipović

F.4A.6 **The possibility of bone fracture prediction in osteoporosis treatment through use of ai -** Gordana Jovičić, Aleksandra Vulović, Arso Vukićević, Miloš Jovičić, Nenad Đorđević, Nenad Filipović

F.4A.7 **Internet of medical things (iomt): smart hearing aids, today and tomorrow -** Vesna Simikić, Ivana Maletić-Sekulić

F.4A.8 **Evaluation of magnetized micro- and nano-object parameters using artificial intelligence -** Vitaly Goranov, Alexander Makhaniok

18:30 - 19:00	Closing Ceremony

Book of Abstracts

PHYSICS-INFORMED NEURAL NETWORKS FOR STREAMLINED SNAP-THROUGH INSTABILITY ANALYSIS OF SHALLOW TRUSS

Filip Đorđević[*] and **Marko Marinković**

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Abstract

This study explores the application of physics-informed neural networks (PINNs) to the problem of analyzing snap-through instability in symmetric shallow trusses. Snap-through is a critical issue in civil engineering that, in nonlinear analysis, leads to a change in the static system exposed to loading. Traditionally, the analysis of nonlinear effects requires complex modeling and substantial computational resources, often making the process cumbersome and time-intensive. By integrating PINNs, which embed physical laws into the machine learning framework, this research not only ensures that predictions adhere strictly to established physical principles, but also significantly enhances computational efficiency. This paper demonstrates the capability of PINNs to model the nonlinear structural responses accurately, leveraging their potential to streamline the complex geometrically nonlinear analysis. Through detailed simulations, validated by load-displacement curves under various stiffness of the spring, the findings showcase the effectiveness of PINNs in overcoming the limitations of traditional computational methods. This approach opens up new pathways for applying advanced machine learning (ML) techniques in structural engineering.

Keywords: nonlinear analysis, machine learning, geometric nonlinearity, numerical modeling, physics-informed neural networks.

SUSTAINABLE CONCRETE MIX DESIGNS BY MACHINE LEARNING APPROACHES

Ayman Karaki[1], Ahmad Hammoud[1], Bekassyl Battalgazy[2] and Miloš Dujović[2*]

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Abstract

Concrete, as a cornerstone of Civil Engineering, exhibits a complex behavior due to a series of chemical reactions between its constituents. It is the material that has been present in human society for millennia as the most omnipresent man-made material. As the demand for it constantly increases, its sustainable production and development must follow. Implementation of innovative methods of concrete production is more a demand than a request. The main constituent of concrete, cement, is currently responsible for 8% of anthropogenic green gas production, and that reduction is pivotal. Improving the sustainability of overall concrete production by adding supplementary cementing materials such as fly ash and blast furnace slag while maintaining the concrete's mechanical and rheological properties is an essential challenge to overcome. This project proposes to utilize the power and customizability of machine learning algorithms, particularly neural networks, to investigate complex relations between the constituents of concrete samples and the aging time on the compressive strength of concrete. By creating a design space based on the composition of the concrete, the project aims to optimize concrete mix designs to understand material-property relations better and design a concrete mix with the highest compressive strength (given the investigated constituents). The approach that the project exploits starts with using a diverse dataset of mixtures. The dataset is analyzed using advanced machine learning techniques from classical regression models to modern advance ensemble and boosting models. The ultimate goal is to refine the best-performing machine learning models through hyperparameter tuning, and employing methods like Grid Search, Random Search, and Bayesian Optimization to enhance performance. Moreover, developing a neural network model was a priority, given the non-linear relationships in the concrete mix data. The exploratory data analysis has provided vital insights into the relationships among the various components of concrete mixtures and their impact on compressive strength. Especially the use of supplementary cementitious materials.

HERITAGE MINING: THEORY AND EXAMPLES

Veljko Milutinović

Guest Lecturer and Former Tenure-Track Faculty, Purdue U., USA Adjunct Professor, University of Indiana in Bloomington, USA Adjunct Professor, Technical University of Graz, Austria Visiting Professor, University of Kragujevac Visiting Professor, University of Belgrade Visiting Professor, University of Montenegro
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Abstract

This presentation elaborates on theoretical and practical aspects of a portal for digital preservation of heritage of any kind, on the levels from institutional to national. Features are presented that are unique in comparison with other established approaches, and give ground for further enhancements into the direction of AI - all done in cooperation between researchers at TU Graz, University Belgrade and University of Kragujevac. A Graz development related to questions answering, with advanced features not found in Chat GPT, and based on the specifics of the presented portal, is briefly specified. A Belgrade/Kragujevac development, related to finding of hidden knowledge based on metadata focusing on time issues, is presented in details, using the history of Serbs as an example. This research sublimates the former research of the presenter and associates, in the domains of questions answering and data mining.

MODELING USER BEHAVIOR IN BIG SYSTEMS

Milan Bradonjić

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Abstract

In this paper, we present the analysis of user behavior over time in extremely big and complex systems. One of the issues we are trying to solve is whether there are certain patterns of user behavior, i.e. how to model and identify given patterns. On the other hand, we are going to present how a distributed computing solution can be developed and used for a given issue. We will also relate the abovementioned topics to global optimization problems - specifically, to examples of maximal allocation in large graphs and data sets under limited resources.

CORRELATION-BASED DIMENSIONALITY REDUCTION FOR MULTI-SOURCE SAMPLES

Saša Malkov[1*], Vladimir Brusić[2] and Nenad Mitić[1]

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Abstract

Advanced data analysis and AI algorithms require large data sets with lots of samples and many different attributes. The corresponding data collection processes are often general and result in very high dimensionality of the data. Often, some dimensions have little significance for specific data analysis. To make data processing more efficient, we need dimensionality reduction. On the other hand, bulk data usually come from different sources. Depending on the complexity of the experiments, some characteristics of the data may vary significantly. Such differences complicate the dimensionality reduction process. Since data from different sources often come with unbalanced size and may have different sets of significant dimensions, dimensionality reduction algorithms may result in a biased dimensions selection.

We present a dimensionality reduction method that takes into account the specific characteristics of different data sources and enables an unbiased selection of dimensions. First, correlation-based dimensionality reduction is applied to each of the data sources independently, and then the selected dimensions are combined. The result is an unbiased selection of dimensions.

We applied the method to single-cell transcriptomics data from different sources, with more than 30,000 dimensions and about 2,000,000 samples from five unbalanced sources. We tested different levels of dimensionality reduction, yielding from 15 to 10800 dimensions, and used the reduced datasets in classification algorithms. The results for data set reduced to 78 dimensions and were almost as good as the results for original (non-reduced) data set, although it had almost 400 times fewer dimensions and about the same data volume reduction factor.

Keywords: data mining, dimensionality reduction, feature selection, correlation-based feature selection, transcriptomics data.

ANALYSIS OF ASSOCIATION BETWEEN SOCIAL MEDIA SIGNALS AND STOCK RETURN ON ASIAN MARKETS

Milan Zdravković[1,2]* and Pavel Dudko[1]

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Abstract

Research behind this paper explores the relationship between social media sentiment signals and market prices, and the predictive strength of these signals for selected assets traded on Taiwanese and Hong Kong markets. The research utilizes data sourced from PTT Bulletin Board System (BBS) and ET Net forum, analyzing sentiment signals and their association with Return on Investment (ROI) through various analytical techniques including signal association analysis, causality analysis, and model back-testing. The findings demonstrate a significant association between high sparsity sentiment signals and ROI, with machine learning models showing improved performance over traditional Buy and Hold scenarios in both markets. Out of 14 assets represented on ET Net forum, machine learning models outperform the Buy and Hold scenarios in 9 cases. Out of 10 assets with data from PTT BBS, models trained with data have shown improved results for 6 assets. ML approach outperforms Buy and Hold scenarios in both markets, with more significant gains (20% in absolute ROI) on Taiwanese market, where also all benchmarks are exceeded.

Keywords: financial market, market forecasting, machine learning, advanced analytics.

INFLUENCE OF DIMENSIONALITY REDUCTION APPROACHES ON VARIOUS MACHINE LEARNING MODELS FOR A BIOMEDICAL HIGH-DIMENSION DATASET

Sandi Baressi Šegota[*]**, Nikola Anđelić, Jelena Štifanić, Daniel Štifanić and Zlatan Car**

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Abstract

Dimensionality reduction is a preprocessing approach that serves to assist in reducing the number of variables (features) in the dataset, based on statistical approaches. This is extremely beneficial in machine learning (ML) applications, as it can serve to simplify the modeling process and improve the performance. In this paper, the authors apply 14 different techniques to reduce the dimensionality of a dataset with over 1200 features and test the influence across five techniques. Results indicate that some techniques have a significantly higher sensitivity to the dimensionality reduction technique applied. For example, a neural network-based technique shows a nearly 20% improvement, compared to the insignificant improvement shown by the support vector-based technique. A sensitivity difference is shown in the type of dimensionality reduction applied as well, with NB demonstrating a significant increase in performance with feature selection techniques, as opposed to decomposition techniques. Execution times are also tested, demonstrating low computational cost of most applied dimensionality reduction techniques. This indicates the need for more detailed research to test which techniques are affected the most across different datasets.

Keywords: dataset decomposition, dimensionality reduction, feature selection, machine learning.

FUZZY-BASED CHARACTERIZATION OF OVARIAN TUMORS

Marija Branković[1,2*], Ana Mirić[2], Tijana Geroski[1,3], Marko Živanović[2] and Nenad Filipović[1,3,4]

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Abstract

Over the years, ovarian tumors have been one of the leading causes of death in women. Due to the unclear etiology of the disease, many different diagnostic models have been developed to distinguish benign from malignant tumors. This paper aims to apply fuzzy logic to the characterization of tumors by looking at the expression of the apoptotic genes *Bax*, *Bcl-2,* and *Cas3*.

Utilizing the MATLAB software, we developed a fuzzy system to categorize ovarian tumors. The input data comprised the relative expressions of apoptotic genes obtained from 12 samples using qualitative polymerase chain reaction (qPCR). Three possible outcomes for the output variable (diagnosis) are benign, borderline, and malignant tumors. The resulting assessment score ranges from 0 to 1, with values below 0.5 indicating benign tumors and values above 0.5 suggesting malignant potential. Scores that are near the 0.5 cutoff indicate borderline tumors. Upon inputting the relative expression values, the system generated results consistent with the known diagnoses of the samples. This approach has the potential to significantly enhance the characterization of ovarian tumors, leading to better treatment outcomes. However, more extensive research and a literature review are necessary to validate these findings.

Keywords: ovarian tumors, apoptosis, bax, bcl-2, cas3, fuzzy logic.

Acknowledgement

ADVANCED RISK MANAGEMENT PRACTICES – THE APPLICATION OF THE EXACT SOLUTIONS METHODS FOR RESILIENCE FACTORS IMPROVEMENT

Aleksandar V. Aleksić, Michael Huber[*], Danijela P. Tadić and Snežana B. Nestić

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Abstract

In the context of organizational resilience, branch and bound algorithms can be leveraged to determine the most suitable management techniques from a set of options, considering factors such as cost and time constraints. This paper presents a novel approach for assessing the suitability of methods aimed at improving organizational resilience factors. The proposed algorithm integrates fuzzy logic and exact solutions methods. The algorithm comprises several steps, including fuzzy rating of method suitability, determination of aggregate suitability values and assessment of method application costs. Furthermore, a multidimensional optimization problem is formulated to maximize the overall effectiveness of selected methods while considering budgetary constraints. To efficiently navigate the solution space and identify near-optimal solutions, a Branch and Bound algorithm is employed. The proposed framework offers a comprehensive methodology for decision-makers to make informed choices regarding method selection and resource allocation for business process improvement initiatives. Experimental results demonstrate the efficacy and practical applicability of the proposed approach in real-world scenarios.

Keywords: resilience factors, optimization, Branch and Bound.

MACHINE LEARNING-BASED PREDICTION OF IMMUNOMODULATORY PROPERTIES OF POLYMERS: TOWARDS A FASTER AND EASIER DEVELOPMENT OF ANTI-INFLAMMATORY BIOMATERIALS

Aghilas Akkachea[1], Lisa Clavier[2,3], Oleh Mezhenskyid[4], Kateryna Andriienkova[4], Thibaut Soubrié[4], Philippe Lavalle[1,2,3], Nihal Engin[1]*and Varvara Gribova[2,3] *

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Abstract

In biomaterials development, creating materials with desirable properties can be a time-consuming and resource-intensive process, often relying on serendipitous discoveries. A potential route to accelerate this process is to employ artificial intelligence (AI) methodologies such as machine learning (ML). In this study, we explore the possibility to predict anti-inflammatory properties of the polymers using a simplified model of inflammation and a restrained dataset that we generated in-house. We conducted cellular assays with 50 different polymers using the murine macrophage cell line RAW 264.7 as a model. These experiments generated a dataset which was used to develop a machine learning model based on Bayesian logistic regression. After conducting a Bayesian logistic regression analysis, we employed two machine learning models, K-Nearest Neighbors (KNN) and Naive Bayes, to predict anti-inflammatory polymers properties. The study found that the probability of a polymer having anti-inflammatory properties is multiplied by three if it is a polycation, suggesting that incorporating polycations in material design could potentially improve their anti-inflammatory properties. Additionally, the analysis confirmed that NO secretion is a good indicator in determining the anti-inflammatory properties of a polymer, which were defined in this paper by tumor necrosis factor alpha (TNFα) expression decrease. These findings highlight the importance of using *in silico* models for comprehensively considering the biological mechanisms underlying anti-inflammatory responses when developing materials with these properties. Furthermore, the study compared the performance of two algorithms, KNN and Naive Bayes, in distinguishing between anti-inflammatory and pro-inflammatory polymers. Overall, the study suggests that KNN is a slightly better model for this particular task, but both models perform similarly well. These findings have important implications for the development of more accurate and reliable methods for distinguishing between anti-inflammatory and pro-inflammatory polymers. The study suggests that with appropriate dataset design, ML techniques can provide valuable information on functional polymer properties, enabling faster and more efficient biomaterial development. This has the potential to accelerate multifunctional biomaterial design, ultimately contributing to patient health and well-being. Overall, the results demonstrate the potential of ML techniques in rapidly developing biomaterials.

Keywords: polymers, inflammation, machine learning, Bayesian logistic regression, predictive models, in silico.

DEEP NEURAL NETWORK MODELS FOR DYNAMIC RESILIENCE ESTIMATION OF A COMPLEX WATER SYSTEM UNDER HAZARDS

Vukašin Ćirović[1*], Milan Stojković[2] and Vladimir Milivojević[1]

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Abstract

The paper investigates feed-forward deep neural networks (DNNs) for estimating dynamic resilience of water resource system affected by unpredictable and dangerous events. Besides different architecture of DNNs, hyper-parameters' values were also explored in order to examine the way they affect the performance of DNNs. The aim of this research was to investigate the capabilities of DNNs in domain of water resources resilience estimation to provide significantly better results than currently developed ANN models from literature. The DNN models were trained and tested using large, generated dataset related to the Pirot water system. In order to generate data, an appropriate model of system dynamics was used alongside MonteCarlo simulations. The dataset contained two hazardous events: flood and earthquake defined in wide range of situations (nearby 2,000), from moderate to severe ones. The efficacy of examined DNNs were evaluated using average error metric as well as time required for training and execution.

Keywords: deep neural networks, dynamic resilience, water resources.

COMPARING VISION TRANSFORMERS AND CONVOLUTIONAL NEURAL NETWORKS FOR FUNGI MICROSCOPIC IMAGE CLASSIFICATION

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Abstract

Based on morphology, fungi are classified as yeasts - unicellular fungi with basal cell blastoconidia (blastospora) and multicellular fungi (molds) with a basic hypha cell. Molds can be primarily divided into dermatophytic and non-dermatophytic fungi. Dermatophytic molds, in other words, dermatophytes, are causative agents of superficial fungal infection (SFI) of skin, hair, and nails with a prevalence of 22-25% worldwide. The other group of molds causes invasive fungal infection (IFI) and, in recent years, incidence of these diseases has been on the rise.

Diagnostics of infections caused by dermatophytic and non-dermatophytic fungi can sometimes be insufficient; they require a longer period of time in laboratory procedures and sometimes may lead to late diagnosis. In the case of SFI, late diagnosis or misdiagnosis can lead to wrong treatment and shortage of implementation measures to prevent the spread of infection. On the other hand, late diagnosis or misdiagnosis of IFI can result in a patient's condition impairment or even mortality. Creating a computer-aided tool, capable of processing fungi microscopic images and performing initial diagnostics efficiently cannot only speed up these procedures, but also help experts to compare, discuss, and exchange data between laboratories.

During our previous research, a Multi-CNN-based architecture was developed, showing a high accuracy of 93% for all trained models used in the solution. Vision Transformers (ViTs), however, show some promising results, with accuracy of 91%, especially for images with noise which are augmented, as microscopic images usually are. Also, a combination of ViTs and CNNs shows some promising results in some research fields, CNNs tend to generalize better, but ViTs learn more information from a smaller amount of images.

The goal of this paper is to develop a model that will perform the identification of infections from fungi microscopic medical imaging, thus accelerating the diagnostics process. The process, which first involves extracting important information from medical imaging, and then performing the classification, is perceived using CNNs, ViTs, or a combination of both architectures, to get a more reliable and accurate tool. Once the architecture is developed, and results compared, the goal is to apply the process to other microscopic images in different fields.

Keywords: CNN, ViTs, medical imaging, deep learning.

TURBOJET ENGINE CONTROL WITH NEURAL NETWORK-BASED FEEDFORWARD

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Abstract

This paper presents an innovative approach to turbojet engine control, addressing the critical sensor signal loss issue while ensuring uninterrupted operation. Conventional feedback control systems alone are insufficient to mitigate the risks associated with the loss of the main feedback signal. To overcome this challenge and ensure better setpoint tracking, a feedforward control mechanism is integrated alongside the conventional feedback loop. A polynomial function as the baseline representation of the feedforward term is employed, aimed at providing simplicity and efficiency. However, complex and nonlinear nature of the turbojet engine demands a more accurate description of the feedforward control.

We employ a neural network trained on data sampled from actual experiments to accomplish this objective. The neural network is tasked with understanding the nuanced correlations between the desired angular speed of the engine's rotor and the associated control signal, providing a more accurate depiction of the feedforward term. The trained neural network is implemented on a microcontroller and the computational efficiency is evaluated to demonstrate real-time feasibility.

Experimental tests are conducted on the actual turbojet engine, comparing the performance of the neural network-based feedforward control with the polynomial function approach. Results illustrate the superiority of the neural network in accurately predicting control signals.
Furthermore, the system's proficiency in maintaining the engine's safe operation amid feedback signal loss is showcased, underscoring the efficiency and dependability of the proposed control strategy.

Keywords: turbojet engine control, neural network, feedforward control, real-time implementation.

HUMAN RIGHT TO ARTIFICIAL INTELLIGENCE: AN ALTERNATIVE REGULATORY FRAMEWORK

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Abstract

Academic and regulatory discourse on artificial intelligence (AI) mainly revolves around one dominant and several alternative approaches. The most dominant approach to AI regulation is focused on the perils of AI applications and the damages they might cause. This approach commonly referred to as a risk-based approach was reflected throughout the legislative efforts of the European Union (EU) to regulate AI. On March 13, 2024, the European Parliament voted to approve the European Union's Artificial Intelligence Act (AI act). In the realm of the EU AI regulation, AI systems are divided into varying levels of risk, based on the potential dangers their abilities may bring. The prohibited AI practices include systems that employ manipulation or deception to influence behavior, target vulnerabilities related to age, disability, or social/economic status, conduct biometric analysis to extract sensitive information like race or political beliefs, and make evaluations based on social attributes. These practices are seen as direct threats to individuals' safety, rights, and well-being. High-risk AI systems, capable of significant negative impacts on safety and fundamental rights, are closely monitored under the AI act. Such systems fall into two main groups: those incorporated into consumer products like toys and medical devices under EU regulations, and those utilized in critical sectors such as law enforcement, subject to regular updates. To ensure compliance, high-risk AI systems must adhere to strict guidelines covering risk assessment, testing, technical reliability, data management, transparency, human oversight, and cybersecurity before entering the market. The legislation also acknowledges limited-risk AI systems, including chatbots and emotion recognition tools, which face specific transparency requirements. Conversely, low-risk AI systems can be developed and operated within the EU without additional legal obligations, though adherence to best practices through codes of conduct is encouraged by the draft AI act.

Drawing from the technical capacities of AI systems, alternative regulatory strategies could center on practical value without obligatorily classifying AI systems based on risk gradations. The strength of this utility-based approach in dealing with the obstacles introduced by AI technologies might lie in its competitive edge over the risk-oriented method, showcasing effectiveness, productivity, and flexibility. A utility-based approach might constitute a subset of a broader regulatory model, entailing the establishment of precise regulations, criteria, and directives for AI systems to comply with. This approach emphasizes establishing stringent prerequisites for AI advancement and implementation without directly evaluating risks. It seems that the utility-based approach is closely related to a principle-centric method that delineates overarching principles for AI systems to adhere to, spanning elements such as equity, transparency, and responsibility.

An alternative regulatory approach distinct from all of the above is to observe AI as a human right. We can accept that all regulatory models share a core concern with protecting human rights within AI applications. Even though human rights are a core concern still, they are only a subsidiary reference in shaping comprehensive regulatory models. Taking human rights as an indisputably significant regulatory ground common to all approaches, we intend to test if human rights are suitable for engineering autonomous regulation. More precisely, we are hypothesizing that AI should be regulated as a human right. Accordingly, human rights provide a competitively legitimate framework to regulate AI applications. Namely, extensive interpretation of human rights instruments enabled the

commencement of so-called new rights. Those rights need not be worded in human rights texts or an optional protocol within an existing human rights agreement. For their establishment, it is sufficient to be discovered by human rights interpreting bodies. Still, there are some rules governing the process of new rights formation. The process relies on the concept of implied rights as well as on the concept of derivative rights. AI regulation is profoundly influenced by both implicit and deductive rights, with the primary goal of guaranteeing that the advancement and implementation of AI adhere to and honor human rights. It is without a doubt that these rights are pivotal in determining the framework of AI regulation. However, we intend to investigate if AI can be regarded as a human right within any of these concepts. In the context of implicit rights, we intend to see if a human right to AI can be observed as inherent in the broader principles of fundamental human rights that are not explicitly mentioned such as human dignity, autonomy, and privacy. As to the concept of deductive rights, we are planning to analyze the legal texts and extract principles that can be applied to the formation of human right to AI.

APPLICATION OF RECURRENT NEURAL NETWORKS IN ASSESSING DRIVERS' OSCILLATORY COMFORT DURING FORE-AND-AFT VIBRATIONS

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Abstract

Vibrations emanating from the environment subject vehicle occupants to conditions that significantly influence their comfort and safety. These vibrations, particularly those stemming from horizontal and vertical movements, are transmitted through the vehicle's structure, from the seat to the driver's body. This study focuses on the seat-to-head transmission response function, which encapsulates the relationship between vibrations at the seat/head interface and the resultant motion responses of the driver's head. To address this, an artificial neural network model was developed based on experimental measurements involving ten healthy female subjects who were exposed specifically to horizontal fore-and-aft vibrations. Training of the artificial neural network was conducted using values from the transfer functions derived from these experiments. The findings indicate that the devised model can accurately forecast transfer function values within the range of the experimental data upon varying the input parameters, thereby offering insights into managing oscillatory comfort for automobile drivers.

Keywords: artificial neural network, experimental measurements, vertical body vibration.

Acknowledgment

SCALING METHODOLOGY AND PHASE PORTRAITS ANALYSIS

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Abstract

In this paper, we present the methodological approach for the optimisation of SNNs as an example using the spinal cord model of Rybak. The high-lever representation of the methodology is depicted in Figure 1. We start with the bio-plausible SNN (Figure 1 b-SNN) created neuron-by-neuron using Hodgkin-Huxley model with the high requirements for bio-plausibility. With the b-SNN, we can use statistical validation (Figure 1a) matching the biological data of the rat SNN (Figure 1 rat model). Using the results of the bio-plausible SNN, we develop the phase portrait that could later be used as validation criteria. Here we identify real-time as: if a biological process takes 5 ms, the computation of this process time must not exceed 5 ms. The real-time SNN (rt-SNN) is the result of the optimisation done as follows (Figure 1c): (1) neuron model simplification instead of Hodgkin-Huxley model we use: Izhikevich or Even Simpler Real-time Neuron (ESRN); (2) we reduce the number of connections to match real-time processing; (3) we implement the simulation in C++ and CUDA over GPU.

The memristive SNN (Figure 1 mem-SNN) is the result of further optimisation where we reduce the number of neurons and synapses to a minimum to be implemented as an electronic schematic: (1) we reduce the number of neurons along with several connections in b-SNN and recalculate the minimal b-SNN; (2) we create the electronic implementation simulation in, for example, LT spice, and test the memristive schematic; (3) we implement PCBs and integrate with memristive devices and validate the results with the original data from the rat model (Figure 1e). Additionally, the rt-SNN is validated via integration to the rat model or after the migration of human parameters to the human model using a neuro stimulator (Figure 1d). The mem-SNN is validated in similar manner to rt-SNN with the biological model using integration via transcutaneous or invasive stimulation.

PARAMETER SENSITIVITY ANALYSIS IN MULTISCALE AGENT-BASED MODELING OF ATHEROSCLEROTIC PLAQUE PROGRESSION

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Abstract

Enhancement of precision and reliability in simulation models requires the exploration of advanced sampling techniques and parameter optimization strategies. This study integrates Latin Hypercube Sampling (LHS) with parameter adjustment methodology to explore the variability of simulation outputs, focusing on an Agent-Based Model (ABM) for atherosclerotic plaque progression sensitive to parameter variations. The ABM model is a multiscale model relying on an input consisting of vessel geometry accompanied with a set of variable and invariable parameters and coefficients. To preserve the integrity of simulations, it was of utmost importance to determine a specific range of variables that can be changed without disrupting the simulation as such. The research emphasizes improving model's generalization capabilities by systematically varying parameters within defined ranges, including constant and dynamic parameters, to evaluate their impact on the simulation results.

LHS was used to generate a comprehensive parameter space, consisting of 8 distinct parameters, with two set as constants and the remaining six subject to variation within specified ranges, as suggested by Corti et al. (2022). The parameters that were considered for LHS were: probability of mitosis, smooth muscle cell (SMC) proliferation in tunica media, parameter driving SMC proliferation in intima, parameter driving mitosis in medial layer, probability of lipid infiltration, probability of extracellular matrix (ECM) degradation, intima thickening coefficient and probability of lipid invading intima. This approach facilitated the generation of diverse, yet evenly distributed, parameter sets to feed into the ABM simulations. The process iteratively adjusted one of the varying parameters to its default value in each simulation run, ensuring a thorough exploration of the parameter space. The simulations were executed based on these parameter sets, and the results were thoroughly analyzed to identify patterns and dependencies.

The application of LHS in conjunction with the parameter adjustment strategy revealed significant insights into the model's sensitivity to various parameters. The patterns observed when performing simulations using parameter sets derived from LHS with the custom-developed ABM are consistent with those observed in relevant literature (Corti et al. 2022). Initial findings indicate a pronounced impact of certain parameters on the simulation outcomes, specifically the parameter driving SMC proliferation in intima increased probability of lipid infiltration and increased ECM degradation led to a 2-fold increase in plaque in the vessels, highlighting their potential as critical levers impacting model's behavior, suggesting areas for further investigation and optimization.

Performing LHS contributes to mitigation of limitations imposed onto the results by intrinsic model constraints, such as model simplifications. By systematically exploring the parameter space and identifying key parameters with pronounced impacts on model outcomes, this research lays the groundwork for future refinement of simulations and results.

Keywords: agent-based model, Latin hypercube sampling, parameter optimization, atherosclerosis.

Acknowledgement

EFFICIENT SEQUENTIAL DETECTION: ENHANCING CANCER DETECTION IN SEQUENTIAL MRI SEQUENCES

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Abstract

Conventional object detection models are typically trained to detect objects in images devoid of sequential correlation. However, in the context of MRI imaging, where data are inherently sequential, valuable information lies within the adjacent slices for cancer detection. While 3D neural networks present a logical avenue to exploit this sequential nature, their high parameter count and complex training dynamics pose significant challenges. Additionally, mutual attention mechanisms, although effective, often necessitate a large volume of training data, which may not always be readily available in medical settings.

In response to these challenges, our proposed method efficiently harnesses the sequential characteristics of MRI data by integrating information from preceding, current, and succeeding slices. Notably, this integration is strategically incorporated into specific segments of the network architecture to optimize performance. We provide empiric results and give practical advice for using our method with existing architectures. By seamlessly integrating this approach into the YOLOv5 framework, we achieved a notable 2.8% enhancement in the mean Average Precision (mAP).

Keywords: object detection, sequential data, YOLOv5, brain cancer, MRI.

TEXT-TO-SQL TRANSLATION: APPLICATION OF DEEP LEARNING APPROACH FOR SERBIAN LANGUAGE

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Abstract

Analytical systems would significantly benefit from allowing users to issue queries in natural languages, as this could expand the user base to include those who are not proficient in SQL, a typical query language used for interaction with data warehouse systems. This served as the motivation for the development of text-to-SQL tools, which have been leveraging large language models (LLM) in recent years to substantially improve the accuracy of translated queries. While mainstream research in this field primarily focuses on English language-to-SQL tools, our work investigates the applicability of state-of-the-art open LLM models, such as Mistral-7B, Google Gemma 7B, and Code Llama 7B, for Serbian natural language-to-SQL translation. We selected these LLMs because they are capable of running in a local computer environment without requiring substantial computational resources, enabling standalone applications without dependencies on external systems. Additionally, we are interested in exploring zero-shot and few-shot learning systems, which should remove the necessity for preparing a large set of natural language-to-SQL query training pairs and thus improve generalization.

Keywords: Text-to-SQL, LLM, zero-shot, few-shot.

IMPROVING VELOCITY ESTIMATION IN GPR RECORDINGS USING MACHINE LEARNING APPROACH

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Abstract

Often, the ground penetrating radar (GPR) is not considered a precise and rigorous measurement tool, but rather a tool for sub-surface exploration. One way of getting precise information about sub-surface objects and their surrounding media is excavation, which is usually demanding, time-consuming and, sometimes, unfeasible. For that reason, the GPR has been widely used in numerous fields. However, the correct interpretation of acquired recordings tends to be challenging, especially when the subsurface propagation velocity is unknown. To avoid wrong interpretations, the precise estimation of velocity is necessary. Underground cylindric objects appear within the B-scans as hyperbola-shaped features with different characteristics. A widely used approach for velocity estimation is the hyperbola fitting method, still, numerous factors can have an impact on the features and thus reduce the effectiveness of such a method. Accordingly, with the assistance of the machine learning method, the velocity estimations of the hyperbola method can be improved. The dataset used in this research is generated using gprMax software consisting of 158 unique B-scans, each with specific characteristics. As a performance measure, the coefficient of determination along with 5-fold cross-validation is used. In order to achieve satisfactory results, ANN architecture with four hidden layers and 128 neurons is utilized. The first hidden layer has a linear activation function while the remaining three have an elu activation function. Additionally, the dropout is applied after the second, third, and fourth hidden layers with the value of 0.2. The output layer has 1 neuron with a linear activation function. For the ANN training process across all 5-folds, the RMSprop optimization algorithm is utilized with the learning rate value of 1e-5 along with the mean squared error as a loss function. Moreover, the early stopping is utilized during the training to prevent overfitting. The traditional hyperbola fitting method achieved an R2 value of 0.669 ($\sigma = 0.095$), while the integration with artificial neural network (ANN) resulted in 0.875 ($\sigma = 0.042$). In the case where additional parameters such as diameter and the angle between the survey line and cylindric object are known, the R2 with the value of 0.984 ($\sigma = 0.011$) is achieved. Obtained results reveal that the proposed integration of the hyperbola fitting method with ANN improves velocity estimation in GPR recordings.

Keywords: ground penetrating radar, B-scan, hyperbola fitting, velocity estimation, machine learning.

TEMPERATURE AS A FACTOR SHAPING DISSOLVED OXYGEN IN THE DANUBE RIVER

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Abstract

With increasing industrialization and urbanization, human activities have led to numerous problems with climate (such as global warming and sea-level rise), terrestrial (such as deforestation and soil degradation), and aquatic ecosystems (such as eutrophication and hypoxia), which may have severe consequences on life on earth. The health of terrestrial waters is of utmost importance for the sustenance of aquatic ecosystems, and dissolved oxygen (DO) represents one of the key indicators used to evaluate water quality. In this study, we used data spanning from 2012 to 2021 on flow velocity and temperature of the river Danube (measuring station Novi Sad), obtained from the State Hydrometeorological Service of Serbia (in Ser. RHMZ) website, and data on DO, obtained from the Serbian Environmental Protection Agency (SEPA) website, to investigate the intricate relationships among these variables.

Firstly, a Random Forest regression algorithm was deployed to predict DO levels using flow velocity and temperature as predictors, resulting in R^2 equal to 0.85 (MSE=0.59; RMSE=0.77). SHapley Additive exPlanations (SHAP) values highlighted that temperature exerted a more pronounced influence on DO levels than flow velocity. Building upon this foundation, an autocorrelation function was integrated into the Random Forest regression algorithm, incorporating DO data from previous time steps, and this enhanced model achieved an R^2 equal to 0.97 (MSE=0.11; RMSE=0.33). SHAP values further elucidated that O2 from preceding time steps had the most substantial influence on the predictive accuracy of the model, followed by temperature and flow velocity. Autocorrelation and partial correlation function plots (ACF and PACF) for DO, underlined its strong correlation with adjacent time steps. Cross-correlation analyses of the studied variables revealed distinct relationships between them. Notably, temperature exhibited a strong negative correlation with DO, again emphasizing its pivotal role in shaping dissolved oxygen levels, while flow velocity exhibited moderate negative correlation with DO.

In conclusion, this research contributes valuable insights into the dynamics governing terrestrial water health, emphasizing the indispensable role of temperature in modulating DO levels. Understanding complex interrelationships between different environmental factors is crucial for effective water management and conservation strategies. In the face of escalating environmental challenges, as global temperatures continue to rise due to climate change, safeguarding the quality of terrestrial waters becomes increasingly imperative.

Keywords: water health, dissolved oxygen, Southeast Europe, hydrology, climate change.

DEEP LEARNING SEGMENTATION OF THE PORCINE SUPERFICIAL FEMORAL ARTERIES OCT IMAGES

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Abstract

Peripheral artery disease is an atherosclerotic disease that represents accumulation of cholesterol in any artery, excluding coronary arteries, while forming different types of depositions called plaques, which cause thickening of the arterial walls making it difficult for the blood to flow to lower extremities. According to the statistics, approximately 8.5 million Americans over 40 are affected by peripheral artery disease, out of which one fourth falls into the severe category. For these reasons, it is extremely important to detect the disease as soon as possible. In this paper, we provide a deep learning approach for lumen and intima segmentation of porcine femoral arteries as an important pre-step for the use in humans. Method proposed in this paper focuses on tree different convolutional neural networks and highlights the difference in results. Proposed networks include modified U-Net, SegNet and PSPNet networks. Modifications include the use of different encoders in the case of SegNet and PSPNet and modification from the aspect of depth for U-Net architecture. We evaluated our methods on manually annotated OCT images from 8 specimens in terms of F1-score and overall quality of the reproduced masks. Experimental results show that modified U-Net provides us with the best results for lumen and intima segmentation with F1-scores 0.9842 and 0.9672. Results also show that modified U-Net outperformed other architectures proposed in the literature.

Keywords: convolutional neural networks, segmentation, peripheral artery, optical coherence tomography, deep learning.

Acknowledgement

RECURRENT NEURAL NETWORKS FOR ENERGY MANAGEMENT SYSTEMS: A CASE STUDY

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Abstract

Hybrid energy systems, which integrate diverse energy sources including solar power plants, supercapacitors, UPS batteries, generators, hydrogen cells, and the grid, represent sophisticated yet highly promising approaches to enhancing energy efficiency, reducing operational costs, and supporting renewable and grid-independent initiatives. The inherent complexity of these systems necessitates the energy management strategy (EMS) capable of judiciously allocating resources in line with demand forecasts. A critical component of devising an effective task scheduling system within this framework is the ability to generate precise forecasts of energy production from renewable sources - solar power in this case. This paper showcases the deployment and comparative evaluation of two advanced deep learning models, Long Short-term Memory Recurrent Neural Networks (LSTMs) and Bidirectional Long Short-term Memory Networks (BiLSTMs), and our proposed Ensemble model, which averages the forecasts from LSTM and BiLSTM models, developed at our Laboratory for Energy Management ({LabE). Our primary goal is to predict solar power output for three days at 15-minute intervals. Incorporating thirteen weather features, our findings reveal that the proposed models perform well in predicting energy production data, with the Ensemble predictions showing the best performance for 15-minute interval forecasts spanning three days.

Keywords: solar power, energy management, recurrent neural networks, LSTMs, BiLSTMs, deep learning.

DATAFLOW HARDWARE ADVANCEMENTS FOR SUPPORTING ARTIFICIAL INTELLIGENCE ALGORITHMS

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Abstract

The raising need for artificial intelligence applications poses new demands on computer hardware and algorithms development. Both faster processing and lower power consumption are needed. Dataflow hardware proves to be more energy efficient due to the lower frequencies and denser computing compared to control-flow programming. However, the utilization of dataflow chip die surface is not uniform. The diversity is the result of dataflow hardware implementation of algorithms and diversity in algorithm execution. If an algorithm is presented as a dataflow graph, certain paths might be utilized more than others. However, each path requires amount of FPGA resources comparable to the length of the path. This paper aims to present a new model for controlling frequencies of dataflow kernels adjusted to the expected amount of processing of available kernels. Results indicate that trading between frequencies of certain kernels can improve the execution speed of the dataflow hardware, without jeopardizing the durability of the chip die due to the heating.

Keywords: dataflow hardware, dataflow kernels, hardware frequencies.

ARTIFICIAL INTELLIGENCE ANXIETY AMONG YOUNG ADULTS IN MONTENEGRO

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Abstract

Rapid development followed by integration of artificial intelligence (AI) across various fields holds promises to enhance productivity and economic growth. However, it simultaneously poses a challenge, necessitating millions worldwide to adapt by changing careers or upgrading their skills, introducing a novel form of anxiety known as AI anxiety (AIA). Artificial Intelligence Anxiety represents a multifaceted psychological phenomenon characterized by feelings of fear, apprehension, or unease regarding the integration and impact of AI technologies on individuals' lives and society. To quantitatively assess this emerging concern, this research employed thoroughly validated instrument Artificial Intelligence Anxiety Scale (AIAS) aimed at measuring the extent and implications of AI anxiety. Notably, this study extended the applicability of the AIAS beyond its initial context by translating it into Serbian and disseminating it among young adults in Montenegro. The survey was conducted on a sample of 200 participants, selection based on age criterion. Statistical analysis (Anova, t-test, correlation) revealed important insights into how AIA affects younger population's learning and adaption behaviors. While the translation and application of the AIAS scale provided valuable cross-cultural insights, potential cultural biases and the limited geographic concentration of participants should be acknowledged. Further research should explore a more diverse age range to fully understand AIA's broader implications. This study contributes to bridging the gap between technological advancements and human responses, particularly within educational and professional development contexts.

Keywords: artificial intelligence, anxiety, artificial intelligence anxiety scale.

EVALUATING BAYESIAN APPROACHES FOR WATER QUALITY CLASSIFICATION: A COMPARATIVE STUDY

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Abstract

This study undertakes an in-depth examination of the performance of various Bayesian models in classifying water quality as safe or not safe, using a comprehensive dataset of chemical water parameters. Water quality is crucial for every segment of life and with the increasing importance of reliable and prompt water quality information for environmental monitoring and public health, advanced computational methods are vital. Bayesian approaches, known for their probabilistic foundation and capability to handle uncertainties, provide a promising method for addressing this need.

The dataset under examination is a collection focused on key chemical indicators of water quality. It includes twenty different chemical parameters, among which are aluminum, cadmium, radium, nitrates, uranium, etc. Given that Bayesian models naturally work with discrete values and all dataset parameters are continuous variables, we employed a quantile-based discretization method. This technique effectively transformed the continuous input variables into categorical counterparts, thereby making the dataset compatible for subsequent analysis with Bayesian models. Next, four distinct Bayesian classifiers - Naive Bayes (NB), Tree Augmented Naive Bayes (TAN), Forest Augmented Naive Bayes (FAN), and a General Bayesian Network (BN) - were implemented and evaluated. Each model's structure and the conditional probabilities distribution tables (CPDs) were carefully derived based on the empirical evidence from the training dataset. This approach allowed for a nuanced representation of the complex relationships between chemical indicators and water safety, ensuring a robust and data-driven predictive modeling process. Each model's performance was rigorously assessed using a variety of metrics, including Accuracy, Precision, Recall, F1 score and particularly Matthews Correlation Coefficient (MCC) to consider the dataset's imbalance. The results indicate that while NB provides a fundamental approach, its performance, along with TAN and FAN, may be compromised by overfitting due to data imbalance. In contrast, the BN model, with its focus on significant features, exhibited consistent performance across training and testing datasets, indicating effective learning and generalization. Specifically, the BN model achieved an accuracy of 91.731%, a precision of 95.121%, a recall of 95.583%, a F1-score of 95.351%, and a MCC of 0.58. These results underscore the model's balanced and robust performance, especially in the context of an unbalanced dataset. Additionally, the CPDs extracted from the BN model explained the relationships between specific chemical concentrations and water safety. Taking all factors into account, this study underscores the integration of Bayesian models into water quality assessment frameworks, particularly advocating for the BN model due to its balanced precision, recall and reduced bias.

Keywords: bayesian networks, water quality, bayesian classifiers, naive bayes, augmented naive bayes.

CAN ARTIFICIAL INTELLIGENCE MITIGATE INTRA-ORGANIZATIONAL MORAL OUTRAGE? A THEORY-BASED MODEL

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Abstract

Research and practice have identified the growing use of artificial intelligence-powered solutions in crisis risk mitigation and crisis communication planning. However, there is limited evidence of artificial intelligence (AI) application in internal crisis communication, particularly in crises caused by internal organizational actions like employee layoffs, closing production plants, or reducing production capacities. Such organizational actions are causing strong concerns among the employees and consequently impact their wellbeing. Research from other fields indicates that artificial intelligence can have mitigating power on the moral outrage caused by unfair and discriminatory actions. Considering moral outrage as a boundary condition of the Situational Crisis Communication Theory (Coombs & Tachkova, 2023), this paper introduces a theory-based construct - the AI-Powered Moral Outrage Risk Mitigation Model. The proposed model, based on the paradigm of internal crisis communication, demonstrates possible capability of artificial intelligence to play risk mitigating role in moral outrage-induced intra-organizational crises. The paper also discusses the necessary assumptions and limitations of the model, highlighting the importance of AI's decision-making transparency for effective mitigation of intra-organizational moral outrage.

Keywords: crisis communication, internal communication, intra-organizational crisis, artificial intelligence, employee wellbeing.

CAN CHATGPT WRITE PARALLEL CODE?

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Abstract

Large language models (LLMs) have been used in many research fields in recent years. Their ability to generalize was observed in many commercial and scientific domains leading to successful applications in customer support, finance, social sciences, machine translation, and programming. LLMs showcased the ability to solve complex programming problems, especially with the advancements of transformer models and introduction of production tools, such as Open AI ChatGPT and Github Copilot, as well as open source solutions, such as StarCoder, Code Llama, WizardCoder, etc. For that reason, more and more software development tools included LLM support for tasks such as intelligent code completion, error detection, code refactoring and similar. In this paper, we conducted a preliminary evaluation of the ChatGPT abilities to produce parallel code based on existing sequential code. We focused on directive-based OpenMP programming model. During the conducted experiment, we asked ChatGPT to annotate three different sequential applications and compared them to baseline sequential and hand-written OpenMP solutions.

In our experiments, we used a simple algorithm for pi number calculation (PI), single precision dense matrix-matrix multiplication application (SGEMM), and Monte Carlo simulation for the calculation of the area of the Mandelbrot fractal (MBROT). PI and MBROT are compute bound applications, while SGEMM is a memory bound application. All three applications exhibit different execution patterns and need different parallelization strategies. Although ChatGPT could manage to correctly annotate the code in all cases, it could not match hand-written parallel code in terms of performance, as it still lacks deeper understanding of different aspects of parallel programming, especially in terms of synchronization and scheduling strategies.

Keywords: ChatGPT, large language models, parallel programming, parallel code.

AI-POWERED PRIOR ART SEARCH: TOWARDS ENRICHING INTELLECTUAL PROPERTY MANAGEMENT?

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Abstract

The purpose of this paper is to examine how efficiently Artificial Intelligence (AI)-supported patent analytics tools such as Patsnap's Eureka, IPRally and others detect relevant prior art connected to a specific patent. AI and Machine Learning (ML) techniques have been prominently used to efficiently solve various problems ranging from bioinformatics to image processing. Both AI-powered patent analytics tools and generative AI using Large Language Models have the same roots in Natural Language Processing (NLP), which predicts semantic probabilities. Our research questions are: can semantic search using NLP better inform intellectual property (IP) management by providing results faster and with greater accuracy than traditional search within patent databases? How well do the results (prior art patents) which we get by traditional database search and AI-powered search match each other? How well do results within different AI-powered IP tools match each other?

We concluded that AI-supported prior art search can provide results faster, they are visually transparently sorted with titles, abstracts and images, which enables quick decisions regarding the relevant state of the art. However, in our case, most of the results proposed by IP tools were not closely connected with the presented invention. Between tools, there were significant differences. Although our assumption was that IP tools should provide similar results if data coverage is the same, our research cannot confirm this assumption. However, AI-supported IP analytics tools develop progressively and in the next few years, they will certainly successfully complement or even displace traditional prior art searching. We believe that utilising generative AI presents a transformative approach to augmenting prior art searches. By harnessing the power of NLP and machine learning algorithms, generative AI will enable the comprehensive analysis of patent texts, research papers, and other documents, thereby enhancing the efficiency of identifying relevant prior art, which will transform the workflow of inventors, IP attorneys, patent examiners, IP management professionals and other users.

Keywords: artificial intelligence, patents, prior art search, state-of-the-art search, AI-powered patent search, AI-powered IP analytics tools.

EVALUATING GDPR AND HIPAA IN THE INTEGRATION OF ML/AI FOR FUTURE-PROOFING HEALTHCARE

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Abstract

This paper provides a comparative review of the General Data Protection Regulation (GDPR) and the Health Insurance Portability and Accountability Act (HIPAA), as two key regulatory frameworks at a time of increased interest in the application of artificial intelligence (AI) in healthcare. The biggest barriers to the widespread application relate primarily to the non-standardized medical records that are in daily use, the limited availability of certain data sets, as well as the strict legal and ethical requirements for ensuring the privacy of patients.

For that reason, the focus of the research is aimed at a comparative analysis of the security measures and risks covered in the two mentioned regulations, and to which the health data are exposed in the processes of their processing. By assessing the protocols and standards for health data management recommended in both regulations, special emphasis is placed on the provision interoperability and portability of data, which is of utmost importance for the correct and complete integration of machine learning (ML) and AI.

By providing a summary of the conducted analyses, this study makes a direct contribution to bridging the gap between AI and ML researches and their practical application in the area of healthcare.

Keywords: GDPR, HIPAA, artificial intelligence, machine learning, protocols, regulatory frameworks, healthcare standards.

AI-GENERATED SOFTFAKES AS DISRUPTORS OF POLITICIAN-CITIZEN INTERACTION: ETHICAL CONSIDERATIONS

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Abstract

The elections in Pakistan, held in February 2024, brought a new dimension to using artificial intelligence in communicating with politicians and citizens. During the campaign, opposition leader Imran Khan was imprisoned. Due to his inability to participate, AI-generated videos with his reactions to election events have been created and broadcasted with his consent. Audio and video content that untruthfully shows that a person has said or done something is labeled as deepfake and belongs to the category of fake news. Generative AI development enabled users to create deepfakes easily with minimal technical knowledge. The public's desire for sensationalism and the need for immediacy in transmitting information are triggers for massive creation and quick dissemination of deepfakes. In the political arena, this type of content is typically used as a tool for defamation of political opponents. Nevertheless, the purposeful application of AI-generated videos created with the subject's consent, as during the Pakistan elections, sets the stage for a completely new category of content – softfakes.

This innovative approach opens numerous ethical dilemmas. The systematic review of the available literature indicates that the creation of deepfakes is associated with numerous challenges, irrespective of whether it is created with the subject's consent. Generative AI can be used to create and convey multiple pseudo-authentic political messages. Its application in campaign content creation can save time, increase the amount of broadcast content, and enable candidates to reach wider audiences. Opposite to softfakes, AI can be used to hyper-reproduce fake audio and video content, aiming to discredit the opponent and negatively affect his or her reputation. This paper aims to draw the boundaries between deepfakes and softfakes in political campaigns and outline ethical standards for the use of AI in the communication of decision-makers and election candidates with citizens.

Keywords: softfake, political communication, deepfake, artificial intelligence, disruptive technology, AI ethics.

APPLIED ARTIFICIAL INTELLIGENCE IN DETECTING HATE SPEECH

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Abstract

The term "Hate Speech" has been known for a long time. Still, with the development of the Internet and the more significant number of users on the Internet, it has become very popular on a global level. By spreading from traditional media to the Internet, this phenomenon has led to the creation of cyberbullying (electronic violence), which unfortunately retains all aspects of traditional violence. One of the key problems of today's Internet is that hate speech needs to be regulated in a comprehensive manner, in a way that incorporates all principles, standards and determines the particular responsibilities of authors of hate speech, internet service providers, web forums, and hosts, social media platforms, online intermediaries, moderators of blogs and others performing similar roles. To solve this increasingly massive problem, it is desirable to automate the detection and classification of such written hate speech texts. In this paper, machine learning model is applied to detect hate speech and classify it. The concept of the proposed solution uses the datasets that will be formed in project STOP (http://stop.etf.bg.ac.rs).

The research aims to generate and collect textual data in the Serbian language from various online sources, including social media platforms, media/news portals, blogs, online forums, and websites that encourage user-generated content. These sources have been identified as rich repositories of user interactions and public discussions, making them valuable for capturing instances of hate speech. The textual data collected form the foundation for training, optimising, and evaluating the hate speech detection software system. It can be concluded that the topic of this research is state-of-the-art at the moment. On the other hand, it can be noted that more than 96% of scientific research on hate speech and the application of artificial intelligence in detection is oriented towards English, followed by Chinese and Arabic languages. The number of researches for the detection of hate speech in the Serbian language is negligible and thus further studies are necessary.

Keywords: hate speech, Serbian language, convolutional neural networks, recurrent neural networks, BERT architecture

DATA ANALYSIS TECHNIQUES AND DETECTION OF PROPAGANDA IN SERBIAN ONLINE MEDIA IN 2023

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Abstract

The detection of propaganda, or propaganda techniques, in the field of natural language processing, is defined as the task of text classification. Natural Language Processing (NLP) represents a narrower area of the branch of computer science called machine learning and deals with the study of methods and techniques for computer processing and interpretation of textual data written in one of the natural languages. Detection of propaganda in the context of text classification is a task characterized by a high degree of complexity, primarily due to the existence of a large number of different propaganda techniques and the variety of topics they cover, and it represents a challenge for building models for binary, and especially for multi-class classification.

The main task in this paper is the construction of a system for detecting propaganda, which in the context of NLP belongs to the problems of text classification. For these purposes, a linear classifier was used as the basic, baseline model, which uses features obtained according to the bag-of-words (BOW) principle, that is, a bag of n-grams, where each text is represented in the form of an unordered set of words or n-grams in them, and each word or n-gram represents one feature. After that, linear models that use features obtained according to the bag-of-embeddings principle (BOE) were examined, where each text is represented as an average of the vector of word meanings in it, and each dimension of such an averaged vector is treated as a feature in the classification. The concept of word meaning vectors is explained later in this chapter.

Transfer learning represents one of the approaches for improving the development of statistical solutions in the context of limited annotated resources. It includes a large number of methods, the basic idea of which is to train a model or some part of it on a problem or domain for which there is sufficient data, and then to use such a model to solve a specific problem of interest, for which there is a limited amount of available data.

In the processing of natural languages, the use of word meaning vectors is extremely widespread, as a form of transfer learning. They represent vectors of fixed length, which numerically represent the meaning of words, and are based on the distributional hypothesis that words with similar meanings are used in similar contexts. The vector representation of the meaning of words leads to the effect that semantically close words are located close to each other in the vector space, and allows the meanings of words to be compared through the similarity of their vectors. Nowadays, the most widely used approach is the construction of word meaning vectors using neural networks, and these include the popular models word2vec, GloVe, and fastText, which was used when creating the solution in this paper.

This research included texts from 2023 that were published on the portals of RTS, Politika, B92, Blic, N1 and Danas. The texts were collected in real time, because some media portals do not have an archive. The analysis included news from the politics category, due to assumptions that the largest number of propaganda articles are in that category. By analyzing the static content of internet pages, it was concluded that all newspaper portals that are the subject of analysis are suitable for parsing. The Scrapy and BeautifulSoup libraries were used as the main tools for this purpose.

Five topics were selected in the research: the president, the opposition, elections in Serbia, Kosovo and the European Union, and the data set after filtering contained about 7 thousand newspaper articles. After sampling, the research and definition of propaganda techniques that are present in the Serbian electronic media was started, after which, with the obtained set of 10 propaganda techniques and their associated instructions, the procedure of data annotation followed. For the binary classification task, even simpler linear classifier models show some ability to distinguish propagandistic from non-propagandistic content, however, on the thirteen-class classification task, they fail to find a way to distinguish specific propaganda techniques.

Keywords: natural language processing, web scraping, propaganda, Serbian language.

SCIENTIFIC PRODUCTION AND COLLABORATION PATTERNS OF MEDICAL RESEARCHERS: A CASE STUDY IN EPIDEMIOLOGY AND INFECTUOUS DISEASES

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Abstract

This study employs social networks analysis to investigate scientific collaboration within the field of immunology and infectiology at the University of Belgrade, Faculty of Medicine. A primary dataset for this analysis is obtained using publicly available data about employees and their publications registered in the Scopus database between 1982 and 2020. A co-authorship network is constructed and analyzed using both integer and fractional counts for co-authorship. Basic network metrics reveal the network's classification as a small-world network with medium density and high clustering. Further analysis focuses on the organizational division of authors into four departments, unveiling significant collaboration between authors across departments. Community detection techniques are employed to reveal finer community structures within the network. Assortativity analysis, calculation of the rich-club coefficient, and exploration of power-law properties indicate a healthy research environment with minimal centralization of node influence. Centrality and brokerage analyses distinguish researchers with numerous co-authors from those with fewer co-authors, validating the utility of both weighting schemes, while ranking the distinguished researchers by each of these criteria, thus giving further insight into the collaboration dynamics of the environment.

Keywords: social networks analysis, co-authorship networks, community detection, rich-club phenomenon, small world networks.

Acknowledgement

PREDICTING ELECTROSPUN PCL/PEG NANOFIBER DIAMETER USING ARTIFICIAL NEURAL NETWORK

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Abstract

The formation of electrospun fibers can be influenced by numerous parameters, so the prediction of morphological characteristics of the fiber is a very demanding task. The impact of different parameters on the diameter of nanofibers is most often examined. In order to facilitate and speed up the process of obtaining the thinnest fibers, in this research the artificial neural network method was applied to predict the diameter of the nanofibers made in the electrospinning process. Fibers were produced from polymer solutions containing polycaprolactone and polyethylene glycol and then analysed with an optical microscope. Mean diameters were measured from obtained images by ImageJ software. A three-layer ANN model was designed, with solution concentration as input variable and measured fiber diameter as the output. The R^2 coefficient value of 0.999 indicates the high accuracy of the model. The results show that the actual and predicted diameter values agree to a large extent. The thinnest fibers had a diameter of 0.531 µm and were obtained for a solution concentration of 23.17%. The effectiveness of ANN in predicting the diameter of nanofibers has been proven.

Keywords: electrospinning, nanofibers, diameter, prediction, artificial neural networks.

THE FUTURE OF MANUFACTURING: GENERATIVE AI AND BEYOND

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Abstract

This paper examines the transformative role of generative artificial intelligence (AI) in revolutionizing manufacturing processes. By harnessing the power of generative AI models, manufacturers can unlock new frontiers of creativity, efficiency, and sustainability. These models enable the automatic generation of design variations, optimization of production workflows, and customization of products to meet individual consumer preferences. Moreover, by leveraging machine learning algorithms to analyze vast datasets and simulate complex scenarios, generative AI empowers manufacturers to make data-driven decisions, anticipate market trends, and mitigate operational risks. Generative AI plays a crucial role in data-driven decisions and analysis across various fields i.e. data augmentation, imputation of missing data, generating insights, simulation and scenario planning, anomaly detection, personalization and recommendation systems. Primarily focused on generating new data points that are similar to the training data it has learned from. The goal of generative AI is to create new content, fill in missing data, or simulate realistic scenarios. Generative AI Outputs generate data points that mimic the statistical distribution of the training data. These outputs can be images, text, music, or any other type of data. Trained on a dataset without specific target labels. The generative AI model learns the underlying distribution of the data and tries to generate new data points that fit this distribution. Despite the undeniable potential of generative AI in manufacturing, several challenges and considerations merit attention. Ethical concerns surrounding data privacy, algorithmic bias, and job displacement loom large in discussions about the widespread adoption of AI technologies in industrial settings. Moreover, the technical complexities of implementing generative AI solutions, the need for skilled workforce training, and the integration of AI systems with existing manufacturing infrastructure pose significant hurdles that must be addressed. This paper seeks to stimulate further research and dialogue on the transformative impact of generative AI in manufacturing, prompting scholars, industry practitioners, and policymakers to collaborate in harnessing the full potential of AI-driven innovation. By illuminating the synergies between human creativity and machine intelligence, this research aims to pave the way for a more sustainable, adaptive, and dynamic future of smart manufacturing.

Keywords: smart manufacturing, generative AI, machine learning.

AI AS A CATALYST FOR RESEARCH TALENT DEVELOPMENT: ELEVATING EMPLOYER BRANDING TO FORGE A CUTTING-EDGE WORKFORCE

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Abstract

The rapid evolution of Artificial Intelligence (AI) has emerged as a disruptive force in the realm of talent development and employer branding strategies, redefining the approach to cultivating a leading-edge workforce. The main aim of this paper is to examine the multifaceted role of AI as a catalyst for fostering a cutting-edge workforce, emphasizing its potential to significantly elevate employer branding and attract, develop, and retain top-tier research talent. It also presents a comprehensive examination of the dual impact of AI on enhancing research talent capabilities while simultaneously elevating employer branding strategies. Through a comprehensive analysis of current trends, challenges, and opportunities within the domain, the paper examines how AI-driven tools and platforms can revolutionize talent acquisition processes, personalized learning pathways, and the overall employee experience.

It also focuses on how effective utilization of AI in employer branding not only positions scientific organizations as leaders in innovation but also as attractive destinations for ambitious researchers seeking to advance their careers in dynamic and supportive environments. By exploring successful case studies, the paper identifies key strategies and best practices at the intersection of AI, talent development, and employer branding. Additionally, this paper aims to provide significant contributions to understanding how AI can be leveraged to enhance employer branding and forge a resilient and adaptive workforce, poised to meet the challenges and seize the opportunities of the contemporary research landscape.

Keywords: artificial intelligence, employer branding, talent acquisition, workforce, research talent development.

FACTORS INFLUENCING AI PREDICTION OF SOCIALLY UNDESIRABLE BEHAVIORS OF FOSTER CARE CHILDREN

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Abstract

The social protection system aims to empower the individual and the family for a productive life, and to eliminate the causes and consequences of possible social exclusion of the individual and the family. In such a setting, children without parental care are among the most vulnerable categories of the population that social protection deals with. Literature and practical insights suggest that children come to foster families highly traumatized from biological families due to various events: death of parents, physical, psychological, or sexual abuse, gross neglect, labor exploitation, etc. These risk factors greatly influence the manifestation of various socially unacceptable behaviors.

The purpose of the research is to identify factors for children aged 7 to 17 that need to be included in a predictive AI-powered model that will enable the determining of possible manifestation of socially undesirable behaviors. The systematic review of literature indicated that key risk factors come from the biological family, the environment, and the peer group. Key predictive behaviors include dropping out of the school system, premature entry into sexual relationships, underage marriages, use of psychoactive substances, lower educational achievements. The data set was balanced different smooth technique, and then a stacking classifier was employed to ensemble multiple algorithms to predict various types of different behaviors. The proposed approach successfully predicted undesirable behavior types with 93% of accuracy, precision, recall, and *F1*-Score. The AUC value of the same was 0.89. Deep Learning methods effectively evaluate the demographic and spatial-temporal characteristics of the undesirable behaviors and predict the occurrences of various subtypes behaviors.

The future AI-powered model needs to facilitate identification and prediction of children who enter the social protection system with a high possibility of exhibiting some socially unacceptable behavior. Creation of such a model will enable professionals to intensify their work and direct it to areas that are potentially risky for a particular child. Moreover, adequate use of AI in combination with professional counselling would prevent the occurrence and possible escalation of socially undesirable behavior.

Keywords: artificial intelligence, social care, social services, predictive analytics, behavioral psychology.

A NOVEL MODEL FOR DIVERSIFYING AI BASED RECOMMENDER SYSTEMS FOR SOCIETAL WELL-BEING

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Abstract

In this study, we explore the potential societal impact of recommender systems, focusing on their capability to shape user experiences and provide personalized content recommendations. Despite their promising advantages, one cannot overlook the considerable risks recommendation algorithms introduce. These risks encompass the reinforcement of echo chambers, the enlargement of extreme viewpoints and discrimination, and the invitation of addictive behaviors. These problematic aspects have cumulatively sparked public alarm about polarization, addiction, and reduced creativity due to algorithmic biases, significantly influencing our daily digital channel recommendations.

In order to anchor our proposal within the existing landscape of recommendation system research, we analyze seminal works of literature, emphasizing the steps taken by previous studies as well as the gaps that persist in existing models. We elaborate on how our model distinguishes itself from extant literature, by integrating aspects of artificial intelligence (AI) into its methodology, instead of merely discussing AI on a rudimentary level.

Aiming to confront these emerging challenges, we have formulated a novel model that promotes recommendation diversity across various dimensions. This includes different emotional tones, content categories, and political attitudes. We have maintained an explicit focus on algorithmic processes and parameters, ensuring that our methodology is robust, innovative, and replicable.

We shall use a similarity score model that incorporates diverse factors. The model could be represented as:

$$S(u, c) = w1*E(u, c) + w2*C(u, c) + w3*P(u, c)$$

Where:
- $S(u,c)$ is the recommendation score for user u and content item c
- $E(u, c)$, $C(u, c)$, and $P(u, c)$ are the emotional, content, and political similarity scores between user u and content item c, respectively
- $w1$, $w2$, and $w3$ are weights for each dimension that sum to 1. These weights can be adjusted to emphasize or de-emphasize certain dimensions, depending on the goal of the recommendation.

To build out this model and determine optimal weights, we could apply machine learning techniques or conduct experimental studies. While $w1*E(u, c)$ focuses on matching the emotional tone of user u and content c, $w2*C(u, c)$ ensures that the recommended content falls under a category that user u is interested in. On the other hand, $w3*P(u, c)$ ensures a range of political attitudes are represented in the recommendations. This formula encapsulates our approach to creating a diverse, balanced, and personalized set of recommendations while minimizing the risk of fostering echo chambers or promoting extreme viewpoints.

This model serves as a computer science remedy designed to cultivate ethical and responsible deployment of recommendation algorithms, thereby fostering a more inclusive and balanced digital environment. Besides expanding content diversity, our approach also aspires to enhance user

engagement, spur critical thinking, and fortify societal cohesion. The model represents a computer science solution to enhance the ethical and responsible deployment of recommendation algorithms, fostering a more inclusive and balanced online environment. Our model offers a comprehensive and technically feasible solution for fostering a more inclusive and balanced online environment, promoting user engagement, critical thinking, and societal cohesion through diverse content recommendations.

Further research and testing are essential to validate the effectiveness and scalability of our proposed model in real-world settings. We acknowledge the importance of further research and real-world testing as vital next steps to verify the effectiveness and scalability of our proposed solution.

TRANSFORMING LEARNING: ADAPTING TO GENERATIVE AI TECHNOLOGIES IN THE SERBIAN EDUCATIONAL PARADIGM

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Abstract

This paper explores the transformative potential of Generative Artificial Intelligence (GAI) technologies in revolutionizing the Serbian educational system. With the rapid development and widespread adoption of GAI tools like ChatGPT-4, Serbian education stands at the cusp of a significant paradigm shift. This document provides a comprehensive examination of the integration of GAI technologies, highlighting the challenges, opportunities, and strategic measures necessary for successful implementation. It delves into critical areas such as infrastructure enhancement, ethical considerations, data protection, and the professional development of educators. By outlining a phased implementation strategy, the paper aims to equip policymakers, educators, and technologists with actionable insights for leveraging GAI to enhance educational equity, improve learning outcomes, and prepare students for a future dominated by digital literacy. Ultimately, this exploration contributes to the broader discourse on leveraging advanced technologies to foster an inclusive, innovative, and effective educational environment, emphasizing the urgency and necessity of GAI's benefits in the Serbian educational system.

Keywords: generative artificial Intelligence, Serbian educational system, digital literacy, ethical considerations, technological integration.

BENCHMARKING GPT-4 IN SENTIMENT ANALYSIS AND BIAS DETECTION: AN EVALUATION OF ADVANCED LARGE LANGUAGE MODELS IN TEXTUAL UNDERSTANDING

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Abstract

In the evolving landscape of Natural Language Processing (NLP), advanced models such as GPT-4 have heralded a transformative shift in machine-based textual understanding. Through a comprehensive evaluation workshop, this research paper aims to analyze the comparative grading of GPT-4 with a human triple rating procedure delivering insights on the efficacy, stability, and potential biases of the GPT-4 model in textual analyzes. The objective is to scrutinize the GPT-4 model's performance, focusing on its application in analyzing sentiment, political alignment, and social values. Linked to linguistic pragmatics, the research design also seeks to uncover any biases inherent in the GPT-4 model while processing these textual constructs. Utilizing a diverse sample of experienced participants, our workshop employs a parallel design where human gradings and GPT-4 analyses are conducted on the same text segments. The research extends beyond a single grading session to include subsequent repetitions of GPT-4 analysis for consistency validation. Exploring the temporal stability of GPT-4 will yield insights into its constancy and predictive validity over time. Envisioned as a foundational step, this research paves the way for future engagements with AI in textual understanding, informing the development of more sophisticated models. By exploring the convergence and deviation of AI machinery with the human cognition process, this research paper strives to contribute to the broader scientific discourse on machine learning and textual analysis. As we venture deeper into the era of cognitive computing and NLP, such studies advance our understanding of AI's capabilities, informing its ethically sound application in the future.

Keywords: GPT-4, textual analysis, sentiment analysis, large language model, bias detection.

THE ROLE OF ARTIFICIAL INTELLIGENCE IN TRANSFORMING HOTELS IN DEVELOPING COUNTRIES, WITH A SPECIAL FOCUS ON THE REPUBLIC OF SERBIA

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Abstract

This study explores the role of artificial intelligence (AI) in transforming hotels in developing countries, with a focus on the Republic of Serbia. Conducted among hotel management and staff across Serbia, the research involved 214 respondents. Results indicate a high level of support for the implementation of AI, highlighting its potential to enhance efficiency, customer experience and competitiveness. The study emphasizes the importance of technological innovation in the hospitality industry and provides insights into the industry's readiness to adopt and embrace AI technologies. This paper contributes to an understanding of current trends and future perspectives on the use of AI in the hospitality sector, with special attention to the challenges and opportunities in developing countries like Serbia.

Keywords: AI, hospitality, developing countries, Republic of Serbia.

FEATURE SELECTION FOR LYING POSTURE CLASSIFICATION

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Abstract

Introduction: Tracking sleep postures is essential for analyzing a persons' in-bed behavior and sleep quality. Monitoring sleep postures over time in bedridden patients who are unable to move or change their position regularly, can be crucial in preventing pressure ulcers. The goal of this paper is to select appropriate features for classifying lying postures by applying both statistical analysis and machine learning (ML) techniques.

Method and materials: We use the Pressure Map Dataset for In-bed Posture Classification (PMD) which is openly available on the PhysioNet repository. A total number of topographic maps is 685 and they are divided into three classes: Supine (SP), Left Lateral (LL), and Right Lateral (RL) in-bed positions. The proposed methodology for feature selection includes data preprocessing to standardize measurements from two subsets of data. We extracted 9 features overall to identify key posture characteristics suitable for the subsequent posture classification. To address the class imbalance of the PMD dataset, data augmentation techniques employing Gaussian and pink noise are implemented. The normality of data is tested using the Shapiro-Wilk test. Since data are not normally distributed, we use the Kruskal-Wallis test with Dunn's post-hoc testing and with adjustments for multiple comparisons for non-normally distributed data. For all tests, the *p*-value is set to 0.05. In parallel, we employ the Random Forest (RF) classifier. RF is chosen for its proficiency in feature selection and its effectiveness in relatively small datasets. The model is initially trained on the whole feature set. Subsequently, the recursive elimination of features is conducted to obtain the feature subset with the best-performing RF evaluation parameters. The assessment of models' performance is conducted using accuracy and F1 scores.

Results & Discussion: Kruskal-Wallis and post-hoc tests reveal that only one feature is indicative of a statistically significant difference between classes (SP, LL, and RL) in the original dataset. The augmentation by adding Gaussian noise and pink noise results in three and two significant features, respectively. Feature *frame_width* is the only consistent parameter across all three comparisons. On the other hand, the best-performing RF model achieves an accuracy of 91.1% and an F1 score of 91.0% with augmentation obtained by adding pink noise. Interestingly, the best RF model is achieved when the *max_body_width* feature is excluded from the initial dataset. Although similar at first glance, *frame_width* and *max_body_width* carry different information as revealed by both statistical tests and RF evaluation parameters. Regardless of the feature selection procedure, RF successfully distinguishes SP and both lateral classes, but it has degraded performance when distinguishing lateral postures from each other.

Conclusion: The applied comprehensive approach for feature selection results in a recommended set of features and in the proposed augmentation strategies to improve classification performance in the

context of in-bed posture analysis. Yet, the recognition of LL compared to RL classes should be addressed in our future research.

PROCESSING OF BIG DATA AFTER TRANSCRIPTOME SEQUENCING AT SINGLE CELL RESOLUTION

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Abstract

Characterizing the transcriptome of each individual cell is crucial for understanding complex biological systems and molecular mechanisms. In our case, we investigated the immune reaction, i.e. peripheral blood mononuclear cells (PBMCs), to the contamination of polystyrene nanoparticles. A total of 4 single-cell sequencing samples (one control and three different treatments) were analyzed. Raw sequencing data were analyzed with the Cell Ranger software and visualized using Loupe Browser software. Cell Ranger is a set of analysis pipelines that processes Chromium Single Gene Expression data to align reads, generate Feature Barcode matrices and perform clustering and gene expression analysis. Each element of the matrix is the number of UMIs (Unique Molecular Identifier) associated with a feature (row) and a barcode (column). Principal component analysis (PCA) and t-distributed stochastic neighbor embedding (t-SNE) algorithms on single-cell sequencing samples were carried out. Loupe Browser is an interactive data tool that enables the visualization and analysis of the single-cell data. This desktop application requires no prior programming knowledge and it is very user-friendly for researchers in the field of biology, medicine or pharmacy. The expressed cells were clustered during which typical cell marker genes were used for annotation. Genes showing adjusted p-value < 0.05 and |log2 (fold change) | > 0.5 were considered to be marker genes. In this way, gene markers for individual cell types obtained based on single-cell sequencing are a good model for the analysis of biological events.

Keywords: bioinformatics, scRNA-seq, sequencing, big data, single-cell.

MULTILABEL CLASSIFICATION PROCESS OPTIMIZATION THROUGH THE UTILIZATION OF TRANSFER LEARNING APPROACHES SUPPORTED BY DECISION POSTPROCESSING TECHNIQUES

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Abstract

Transfer learning, as a machine learning technique, is based on transferring previously acquired knowledge from one classification task to another. The application of transfer learning in the creation of deep neural networks allows for the newly created model to start with predefined weights instead of randomly assigned weight values, and thus achieve better classification achievements, have reduced training time and even in some situations require less training data. In this concrete study focused on a multilabel classification problem of uncovering one or more respiratory diseases or radiological findings in chest X-ray images, a comparison was made between models trained with and without the utilization of transfer learning. Both approaches were supported by a result postprocessing system which was made to rectify possible mistakes which can arise as a byproduct of the nature of multilabel classification. Comparison was made between these models using two modified classification accuracy metrics. Neural networks trained with randomized starting weight values achieved 61% and 94% patient-based and disease-based accuracy, respectively. In contrast, the model that utilized transfer learning by using weights from a network which solved a similar respiratory disease classification problem achieved 64% and 96% patient-based and disease-based classification accuracy, respectively. While the increase of 3% over the stricter accuracy metric does not seem like a large improvement, the number of mistakes made on a disease by disease basis was reduced by one third, since the number of incorrectly classified instances was reduced from 6% to 4%. In addition, the models trained from transferred weights required significantly less training time to reach results that are up to standard, requiring 5 hours for model training, in contrast to 16 hours required for the other approach.

Keywords: deep learning, multilabel classification, transfer learning, postprocessing.

PIXELS TO PROGNOSIS: A DATA-DRIVEN DEEP LEARNING APPROACH FOR GASTRIC CANCER DIAGNOSIS

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Abstract

Gastric cancer is one of the most frequently identified malignant tumor types, responsible for approximately 18% of global cancer-related deaths. Human factor can limit the decision-making process, leading to potential oversights during the diagnosis. Integration of the Convolutional Neural Networks (CNNs) offers a promising solution for gastric cancer diagnosis. CNNs excel in automatic feature detection extraction, making them ideal for tasks such as histopathological image analysis and classification of the gastric tissue. We define elemental convolutional and fully connected blocks, and three CNN architectures were proposed which differ one from another in terms of complexity, number of blocks and parameters. Utilizing various image analysis methods accurately describes the underlying structure of gastric tissue, enabling intelligent classification system design. Careful examination of the tissue allows for informed selection of the CNN architecture, leading to 15% increase in model's accuracy compared to uninformed CNN architectural design. Evaluation of performance on three gastric tissue datasets with different resolutions, 80x80, 120x120 and 160x160 resulted in model achieving 86.6%, 88.17% and 85.3% accuracy, respectively. Although this approach defines a CNN model which yields results slightly worse than the results of commonly known pre-trained models, it performed results with a lot less parameters. Our approach employs a specialized CNN demonstrating slightly inferior performance compared to large, pre-trained models while requiring notably fewer parameters for the task of binary classification of histopathological gastric tissue images. This study shows the potential for achieving satisfactory results using neural network models on standard computing hardware, making the technology accessible to a broader audience, as supported by its cost effectiveness and reliability.

Keywords: deep learning, convolutional neural networks, image classification, computer vision.

Acknowledgement

LOCAL EXECUTION OF LARGE LANGUAGE MODELS: DEMOCRATIZING AI THROUGH ON-DEVICE OPTIMIZATION

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Abstract

Large Language Models (LLMs) have transformed various domains but their ubiquitous reliance on third-party cloud services raises concerns regarding accessibility and privacy. This research addresses these challenges by exploring optimization techniques for efficient local execution of advanced LLMs on standard user devices, thereby democratizing AI and empowering users with privacy-preserving experiences.

The study includes an in-depth examination of current transformer architectures, identifying their inherent vulnerabilities, emphasizing the necessity of local execution to ensure user privacy, and addressing challenges with model-specific optimizations. A systematic categorization and evaluation of optimization techniques are presented, featuring a comparative table that highlights the trade-offs between effectiveness and implementation complexity. We then present a dual optimization strategy: Algorithmic optimization, including Activation-aware Weight Quantization (AWQ), which significantly reduces model size while maintaining high response quality; System-level optimization using parallel computing to enhance processing speeds on consumer-grade devices.

Industry assessments examine ongoing developments and the potential for on-device LLM inference.

Preliminary tests with chat-based models demonstrate CPU feasibility with good user experience (tokens/second, answer quality). We find optimal LLM-device configurations (e.g., LLaMA-2-7B on CPU with 16GB RAM for best balance between model complexity and hardware affordability, Phi-2 on CPU with 8GB RAM for more accessible solution).

This critical review of AI's current landscape anticipates further refinement in optimization techniques with examination of emerging models and industry advancements. By addressing critical challenges and proposing viable solutions, this research aims to facilitate the potential of broader adoption of LLMs while ensuring responsible development and more inclusive application of AI.

Keywords: large language models, efficient ML, quantization, Edge AI, democratization of AI.

AUTOMATIZATION OF 3D RECONSTRUCTION OF CORONARY ARTERIES FROM ANGIOGRAPHY PROJECTIONS USING AI-ENHANCED SEGMENTATION TECHNIQUES

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Abstract

Fractional flow reserve (FFR) is one of the clinical diagnostics measurements that are performed to assess the physiological significance of stenosis potentially present in coronary arteries. Virtual fractional flow reserve (vFFR) is an alternative non-invasive approach that consists of performing the 3D reconstruction of the patient-specific coronary artery and afterwards applying techniques of computational fluid dynamics (CFD) to obtain the vFFR value. Within this paper, the patient specific DICOM images obtained during X-ray angiography (XRA) examination are used to extract the information necessary to describe geometry of the vessel. Several techniques were previously proposed in literature for this task, but they mostly include manual intervention from the clinician. In this study, this process was automated by using image filtering techniques for region of interest extraction coupled with binary image skeletonization for obtaining centerline information. Additionally, branch length equalization based on multipoint matching and duplicate removal was conducted in order to avoid manual point annotation in multiple X-Ray views. Epipolar geometry based on XRA C-ARM position and matching point pair positions in different views was used to create the centerline and surface point cloud reconstructions in 3-dimensional space. After the positional argument extraction, the meshing procedure was applied, to generate the 3D finite element (FE) mesh that is then employed to perform CFD simulations using the software based on FE method and calculate the FFR equivalent. The developed software is accurate, executes in a timely manner and is intuitive to use, which makes it a useful tool for the clinicians to perform hemodynamic analyses of the state of the coronary arteries. It can thus provide assistance in the treatment planning that is adapted to a specific patient.

Keywords: X-ray angiography, image segmentation, 3D reconstruction, CFD, FFR calculation.

Acknowledgment

THE EVALUATION OF RETRIEVAL AUGMENTED GENERATION TASKS FOR DIFFERENT LARGE LANGUAGE MODELS FINE-TUNED FOR THE SERBIAN LANGUAGE

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Abstract

Large Language Models (LLMs) have revolutionized the field of Natural Language Processing (NLP) in recent years by enabling the use of far more advanced and complex model architectures. Having models with millions or even billions of available parameters suggested that the typical NLP tasks such as Text classification, Text Summarization, Text Generation and Question answering will be even more straight-forward and reliable. But, bearing in mind that the vast majority of Large Language Models tend to include various biases and express hallucinations, different approaches were introduced to tackle such problems. Concretely, in the domain of Question Answering, techniques such as Retrieval Augmented Generation (RAG) have been proposed. The idea behind this paper is to incorporate RAG based technique into an environment where different LLMs fine-tuned using different data sets in the Serbian language will be used. The proposed implementation focuses on the task of Question answering using RAG with LLMs specifically fine-tuned for such a problem. The evaluation metrics in question are specific to the use-case of Retrieval Augmented Generation and not just Question Answering. By doing so, an approach using the Metrics-driven development can be incorporated. In that way, the answers given by the Large Language Models are subjected to an even higher degree of reliability. It is important to keep in mind that the true challenge of such an implementation also lies in the limited availability of datasets in the Serbian language and adequate Language Models equipped for such a task.

Keywords: retrieval augmented generation (rag), large language models (llms), natural language processing, evaluation of rag systems, metrics-driven development.

APPLICATION OF REMOTE SENSING INDICES IN VEGETATION MONITORING

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Abstract

This study demonstrates the effective use of remote sensing indices, particularly the Normalized Difference Vegetation Index (NDVI), for monitoring vegetation changes over a period of five years, from 2018 to 2023. Utilizing Sentinel-2 satellite imagery accessed through the Google Earth Engine Code Editor, we conducted a comprehensive analysis to quantify vegetation dynamics in specified areas of interest, i.e. the Republic of Serbia. The research focused on calculating the NDVI values for the years 2018 and 2023, thereby facilitating a detailed assessment of vegetation loss, gain, and no-change status across various landscapes. Our findings reveal significant temporal fluctuations in vegetation cover, attributed to a combination of natural and anthropogenic factors. The study underscores the utility of NDVI, derived from Sentinel-2 images, as a reliable indicator for tracking vegetation health and changes at high spatial and temporal resolution. This research contributes to the growing body of knowledge on environmental monitoring and management, offering insights into the patterns and drivers of vegetation dynamics. The methodology employed showcases the potential of leveraging satellite remote sensing technologies for enhanced understanding and stewardship of natural resources.

Keywords: remote sensing, vegetation, monitoring, Sentinel-2, remote sensing indices.

ARTIFICIAL INTELLIGENCE-BASED ANOMALY DETECTION WITH IDENTIFYING AND MITIGATING ABNORMAL TRAFFIC PATTERNS ASSOCIATED WITH THE DDOS ATTACK IN SOFTWARE-DEFINED NETWORKING

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Abstract

Software-Defined Networking (SDN) has emerged as a revolutionary paradigm for network management, offering dynamic control and programmability. However, the open and programmable nature of SDN introduces new challenges, particularly in terms of security. Abnormal traffic does not necessarily mean an attack, but the detection of anomalous patterns and their mitigation in abnormal traffic is a critical aspect in terms of effective protection of SDN entities. In this context, artificial intelligence (AI) techniques have shown great promise in enhancing network security by enabling the identification and mitigation of abnormal traffic patterns. This paper explores the use of AI-based anomaly detection algorithms in SDN environments to detect and mitigate network attacks patterns in abnormal traffic effectively. Initially, specific features were extracted from the SDN environment under normal conditions and during DDoS attack scenarios to create a dataset that contains over 100.000 records which is a substantial amount for conducting analysis. Since different protocols differ in their structure, the entire data set was divided into four sub-datasets according to their specific characteristics (ARP, ICMP, TCP, UDP). As the basis of AI, we employed a variety of machine learning (ML) techniques, including Support Vector Machine (SVM), Decision Tree (DT), Logistic Regression (LR), Random Forest (RF), and Naive Bayes (NB), to train and classify different types of anomalies. The results we have obtained underscore the ability of AI to effectively recognize and detect anomalies in abnormal traffic.

Keywords: software defined networking, machine learning, artificial intelligence, abnormal traffic, anomaly detection.

HOW ARTIFICIAL INTELLIGENCE IS TRANSFORMING HUMAN RESOURCE MANAGEMENT?

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Abstract

Traditional procedures, manual processes and intuition are no longer sufficient to navigate the complex sea of modern dynamic workforce management. Artificial intelligence is increasingly being implemented in the human resource management function in companies due to its great potential to improve business and create new value for consumers, employees, the environment, the social community and the companies themselves. Constant research in this area, of which there are very few in our country at the moment, can establish the prerequisites for the development of human resources and methods of improvement. From predictions derived from scientific research in the world, it is assumed that the implementation of artificial intelligence in human resources management will create the possibility for the application of a much more extensive range of activities and ways of working, an incomparably faster flow of information and its processing, improvement of motivation, creativity, efficiency and effectiveness of employees, which it can further significantly improve the efficiency and effectiveness of companies, and therefore the overall operations of companies and their success.

In the world, great importance is attached to this topic, which, without a doubt, indicates the fact that it is a current and important field of management and which confirms the fact that the application of artificial intelligence has a great impact on the growth and development of the company, to achieve its effectiveness, efficiency and innovation , but only if it is used correctly, ethically and with understanding and the necessary knowledge for its application, because otherwise, as in all other areas of work, its application can lead to various abuses or bad and harmful use if it is managed by a person who does not have enough understanding, knowledge and creativity for it.

The application of artificial intelligence in the management of human resources has been very little theoretically and methodologically examined and analyzed in Serbian scientific theory and practice. However, in recent times, interest in studying the concept of human resource management development through the application of artificial intelligence has been increasing.

In modern business conditions, the most valuable resources are people and their knowledge, skills and abilities, so the application of artificial intelligence in companies in Serbia in all aspects, including in the aspect of human resources management, will depend on the ability of employees in companies to understand, accept and implement new knowledge and new techniques of its application. Existing research in the world serves as a basis for understanding the current operational state of use and benefits for companies and provides useful information for the future development of the human resources management system. However in many companies in our country the application of artificial intelligence is not even in the long-term plans, so this paper contributes to the development of the application of artificial intelligence in Serbian companies.

The goal of this paper is to raise awareness among human resources managers and other employees in companies in Serbia about the importance of applying artificial intelligence in all phases of human resource management, from the selection of job candidates to the development of employee skills and the retention of talented employees.

Keywords: human resources management, artificial intelligence, company, employees.

DEVELOPMENT OF A CONVOLUTIONAL NEURAL NETWORK FOR CLASSIFICATION OF HEART SOUNDS UTILIZING MEL-FREQUENCY CEPSTRAL COEFFICIENTS

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Abstract

Cardiovascular diseases are the leading cause of death worldwide, accounting for more than 30% of all global deaths. It is estimated that more than 17 million people lose their lives each year due to the heart attacks and strokes. In daily clinical practice, monitoring and analyzing a patient's heart sounds via auscultation is essential in detecting any irregularities, such as murmurs, clicks, snaps, etc. This non-invasive initial screening procedure allows doctors to gather information about the heart's condition without any invasive procedures, proving to be time-saving and cost-effective. High prevalence and mortality rates of heart diseases have led to an increased need for automatic and efficient diagnostic tools that could assist medical professionals in the analysis of heart sounds. This paper introduces a convolutional neural network (CNN) model that is designed to identify and categorize various irregularities in heart sounds from stethoscope audio recordings. In order to train the proposed CNN model, a publicly available dataset containing hundreds of heartbeat audio recordings was utilized. Since sound signals can be quite complex, it was necessary to extract the main characteristics of the sound and format them in a way that is suitable for the training of the CNN model. Mel-Frequency Cepstral Coefficients (MFCCs) are designed to capture key spectral properties of a sound signal automatically and format them as small sets of numbers that are easily understandable by a deep learning model. Our proposed model achieved promising results, not only in the detection of irregular heart sounds, but also in the classification between different types of heart sound abnormalities.

Keywords: convolutional neural network, deep learning, heart disease, Mel-frequency cepstral coefficients, voice processing.

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EXPLORING MACHINE LEARNING APPROACHES FOR PREDICTING THE RESILIENCE OF WATER RESOURCES SYSTEM UNDER HAZARDOUS EVENTS

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Abstract

Climate change-induced extreme weather events affect water systems, causing operational challenges and functional failures. Earthquakes and consequential landslides are other common causes of disruption. Assessing system resilience is crucial to avoid the failure of water systems.

This research aimed to explore various approaches in developing a machine learning model to predict the water system's robustness and the system's recovery time from external or internal hazards (rapidity). The dataset was obtained by simulating the system dynamics model and hazard model of the hydroelectric power plant. A thorough examination of the data preceded the model's construction. Random Forest (RF) and Artificial Neural Network (ANN) models were fitted to the training dataset. The ANN model fine-tuned using the Keras-tune approach yielded a high R^2 score. To overcome the imbalanced dataset problem, the synthetic minority oversampling technique (SMOGN) was utilized. Due to highly imbalanced data for the Robustness values over 0.2, even the implementation of the SMOGN technique could not yield an R^2 score over 0.8.

The dataset was also modeled as a classification problem, using K-means clustering to group Robustness and Rapidity values into classes. The best classification model obtained was compared with the existing Fuzzy rule-based model which enables comprehensible reasoning using natural language. Precision, Recall and F1 score values of the ANN Keras-tuned model were better than the same metrics for the fuzzy model, but the explanatory capability was lost.

Keywords: exploratory data analysis, imbalanced data, machine learning.

AI- AND COMPUTER-BASED MODULE FOR 3D RECONSTRUCTION OF PATIENT-SPECIFIC CAROTID ARTERIES AND PLAQUE PROGRESSION SIMULATION

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Abstract

The main purpose of this study was automatic segmentation and 3D reconstruction of patient-specific carotid artery and simulation of plaque progression in order to provide more detailed understanding of processes related to atherosclerotic disease. The proposed method integrates deep learning techniques to automatically segment ultrasound (US) images, alongside meshing techniques for reconstructing a 3D patient specific model, utilizing the segmented regions of interest as input. After creation of 3D models of carotid arteries, the simulation of time-dependent plaque progression was performed using PAK-Athero software based on Finite Element Analysis (FEA) and Agent Based Method (ABM). This module, as part of the TAXINOMISIS platform, was evaluated in the TAXINOMISIS clinical study, involving the longitudinal collection of data among six European clinical centers (baseline and three follow-ups) from patients diagnosed with moderate to severe carotid stenosis (stenosis degree >50%) over a period of two years. Utilizing the imaging data of these patients, 3D patient-specific models of carotid arteries were reconstructed using coupled AI and computer-based methods. Afterwards, the dynamic evolution of atherosclerotic plaque under various patient-specific geometries and conditions was quantified by analyzing velocity, shear stress distribution and Low-Density Lipoprotein (LDL) concentration. The resulting values were correlated with zones of plaque formation and progression, which was validated by comparing the observed plaque with clinical data across different time points.

Keywords: 3D reconstruction, plaque simulation, deep learning, image segmentation, finite element modelling

Acknowledgment

ADAPTING ALL-OPTICAL ACTIVATION FUNCTIONS FOR PREDICTING STOCK PRICES ON THE FRANKFURT STOCK EXCHANGE

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Abstract

One of the primary objectives of Fintech is to assist the general population in making better and optimal financial decisions, ultimately leading to improved wealth and satisfaction. This emerging multidisciplinary field is based on new technologies, such as machine learning i.e., artificial intelligence, predictive behavioral analytics, and data-driven marketing. It aims to remove guesswork and habitual decision-making from financial decisions, thereby significantly impacting social well-being. Furthermore, it will enrich social interactions among scientists and researchers from different institutions and fields of expertise, such as physics and finance. This will influence how they connect, collaborate, and build virtual communities.

This paper extends previous research on the appliance of machine learning for stock price prediction of the BELEX dataset. However, for future real-time applications involving big data, it is crucial to exploit the advantages of photonic hardware accelerators, i.e., high-speed operation and a high-level of workload parallelization with low-power cost of computation. Therefore, we employed a model of an all-optical activation unit in a fully connected neural network to predict the stock prices of individual companies of the Frankfurt stock exchange. The activation unit, based on the Fabry-Perot laser diode under optical injection, has been implemented both numerically and experimentally. The achieved optical nonlinear transfer function can be tailored by controlling the frequency detuning between the input optical signal and the Fabry-Perot laser's side mode under injection, resulting in sigmoid-like profiles with different threshold and saturation points. Therefore, the profile of the activation function can be adjusted to fit to a specific application.

For the testing, a financial dataset of the Frankfurt Stock Exchange (FVB) was created, comprising 38 major German companies, in the period 2013-2020. The target was to predict the stock prices of individual companies in the next January, based on data from the previous year. The selected dataset includes several variables such as average price, average market volume, and monthly average of several economic indicators. The standard activation functions are not normalized, thus there are no input constraints imposed during the training procedure. Conversely, our activation functions are normalized and the analytical form with which they are fitted requires positive input values. In this case, the algorithm is structured such that input normalization within each layer is conducted to span the range from 0 to 1, thereby leveraging the complete profile of the activation function. Among the standardly used activation functions, the best mean absolute percentage error (MAPE) is 15.7%, achieved by the ELU activation function. Our work demonstrates that by reconfiguring the activation unit to provide optimal nonlinearity, we can reduce MAPE to 9.5%, using the exact same neural network architecture.

Acknowledgment

COMMUNITY EVENT DISCOVERY USING 'X' DATA STREAM

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Abstract

In recent years, significant research has been carried out to discover current events and the number of events from X's data stream and to reveal the contextual dimension of events. One of the major challenges in this context is that most traditional methods have to estimate the number of events in order to contextually analyze events. Another problem is that some methods tend to detect events that often trigger a significant volume of communication. In this study, we propose a community-based event discovery system that reveals events by applying community detection on the graph representing the co-occurrence relations of n-grams that are frequently observed in X's posts. We evaluate the effectiveness of the proposed system over a dataset used as a comparative dataset. Our system shows the success of discovering as many events as the number of existing events in an unsupervised manner. It also represents each event with words and multiple-word distributions, helping to analyze the subject of events contextually.

Keywords: community detection, event detection, event discovery, N-gram, X, Twitter.

FOLDER DESIGN OPTIMIZATION WITH GENETIC ALGORITHM FOR DRUG COATED BALLOON FOLDING

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Abstract

Peripheral Artery Disease (PAD) significantly impacts patient quality of life by reducing blood flow to the extremities, leading to severe complications. The treatment protocol often includes the use of drug-coated balloons (DCB) during percutaneous transluminal angioplasty, which can reduce the recurrence of arterial narrowing. However, the effectiveness of DCBs is highly dependent on the precision of the balloon folding process prior to deployment. In this paper, we introduce an innovative application of artificial intelligence (AI) to optimize the folding geometry of DCBs. Utilizing a dataset from Boston Scientific, we employ a genetic algorithm (GA) to explore and optimize folder shapes, aiming to enhance the effectiveness and consistency of balloon folding. Our methodology includes defining fitness functions that evaluate the geometrical configuration and operational functionality, ensuring that the folding process minimizes potential damage to the drug coating and maximizes therapeutic outcomes. Results indicate that AI-driven optimization can significantly refine the folding process, offering potential improvements in the clinical application of DCBs. This study not only advances the engineering of medical devices, but also illustrates the potential for AI to enhance therapeutic efficacy in the treatment of PAD.

Keywords: peripheral artery disease, DCB, design optimisation, genetic algorithms, AI optimisation.

Acknowledgment

MACHINE LEARNING APPROACH FOR PREDICTING JUDICIAL CASE OUTCOME

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Abstract

As a developing country, Nigeria is grappling with the challenge of population explosion. With a huge number of people seeking legal remedies every day, the judicial system in the country appears to be overwhelmed and unable to keep up. This has led to situations where several cases remain pending for extended periods due to limited manpower and infrastructure. To safeguard the vulnerable population and ensure that they receive justice, it has become imperative to resolve all pending legal cases and establish a system that can enhance the effective and timely delivery of justice. In this paper, we propose a machine learning-based approach for predicting judicial case outcomes by training our model on data collected on electoral jurisprudence in Nigeria. We obtained datasets from Sierra Leone and Mali to test our model in other jurisprudences with similar socio-economic profiles to Nigeria.

Keywords: machine learning, judicial decision, electoral jurisprudence, N-gram, X, Twitter.

UNMANNED VEHICLES - TECHNICAL PERSPECTIVE OF AI APPLICATIONS AND SOCIAL IMPACT

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Abstract

Unmanned autonomous vehicles, driven by advancements in artificial intelligence (AI), are transforming numerous sectors including transportation, exploration, and public service. This paper reviews the technical and social dimensions of autonomous cars, boats, and drones, emphasizing their AI applications in perception, decision-making, and control. An autonomous vehicle requires a comprehensive sensor suite to perceive its environment, navigate safely, and make informed decisions. The sensor suite typically includes a combination of sensors such as LIDAR, RADAR, GPS, IMU, cameras, and depth sensors. These sensors provide vehicles with essential information about their surroundings, enabling them to operate autonomously and avoid obstacles. The essential modules and systems that enable autonomous navigation are Guidance, Navigation, and Control (GNC), Perception, and Prediction. The basis for transport automation is the GNC system that utilizes GPS and IMU sensors. Perception is the term used in robotics since a robot needs to perceive, be aware, sense the world / objects around it so it can avoid them if they are on its way. Prediction is a module that anticipates the future motion trajectories of the perceived obstacles. The output of this module gives information to a robot path planner which generates an appropriate trajectory to go around or avoid an obstacle (other traffic participant) that is on the way.

This abstract discusses the dual nature of AI in autonomous vehicles highlighting significant benefits such as improved safety, reduced congestion, and enhanced energy efficiency while addressing critical challenges including data integrity, safety reliability, ethical conflicts, and potential job displacement. Particular attention is given to unmanned aerial systems, detailing their diverse applications from aerial surveillance to disaster response, and discussing the accompanying technical hurdles in localization and navigation. The paper also examines ethical considerations concerning AI in autonomous vehicles, with a focus on decision-making algorithms, accountability, and societal impacts such as privacy and cybersecurity. In conclusion, while unmanned vehicles present remarkable opportunities for innovation and efficiency, they require careful regulation, rigorous interdisciplinary research, and robust ethical frameworks to fully realize their potential and safeguard societal interests.

Keywords: AI-driven systems, autonomous systems, ethical considerations, societal impact, unmanned vehicles.

DESIGN OF NEW POTENTIAL INHIBITOR OF THE GABAA RECEPTOR ASSISTED BY ARTIFICIAL INTELLIGENCE

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Abstract

Nitrogen and oxygen-containing heterocycles have been important synthetic targets of research due to their applications in medicinal chemistry, materials chemistry, photochemistry, etc. In addition, the fact that heterocycles are present in many biologically active chemical compounds highlights the important role that heterocycles play in drug development. These compounds exhibit a broad spectrum of biological activities such as anticancer, anti-tubercular, antimicrobial, anti-inflammatory antifungal, antipyretic, anti-depressant, and anticonvulsant activity, etc. Bearing in mind the biological importance of pyrazole, pyrimidine, and chromeno derivatives, the synthesis of compounds containing these units in one molecule is very important. This can be a starting point for the creation of new pharmaceuticals. It is important to emphasize that phenobarbital (a derivative of barbituric acid) has been used as an anticonvulsant drug with clinical application for many years. The 5-(5-methyl-3-oxo-2,3-dihydro-1*H*-pyrazol-4-yl)-1,5-dihydro-2*H*-chromeno[2,3-d]pyrimidine-2,4-(3*H*)-dione (**L**) is a pyrazol-chromeno[2,3-d]pyrimidine derivative which will be used for future studies related to rational drug design. The research employs molecular docking simulations to assess the binding affinity of **L** and its derivatives with the γ-aminobutyric acid type A (GABA$_A$) receptor, a significant target in drug discovery, particularly for anticonvulsant drugs like phenobarbital (**phb**). Using the Chemically Reasonable Mutations (CReM) webserver, a series of **L** derivatives are generated, and virtual screening is conducted using MolAICal software, which utilizes neural networks and classical programming for 3D ligand design. After screening, five **L** derivatives with lower binding energy values are selected for further analysis. The free energy of binding (ΔG_{bind}) is calculated for all chosen ligands and lower values indicating better binding affinity. The results demonstrate that **L** and some of its derivatives, particularly derivatives **L1** and **L2**, exhibit higher binding affinity to the GABA$_A$ receptor compared to the native ligand, phenobarbital (**phb**). This suggests that these compounds could potentially serve as inhibitors of GABA$_A$ and warrant further investigation for their therapeutic potential.

Keywords: GABA$_A$**, L,** derivatives of **L**, artificial intelligence, virtual screening, molecular docking.

DEVELOPMENT OF A PLATFORM FOR DISPLAYING MEDICAL RESULTS

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Abstract

The platform presents a web application with various functions, accessible to users at any time from any device. Without additional installations and burdening the memory space, users can employ different functions. The use of the online platform is not strictly limited to the type of operating system (OS), while the development of the desktop application, features and requests of the OS should be taken into consideration. Keeping the data on the distant servers would leave out the burdening of the user's memory. The client server architecture, which executes the most important tasks on the backend of the application, additionally proposes a complete operating system and working environment agnostic solution, which requires no version downloads, updates and memory constraint management from the user side. Artificial Intelligence (AI) streamlines the creation of cloud platforms for models by automating tasks such as resource allocation, scalability management, and optimization, resulting in efficient and cost-effective deployment of machine learning models. This study deals with the development of a platform that would enable access to the results of the Fractional Flow Reserve (FFR) method, which serves as a case study. However, all the functionalities can be generalized to any other case. The implementation of the web application begins with defining the input parameters, users' roles, functionalities and information that will be presented, and goes on with designing the platform with the help of prototypes and by defining the architecture. The frontend of the web application is created using Angular framework, which includes HTML and CSS for user interface design, and TypeScript for coding the application's functionals. The data processing development environment is Laravel, which enables data processing, uses controllers to process requests and send responses to the user. If there is a need for certain changes and improvements, the users will not have to update the application themselves, but the latest version will automatically be available. A clear and understandable user interface is an unavoidable condition for a simple use of the software solution. The improvement of both the design of the user's interface and functionality can be done at any moment.

Keywords: digital platform, artificial intelligence, cloud, fractional flow reserve.

Acknowledgement

PREDICTING ABSORBANCE FOR DIFFERENT CONCENTRATION OF AGNPS USING ARTIFICIAL NEURAL NETWORK

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Abstract

The integration of artificial intelligence (AI) with nanotechnology offers significant potential to enhance the understanding and development of nanoparticles, particularly silver nanoparticles (AgNPs), which are pivotal in fields such as biomedicine, electronics, and environmental remediation. This study demonstrates the use of neural networks to predict the absorbance of AgNPs across different concentrations, utilizing a dataset enriched by UV-Visible spectroscopy measurements. A custom-designed neural network, featuring a dual-layer architecture and ReLU activation, was trained on interpolated spectral data spanning various concentrations. The network achieved a near-perfect R2 score of 0.9998247, indicating exceptional accuracy in predicting absorbance values that align closely with experimental data. This predictive model not only reduces the need for extensive empirical testing but also significantly enhances the efficiency of nanoparticle research and development. By enabling rapid and accurate predictions of AgNPs' optical properties, this approach could revolutionize nanoparticle synthesis and application, setting a new standard in the integration of AI within nanotechnology and material sciences. This study not only advances the application of neural networks in predictive modeling but also underscores the transformative potential of AI in accelerating scientific discovery and innovation in nanoparticle technology.

Keywords: silver nanoparticles, neural networks, absorbance prediction; machine learning applications, artificial intelligence in nanotechnology.

Acknowledgement

IDENTIFICATION OF POTENTIAL BIOMARKERS AND PATHWAYS IN DILATED CARDIOMYOPATHY USING BIOINFORMATICS ANALYSIS

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Abstract

Dilated cardiomyopathy (DCM) is one of the most common causes of sudden cardiac arrest and ranks as the second most frequent cause of heart failure. The objective of this study was to identify potential biomarkers and explore the underlying mechanisms involved in DCM, using various bioinformatics approaches. The GSE3585 microarray datachip from GEO omnibus database was analyzed using the Limma function in RStudio and identified 101 differentially expressed genes (DEGs). The results showed 68 up-regulated and 33 down-regulated DEGs. All DEGs were functionally enriched, and the pathway analyzed using DAVID and Metascape. The PPI network was created in STRING and visualized in Cytoscape. Hub genes were retrieved using CytoHUBBA plug-in, and GeneMANIA determined their roles and co-expressed genes. From 101 DEGs, 10 were hub genes: STAT3, HSP90AB1, SMAD7, CCN2, H2AZ1, H1-0, SMAD6, EEF1A1, HMGN2, XPO1. STAT3, SMAD6, SMAD7, HSP90AB1, and CTGF play complex molecular roles in TGF-β signalling, cardiac fibrosis advancement, heart response to high oxidative stress, and cardiac muscle contraction weakness. Histone genes H1-0, H2AZ1 and non-histone gene HMGN2 play a role in epigenetic modelling of gene expression. EEF1A1 is expressed in the heart, although its effect on DCM pathophysiology is unknown. XPO1 mediates nucleocytoplasmic transport and affects DCM cardiac remodeling. Despite valuable insights, this study has limitations. The microarray data, sourced from a public database, has a small sample size, and experimental validation is needed to confirm the obtained results. These findings may lead to therapeutic biomarkers and a deeper understanding of DCM pathophysiology.

Keywords: dilated cardiomyopathy, bioinformatics, hub genes, differentially expressed genes, functional enrichment analysis, Rstudio.

APPLICATION OF ARTIFICIAL INTELLIGENCE IN APPROXIMATING 2D HYDRAULIC CALCULATIONS

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Abstract

The Morava Corridor project involves significant infrastructure development, including the construction of the Pojate-Preljina highway. A critical aspect of this project is a long-term assessment of interactions between the West Morava River, the highway, material borrowing sites located in the floodplain, and groundwater in the river valley. These interactions are simulated using a mathematical groundwater model with boundary conditions that include water levels along the West Morava River and dynamic maps of river overflow into the valley. These boundary conditions can be obtained by 2D hydraulic simulations of the river valley, but the existing 2D hydraulic solvers are computationally demanding and are not suited for long-term simulations, due to prolonged running time. In this work, we aimed to devise a methodology for accurate calculation with significantly shorter running time, by avoiding repeated calculations for similar hydrological scenarios within the simulated period. Using 1D hydraulic computation, we obtained water flows and levels along the river basin for each day within the simulation period of 30 years. A sequence of hydrological episodes was generated using a 3-day moving window over the simulation results. To group similar episodes into clusters we employed K-means clustering and determined a representative scenario for each cluster, for which 2D hydraulic simulation was run. Then, for each day of the simulation, instead of running demanding 2D calculations, we take the results from the representative scenario of the most similar hydrological episode. This approach allowed for efficient simulation of the hydraulic behavior over the projected 30-year period with reasonable computational time. The chosen method balanced the need for computational efficiency with the accuracy required for environmental management and planning, which offers a pragmatic solution to managing large-scale hydraulic simulations within a reasonable timeframe, ensuring that environmental impacts are appropriately assessed and mitigated.

Keywords: hydraulic simulation, K-means, long-term simulations, computational efficiency.

Acknowledgment

MULTI-CLASS BIRADS CATEGORIZATION OF MAMMOGRAPHS USING NEURAL NETWORKS

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Abstract

Recent advancements in medical imaging have facilitated the development of deep learning models that offer significant promise in classifying mammographic images. However, most of these models are limited to binary outcomes -cancer detected or not detected. Our research introduces a novel approach that utilizes existing binary classification models as a basis for a more granular, multi-class categorization of mammograms. For such a task, pretrained neural networks originally designed for binary classification of mammograms are leveraged. Specifically, its output layer is removed, and the newly exposed final layer is used for encodedfeature extraction which is then fed into a newly developed compact neural network. This custom-designed secondary model is specifically tailored to differentiate between finer categories of breast imaging, namely, 0 if the breast required follow-up, 1 if the breast was rated as negative for cancer, and 2 if the breast was rated as normal.

Preliminary results indicate a successful adaptation of the model, maintaining accuracy while providing a more detailed diagnostic that can potentially enhance clinical decision- making. The approach not only extends the utility of existing binary classification networks butalso offers a scalable model for incorporating more detailed classification systems within medical imaging. Future work will focus on refining the model's accuracy with larger datasetsand exploring its adaptability to other nuanced classification tasks within the medical field.

Keywords: feature extraction, mammography, multi-class classification, neural networks.

THE USE OF ARTIFICIAL INTELLIGENCE IN PREDICTING THE SIGNIFICANCE OF MARKERS RELATED TO CELL MOVEMENT

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Abstract

Artificial intelligence is widely used in biology to make predictions about specific cellular behavior. Breast cancer presents the most frequent malignancy in women and one of the leading causes of cancer-related deaths due to the development of metastases and the acquisition of migratory and invasive potential. These properties are regulated by significantly increased markers *SLUG* and *MMP7* in prometastatic cells. However, artificial intelligence has not been used so far to predict cell migratory capacity based on these two significant prognostic markers. In treatment of breast cancer, Paclitaxel is commonly used chemotherapeutic whose anticancer properties are mainly analyzed on MDA-MB-231 breast cancer metastatic cell line. This study aimed to predict the migratory potential of these cells based on the *SLUG* and *MMP7* gene expression levels, detected after 24 h and 72 h of treatment (paclitaxel 10μM). RTCA method provided the signal detected every 5 min, while the gene expression was analyzed by qPCR method at 24 h and 72 h. The method of Artificial Neural Network - Multilayer Perceptron (ANN MPL) was utilized to predict cell migration dependent on marker expression. Our results showed that the treatment induced a significant stimulation of cell migration after 24 h, and this promigratory effect was in agreement with the upregulation of *SLUG* (1.75 times increased) and *MMP7* (1.86 times increased) compared to control. Results obtained using ANN MPL showed that expected progression of cell migration for 72 h is in correlation with increased markers (*SLUG* 2.38 times increased, *MMP7* 2.12 times increased after 72 h). Artificial intelligence used in this study successfully proved that the analyzed markers can be regarded as significant for predicting cellular movement.

Keywords: MDA-MB-231, migration, MMP7, paclitaxel, SLUG, Artificial Neural Network, multilayer perceptron.

Acknowledgment

AI-ENHANCED EXTENDED REALITY IN MEDICINE

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Abstract

Artificial intelligence (AI) applied in Virtual Reality (VR) has emerged as a dominant interaction media in multiple application areas, thanks to its advantage of providing users with immersive experiences. Its use in rehabilitative medicine and psychiatry has made significant progress. This paper aims to make extended reality application that can be used to assist patients that have balance disorders. The main idea of the project was to make an application in which users try to catch falling apples by controlling the movement of the basket by moving their head left and right with the Hololens device on their head. The application was made in Unity environment, using inputs for gaze, gesture, voice, spatial sound and spatial mapping. It was designed to be used on the Hololens device by patients with balance disorder helping them to improve their motoric functions and reflexes., AI can enhance personalization in VR games by analyzing player behavior and preferences in real-time to tailor immersive experiences that cater to individual gaming styles and preferences. It is a promising technology with limitless potential; however, nowadays, its use in healthcare has various limitations due to ethical dilemmas, diagnostic accuracy, data privacy and security. With the further maturation of AI technology in countries leading in VR and AR research and technology, we expect it to have impact on clinical practice and on patients' lives.

Keywords: extended reality technologies, virtual reality, augmented reality, artificial intelligence, medicine.

Acknowledgement

ENHANCED BIOMARKER DETECTION AND HEALTH MONITORING USING AI-DRIVEN MULTI-SENSOR INTEGRATION

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Abstract

The convergence of smart wearable technologies and artificial intelligence (AI) heralds a new era in healthcare, personal wellness monitoring and worker 4.0 applications. Throughout recent research projects in the field, we are on the forefront of this revolution, introducing a set of sophisticated wearable device prototypes which combine an array of printed electrophysiological and electrochemical sensors with advanced AI algorithms to deliver comprehensive health insights and biomarker analysis.

We have ventured into this field with the innovative concept behind the SixthSense project, in which we utilized a multi-sensor array to gather diverse biosignals from first responders and conceptualized ways for enhancing the precision and scope of health monitoring through their fusion. In the follow-up project focused on sustainable flexible electronics, we are now working towards cardiometabolic wearable that integrates ECG, bioimpedance, GSR, temperature sensors, and a suite of electrochemical sensors employing potentiostat readouts for detailed biomarker analysis. This multifaceted sensor integration enables the monitoring of a wide array of health indicators, including metabolic byproducts and stress biomarkers from sweat. Iontophoretic stimulation is adeptly used to augment biofluid extraction, boosting the efficiency and accuracy of biomarker detection.

A pivotal innovation in the device we are developing will be its AI-driven data processing framework, which marks a significant advancement over traditional data fusion methods in wearable sensors. Unlike conventional techniques that often process sensor data in isolation or use simplistic combinatorial algorithms, the AI engine in the envisioned cardiometabolic patch will employ sophisticated machine learning models to analyze and integrate data from the device's diverse sensor array. This AI-centric approach enables a more nuanced and context-aware analysis, capturing intricate patterns and interdependencies in the physiological data that might elude traditional methods. The advantages of integrating AI into the cardiometabolic wearable are manifold. Firstly, AI algorithms excel at handling high-dimensional data, allowing for the simultaneous analysis of multiple biomarkers and physiological parameters. This capability is crucial for detecting subtle, yet clinically significant, changes in health status, thereby enabling early intervention and more personalized health management strategies. Secondly, machine learning models can adapt and improve over time, learning from new data to enhance their predictive accuracy and reliability. This adaptability ensures that this type of wearable can remain at the cutting edge of health monitoring technology, continually refining its assessments and predictions.

AI-driven data fusion in the prototype we are developing facilitates a more holistic understanding of the wearer's health, integrating disparate data streams to provide a unified health assessment. This comprehensive analysis can uncover correlations between different health indicators, offering new insights into the wearer's well-being and potentially identifying emergent health issues before they become overt. In conclusion, the integration of AI in a patch that integrates a batch of electrophysiological and electrochemical sensors represents a paradigm shift in wearable health

technology. By harnessing advanced machine learning techniques to analyze and interpret complex sensor data, this type of cardiometabolic wearable can offer unparalleled accuracy, adaptability, and depth in health monitoring. This AI-enhanced approach not only sets a new standard for precision in wearable health devices but also paves the way for more proactive and personalized healthcare solutions, epitomizing the immense potential of AI in transforming health and wellness monitoring, as well as worker safety.

UTILIZATION OF AUGMENTED REALITY FOR IMPROVEMENT OF BALANCE DISORDERS

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Abstract

Falls in the elderly, as well as in younger people and children, can cause injuries. In the elderly, falls are one of the leading causes of injury and death, and the second leading cause of accidental and unintentional deaths. Falls are considered a major global problem because, in addition to high mortality, they cause a large number of injuries and disabilities, and are the main cause of immobility in the elderly. Balance and problems related to them are one of the most common health problems in older people and in most cases are the primary cause of falls. A measure to improve functionality in maintaining balance and preventing falls is balance rehabilitation. Telerehabilitation implies a system of telecommunication technologies for controlling or monitoring remote rehabilitation and is one of the ways by which the rehabilitation of the patient can be improved. This is a technique that facilitates accessibility to physically or geographically isolated groups with disabilities, potentially saving time and money. The platform of the TeleRehaB DSS project is developed to actively engage patients physically and help them in the rehabilitation process. It contains Virtual Coach (VC) support that is adapted in such a way to effectively enable users to achieve various goals. The TeleRehab DSS system for patients with balance problems delivers a training program at home with the help of VC support. The platform contains two types of games: Exergames and Cognitive games, which are adapted to the needs of patients based on their clinical picture. The active participation of the patient in these games results in significant improvements in the rehabilitation process. "Catching Game" is one of the games within the Cognitive Games section, in which the patient has the task to collect apples that fall from a tree at a certain speed using a basket. The patient moves the basket with head movements to the left or right. By practicing the movement of the head, the patient can achieve benefits in the process of their own balance rehabilitation. Regulating the speed of falling apples as well as their quantity can be achieved by introducing the field of artificial intelligence (AI), which will have the ability to recognize the patient's needs and personalize their experiences, thereby raising the functionality of VC support to a higher level. The VC system in this project points to a bright future in building a method for efficient and successful problem-solving in-patient balance as well as improving the quality of their lives. In the future, the goal is to work on the improvement of these types of systems based on augmented reality with the help of AI that contributes to the rehabilitation of patients by increasing the percentage of their efficiency.

Keywords: telerehabilitation, balance, augmented reality, virtual coaching.

Acknowledgement

OVERVIEW OF THE INTEGRATION OF GENETIC ALGORITHMS AND REINFORCEMENT LEARNING TECHNIQUES

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Abstract

Genetic algorithms, inspired by natural selection and genetics, employ evolutionary principles such as selection, crossover, and mutation to evolve solutions over generations. Reinforcement learning, on the other hand, focuses on learning optimal decision-making policies through interaction with an environment, guided by reward signals. This paper provides an overview of the integration of genetic algorithms and reinforcement learning, highlighting the benefits associated with their combination. Lately, researchers have combined reinforcement learning and genetic algorithms to improve the optimization process. Reinforcement learning agents can be used to choose genetic algorithm operators or tune hyperparameters, enhancing the performance of large-scale problems. Genetic algorithms can also be used to optimize the set of agents for reinforcement learning tasks. The integration of genetic algorithms and reinforcement learning represents a synergy of two powerful paradigms, each offering distinct strengths in problem-solving methodologies. This hybrid approach has the potential to address complex optimization problems and enhance learning systems.

Keywords: genetic algorithms, reinforcement learning, optimization algorithms.

Acknowledgement

AI-DRIVEN SOIL PROPERTY ESTIMATION

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Abstract

In this study, AI deep learning models are applied to data obtained from satellite imagery to estimate key soil properties. The training objective is to identify soil properties suitable for estimation through remote sensing and deep learning, as well as their application in Uganda to improve agriculture and identify sampling and testing locations.

Estimating soil properties is essential in many disciplines, including agriculture, environmental protection, urban planning, and sustainable resource management. Understanding soil texture, pH levels, organic content, and other properties enables farmers to optimize fertilizer and water usage while helping to prevent soil erosion and land degradation. In urban planning, soil property information is crucial for building stable infrastructure and maintaining a healthy environment.

The estimation was performed on 17 properties at different depths, resulting in a total of 44 distinct outputs. The model in this study was trained on a dataset of 540,000 satellite images collected from 45,000 locations across the United States. One image per month was used for each month during the year 2023. The data were sourced from the Sentinel-2 satellite and included 13 visible and infrared channels, cloud probability, cloud mask, and data mask. Twenty percent of this dataset was used for model testing. Results in the United States show that Electrical Conductivity and Sodium Adsorption Ratio can be determined with an error margin of 1%, Soil Organic Matter, Bulk Density, and Calcium Carbonate with an error margin of less than 5%. The model faces the greatest challenge in determining the percentage of Sand, Silt, and Clay, where it has a relative error of about 10-15%. Combining multiple images from different months at one location results in some improvement.

After training, the model was applied in Uganda, particularly in the regions of Sironko, Kumi, and Kabale, where it will be utilized to improve agricultural production and identify locations for sampling and testing.

Keywords: artificial intelligence, deep learning, remote sensing, machine learning.

SYMBOLIC AI IN VERIFIABLE DESIGN OF FINANCIAL EXCHANGES

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Abstract

A financial exchange is a platform where buyers and sellers can come together to trade various financial instruments. These instruments include stocks, bonds, commodities, currencies, and derivatives. Computational core of a financial exchange is the order-matching engine, which handles interaction between buy and sell flows of orders.

We look at the relevant models capturing the computation of a general financial exchange. We are focused on sequential models where instructions (to buy or to sell) are handled in one-by-one fashion. Although we are aware that the computation taking place on a trading venue is intrinsically parallel and concurrent, one first needs to grasp the current state-of-the-art in both finance industry and theory, which is still sequential.

This, coupled with the fact that today's electronic markets are implemented on a premise of continuous time, whereas price is discrete (an error at fundamental level of market design), is the source of undesired phenomena. We first look at the minimal market model, with sequential order matching, in a declarative style, and proceed to illustrate how some fundamental properties can be formally proved. Minimal model derives from the previous research on the general sequential model.

Certifying properties of a fundamental system with 100% confidence is challenging in any realm of human endeavour, especially for systems with infinite state space. With the recent development of theoretical frameworks based on logic, which is a type of a formal AI language, it is now possible, although difficult, to both formalize and reason about an object system in the same language.

The violations of regulatory requirements originate either from interactions between order types, or from the way matching logic is specified and implemented. Formalization and formal reasoning are crucial in mitigating these problems. They provide methods to verify the properties of object system with certainty and have already been applied in the domain of financial derivative contracts. Recently trading systems, as another cornerstone system in finance, have being considered as well.

A general sequential core has been formalized, followed by proving properties such as: the trade always takes place at either bid or ask; the market is never in a locked or crossed state, etc. We look at a minimal market model and point in the direction of future models featuring parallelism and concurrency as intrinsic properties of trade on any trading venue. We also discuss the aspects of electronic trade where machine learning models based on artificial neural networks can be employed. Example of such application is in detection of disruptive or prohibited trading practices, such as spoofing, layering, wash trading, etc.

Keywords: automated reasoning, formal methods, market design, financial systems, symbolic AI, safety, fairness.

CARDIAC SEGMENTATION USING UNETR: A TRANSFORMER BASED DEEP LEARNING APPROACH ON THE ACDC DATASET

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Abstract

Cardiac segmentation plays a crucial role in medical image analysis, enabling accurate diagnosis and treatment planning for various cardiovascular diseases. In recent years, deep learning methods have shown promising results in automating the segmentation process, offering potential benefits such as increased efficiency and consistency. While convolutional neural networks (CNNs) excel at capturing local spatial features, transformers demonstrate superior ability in modeling long-range dependencies and global context, making them increasingly popular in various image processing tasks. Therefore, this study proposes a methodology leveraging the UNet Transformer (UNETR) architecture for cardiac segmentation tasks, particularly on the Automatic Cardiac Diagnosis Challenge (ACDC) dataset, which contains cine-MRI images of the heart acquired from patients with various cardiac pathologies. The manual annotation covers 3 semantic classes: left ventricular cavity (LV), myocardium (MYO) of the LV, and right ventricle (RV). Dataset was upfront divided into training (100 patients) and test subsets (50 patients). Fine-tuning was carried out by initializing the UNETR architecture with pre-trained weights on a large-scale dataset (i.e. ImageNet) and then training the model on the ACDC dataset with a reduced learning rate. The Dice similarity coefficient (DSC) was employed as an evaluation metric to quantify the overlap between predicted and ground truth segmentation masks. UNETR, integrating transformers into the classical UNet framework, exhibits promising performance in capturing long-range dependencies crucial for accurate segmentation. Through rigorous experimentation and evaluation, this methodology demonstrates competitive segmentation results, showcasing the potential of transformer-based architectures in medical image analysis. We demonstrate the robustness and generalization capability of our approach through extensive experiments and comparisons with existing methods (i.e. Segment Anything Model (SAM), MedSAM). Additionally, we provide insights into the interpretability and clinical relevance of the segmentation results, highlighting the potential of deep learning-based approaches in advancing cardiac imaging and clinical practice.

Keywords: deep learning, transformers, medical image processing, multiclass cardiac segmentation

Acknowledgement

IMPACT OF THE DEVELOPMENT OF ARTIFICIAL INTELLIGENCE ON THE STOCK MARKET

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Abstract

Artificial intelligence (AI) has great potential to drive innovation and improve efficiency in the stock market. In this sense, the impact of the development of AI on the stock market needs to be examined from two perspectives. First, it is necessary to consider the impact of AI on the movement in stock prices of companies that invest in the development of AI (AI stocks), and secondly, it is necessary to consider the role of AI in the process of trading stocks. From the methodological part, we observed time series financial data and trends in the stock market. Time span of observing variables is limited to the period 2007-2024. Investment applications with AI have the potential to diminish the advantages of institutional investors. In this regard, AI enables small-scale investors to access trading strategies that were previously only available to hedge funds. On the other hand, AI also helps large investors to be more successful. Despite the intensive development of this type of trade, there are opinions that AI poses a threat only to brokers who are not among the most successful in the market, and that it will be very difficult to replace the most successful market participants. Also, the accelerated development of AI can cause excessive expectations among investors, which can consequently lead to similar stock market events as during the Internet bubble at the end of the nineties of the 20th century. The results have shown that companies which are more oriented to AI realized greater profit rate and market capitalization. Due to the great importance and significant role of AI, all US states have defined regulations that regulate and protect the development of AI. Moreover, within the EU countries, initiatives for more intensive regulation of the development of AI are often considered in order to increase the degree of trust in this technique, but with respect for all measures to encourage its further development.

Keywords: artificial intelligence, AI stocks, stock prices, investors.

THE POSSIBILITY OF BONE FRACTURE PREDICTION IN OSTEOPOROSIS TREATMENT THROUGH THE USE OF AI

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Abstract

Osteoporosis is a progressive bone disease that is characterized by low bone mass and deterioration of a bone tissue. Patients with osteoporosis have higher risk of fractures, which is a primary complication of this disease. Early identification of individuals that have high risk of fracture, during osteoporosis treatment, is crucial for implementing timely interventions to mitigate fracture risk and prevent debilitating consequences. Artificial intelligence (AI) has emerged as a promising tool in predicting bone fractures in osteoporosis treatment. By employing machine learning algorithms and data analytics techniques, AI models can analyze a number of patient-specific factors, such as bone density measurements and scans, which are commonly used to assess a problem of interest. The aim of this work is to provide an overview of recent advancements in AI-driven prediction of bone fracture risk in osteoporosis treatment, and to consider the use of machine learning algorithms for estimation of the R-curve slope, toughness threshold and stress intensity factor, based on data such as patient's age and crack length that are collected during clinical examination. This work also highlights the challenges and opportunities associated with implementing AI-based fracture prediction models in clinical practice. The integration of AI-based fracture prediction tools into routine clinical care has the potential to improve osteoporosis management by enabling personalized risk assessment. By identifying individuals at heightened risk of fractures early in the treatment process, healthcare providers can tailor therapeutic strategies, optimize treatment efficacy, and improve patient outcomes.

Keywords: osteoporosis, fracture, prediction.

Acknowledgement

A COMPARATIVE STUDY OF AUTOML LIBRARIES AND HYPERPARAMETER TUNING TECHNIQUES

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Abstract

The field of machine learning (ML) offers immense potential for solving complex problems across various domains. However, the traditional ML workflow can be time-consuming and requires significant expertise which limits the accessibility and scalability of ML for many users. To fit a machine learning model to solve various problems, its hyperparameters must be tuned. Automated machine learning (AutoML) emerges as a powerful solution, addressing these limitations by automating critical stages of the ML pipeline. By leveraging automation, AutoML streamlines the process, reduces development time, and democratizes access to ML for a wider range of users, including those with less specialized knowledge. Several powerful Python libraries, such as Hyperopt, Optuna and TPOT offer comprehensive solutions for AutoML development and hyperparameter optimization. These libraries employ sophisticated optimization algorithms to automate hyperparameter tuning, feature selection, and even model selection within the ML pipeline. Additionally, Tensorflow, PyTorch, scikit-learn and BayesianOptimization libraries also provide methods specifically tailored for efficient hyperparameter tuning. Our research endeavors to provide a comprehensive comparison of AutoML methods, focusing on their performance metrics such as accuracy, loss, etc. and the time it consumes while searching for the solution. By conducting extensive experiments on a diverse set of datasets and tasks, we systematically evaluate the effectiveness and efficiency of different AutoML approaches. Our exploration confirms the efficiency gains of AutoML, but also highlights the time consumption associated with hyperparameter search. While some libraries, such as Hyperopt, Optuna and TPOT, excelled at identifying high-performance models, the trade-off between metrics and time consumption remains a key consideration for AutoML users.

Keywords: AutoML, hyperparameter tuning, performance evaluation, comparative analysis.

Acknowledgment

THE IMPACT OF ARTIFICIAL INTELLIGENCE ON DIGITAL MARKETING

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Abstract

Artificial intelligence has rapidly evolved from an unknown technological concept to an omnipresent and necessary tool in modern marketing. Modern marketing is under strong influence of the digital era and the transformative capabilities of artificial intelligence. The focus of numerous marketing campaigns are strategies managed by artificial intelligence.

This paper highlights the increasing impact of artificial intelligence on digital marketing, exploring its application in digital marketing within marketing agencies, along with the advantages, benefits, and potential it carries.

Interviews were conducted with 28 marketing managers employed in marketing agencies operating in the territory of the Republic of Serbia, regarding the connection between artificial intelligence and digital marketing, and their responses were analyzed using the statistical software SmartPLS4.

In the context of digital marketing, artificial intelligence involves advanced algorithmic programs and machine learning to analyze huge amounts of data and shape marketing strategy. A better understanding of consumer behavior patterns enables better presentation of more tailored marketing messages, the creation of personalized marketing campaigns, providing product purchase recommendations, and meeting specific consumers tastes. Thus, marketing agencies gain insights into consumer behavior, predict trends, and make decisions based on concrete data.

With the help of artificial intelligence algorithms, consumers segmentation into different groups can be performed based on demographic differences, behaviors, and interests. Consequently, marketing agencies can much more precisely target the consumer group, enabling their messages to reach the right people. This technology has not only changed the entire approach to marketing but has also become a major tool for survival in the competitive field of digital marketing.

Keywords: artificial intelligence, digital marketing, marketing agencies, SmartPLS4, remote sensing.

EXPLORING WORD2VEC MODELS FOR CAPTURING THE SIMILARITY OF CODON EMBEDDINGS

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Abstract

Word2vec is a neural network (NN) technique that learns a vector representation of words (tokens) analyzing its context (surrounding tokens), and use some function between vectors to encode the semantic relationship between words. Inspired by its success in NLP, many researchers tried to replicate its idea to biological sequence embedding. However, compared to the NLP problems where it is clear what tokens are as well and their context this is not the case in bioinformatics.

A lot of papers embed k-mers, but there are multiple options for the choice of a context and the length of k-mers, as well as whether there should be an overlap between k-mers. Therefore, we will empirically analyze the quality of 3-mer (codon) embeddings of the genome sequences of V. Cholerae and E. Coli.

The dataset was generated by sliding a window across the DNA sequence and using codons along with their left and right neighbors as input. We experimented with different hyperparameters: numbers of neighbors ($m \in \{3,5,10,20,40\}$) and whether the windows overlap or not. We evaluated the results by analyzing the vector representation of the codons. There were 64 codons grouped into 21 categories according to the amino acids they encode. For each codon, we defined recall as the ratio between the number of codons from the same group found among its top 6 closest neighbors, determined by cosine vector distance, and the total number of codons in the group.

Experimental results reveal that the use of overlapping windows and about five neighbors results in the highest similarity among vector embeddings for codons within the same group.

In future work, different contexts could be explored for gene embedding and models could be trained on a greater variety of different organism's genomes because the best context may vary between organisms.

ON SEMANTIC ASSOCIATION CAPABILITIES OF GPT LLMS IN A GAME OF WORD ASSOCIATIONS

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Abstract

Large Language Models (LLMs) excel at language pattern recognition and prediction of words. The current largest models, such as OpenAI's GPT models, have attained unprecedented levels of success in their ability and versatility at performing a variety of tasks, reaching the level of humans in some areas. This paper focuses on an LLM's core strength—its linguistic predictive capabilities—and how effectively it can be leveraged to find semantic associations between different words. A game of word associations is played with GPT models, in which a set of four words is provided to the player who has to correctly guess the fifth word which is semantically related to all four words in possibly different contexts. The four provided words are not necessarily semantically related to each other. The testing is done in Serbian language, with data obtained from the associations' segments of the Serbian national TV quiz "Slagalica" being used to measure the effectiveness of GPT models—notably the currently most powerful GPT-4 Turbo model—as players of this game. In a round of the game, ten attempts are given to the model to guess the correct word. It is found that GPT models can discover the correct answer in the majority of the rounds played, with a notable portion of answers being guessed correctly on the first try by the GPT-4 Turbo model.

Keywords: LLM, word prediction, GPT, semantic associations, game, Slagalica.

A BRIEF SURVEY OF AI-BASED METHODS IN ASTRODYNAMIC PROBLEMS WITH DISTURBANCES, NOISES AND UNCERTAINTIES

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Abstract

This survey is devoted to the analysis of superposition of gravitational and magneto-electric effects in the problems of dynamics and control of the orbital and angular motion of spacecraft (SC) and SC constellations under the conditions of disturbances, noises and uncertainties. We consider spacecraft and constellations of spacecraft interacting with the geomagnetic field through Lorentz forces and moments, as well as moments caused by magnetic interaction. We briefly analyze a wide range of papers which describe the dynamics of the controlled motion of spacecraft and constellations of spacecraft moving in the gravitational and magnetic fields of the Earth with disturbances, noises and uncertainties and reduce their negative impact due to application of such methods of artificial intelligence (AI) as randomized algorithms of optimization and estimation, genetics algorithm, fuzzy logic satellite attitude control, deep reinforcement learning applied to spacecraft attitude control, neural network-based method.

Keywords: artificial intelligence, spacecraft, satellite, attitude control, attitude stabilization, disturbances, uncertainties, asymptotic stability, geomagnetic field.

INTERNET OF MEDICAL THINGS (IOMT): SMART HEARING AIDS, TODAY AND TOMORROW

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Abstract

The history of wireless headphones represents the pinnacle of technological evolution in audiology, from the early days of radio technology to today's high-end smart headphones. As technology continues to advance, these devices will continue to empower people with hearing loss to fully engage and enjoy the world around them.

Smart hearing aids offer a range of features and benefits that significantly improve the quality of life for people with hearing loss. Using the power of connectivity and intelligent technology, these devices enable users to stay connected, engaged and active in their daily lives.

While the advent of smart hearing devices offers exciting opportunities to improve the lives of individuals with hearing loss, emphasis is placed on the major safety risks in their use. Even this modern technology is not immune to hacker attacks, so it is essential to take care of the cyber security of these devices in order to ensure their safety and privacy in an increasingly interconnected world.

The integration of artificial intelligence into smart hearing aids holds great promise for improving the efficiency, usability, and accessibility of hearing aid technology. Using AI-driven innovation, these devices can provide users with personalized, adaptive and intelligent solutions that improve their hearing experience and quality of life.

Keywords: IoT, smart hearing aids, artificial intelligence, cyber security, healthcare.

GRAPH NEURAL NETWORKS AND TRANSFORMER EMBEDDINGS: A HYBRID APPROACH TO IMPROVING RECOMMENDER SYSTEMS

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Abstract

In this work, we propose a recommender system that uses Graph Neural Networks (GNNs) alongside BERT-based Sentence Transformer text embeddings to enhance recommendation accuracy. Utilizing the MovieLens dataset, which contains user profiles, detailed movie attributes, and user ratings, we constructed a heterogeneous bipartite graph comprising users and movies as nodes, with ratings serving as edges. Movie synopses were embedded using BERT-based Sentence Transformers, based on the hypothesis that a hybrid approach combining these embeddings with GNNs would give more personalized recommendations by leveraging the semantic content of the text and the intricate relationships within the graph structure. We employed an edge sampling technique to facilitate training on large-scale graphs, aiming to predict the ratings users would assign to movies. The primary performance metric was the Root Mean Squared Error (RMSE). Our results indicate that this hybrid approach significantly outperforms a baseline model that utilizes only tabular movie attributes. Additionally, applying Principal Component Analysis (PCA) to reduce the dimensionality of movie embeddings further enhances performance. This study highlights the potential of integrating graph-based methods with advanced natural language processing techniques in domains rich with textual data.

Keywords: graph neural network (GNN), transformer, recommender system, principal component analysis (PCA), textual embeddings.

APPLICATION OF THE AHP METHOD TO THE INVESTMENT MANAGEMENT OF LOCAL MUNICIPALITIES AND COUNTRIES

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Abstract

This study applies the analytic hierarchy process (AHP) method to the field of managing investment for local municipalities and countries. The AHP method is a multi-criteria decision-making technique that allows decision-makers to prioritize and allocate resources effectively and evaluate and compare different investment options, considering multiple criteria and stakeholders' preferences. The AHP method is selected as a basic method in this study because it facilitates a systematic process for identifying and defining investment objectives, enables decision-makers to assess and prioritize various investment criteria, and ensures a comprehensive evaluation of investments, considering both quantitative and qualitative factors. In addition, the AHP framework allows stakeholders to participate in the investment decision-making process. Moreover, using the AHP method helps promote transparency, inclusivity, and accountability in investment management. However, applying the AHP method to investment management faces certain challenges. Namely, it requires reliable data, expertise in constructing decision models, and careful processing of the obtained results. Also, the subjectivity of the weighting criteria and comparing alternatives can introduce certain biases that can affect the final result. In this study, the AHP method is applied to real data on several local municipalities, and the evaluation results demonstrate that the proposed framework performs well in investment management.

Keywords: AHP methodology, decision-making, investment management, public sector policy, social wellbeing.

EVALUATION OF USING BALANCED AND UNBALANCED DATA FOR SMART CITY SOLUTION BASED ON IOT USING CLASSIFICATION AND ADABOOSTM1

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Abstract

Smart cities are still at their beginnings. They add intelligence to existing city systems, enabling more to be done with less. Artificial intelligence can be helpful for this. The result is applications with transparent real-time information that aid in making better choices. This can be useful for everyday cases, but even for many natural conditions, like earthquakes, tsunamis, floods, and sleet, which cause major disasters. The question is how to set up the concept of a smart city so that the city would be more resilient to disasters and climate change. The problem we are addressing is to forecast the daily number of incoming calls based on data from IoT sensor devices, which includes river flows and weather data. The proposal is made for a safe city system, which is a smart city subsystem. The data refers to Slovenia as a whole and consists both of balanced and imbalanced data. AdaBoostM1 classification algorithm is used. The given evaluation will help in a more detailed analysis and preparation of a comprehensive concept for the blueprint of a smart city.

Keywords: IoT, AdaBoostM1, AdaBoost, machine learning, smart city, classification, safe city.

MULTI-LAYER SPECTRAL CLUSTERING ALGORITHM BASED ON AN ADJUSTMENT OF LAPLACIAN MATRIX

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Abstract

In clustering, the goal is to group similar objects together. Here we introduce a multi-layer spectral clustering method, relying on spectral analysis of a graph matrix derived from a multi-modal dataset represented by independent feature vectors. Unlike certain popular partitioning methods, spectral clustering techniques possess the capability to uncover clusters of diverse shapes and sizes. In the multimodal scenario, the algorithm functions on multi-layer graphs, formed by combining graphs with the same vertex set, each with edge sets derived from the corresponding multi-modal data.

Single-layer spectral clustering is more established and understood compared to its multi-layer counterpart. It is clearly motivated by the discrete relaxation of graph cuts to derive Laplacian matrix eigenvectors and is supported by theoretical analysis. In contrast, multi-layer spectral clustering lacks both discrete motivation and theoretical analysis. Typically, it relies on algebraic analysis of Laplacian matrices from individual graph layers without clear graph-based reasoning. However, in this paper, we propose a departure from this approach. We start by examining the graph cut of the multi-layer graph, resulting in different Laplacian matrices. Instead of using normalized Laplacian matrices, we use normalization based on the degree matrices of different layers, providing a clearer graph-based rationale. Our empirical results on real-world datasets, demonstrate the superior performance of our approach.

Our algorithm *Scml_improved* was compared to the *scml* algorithm using real-world datasets from the UCI ML Repository, such as *wine*, *iris*, *seeds*, and *ionosphere*. We form a multi-layer graph, the layers of which are derived from a randomly chosen subset of features using the RBF kernel. The evaluation was performed using the Rand Index (RI).

The *MultilayerCH* dataset originates from the California HCUP database, comprising 35,844,800 inpatient discharge records accumulated over nine years, equivalent to 107 months or time steps. Each layer of the multi-layer graph, consisting of 189 diseases, is generated similarly to the approach in the study where monthly disease graphs are constructed, with each node representing a single disease. To be more precise, in our experiment, we initiate with the disease-symptom similarity network as an initial layer, and subsequently, each succeeding layer is constructed using the RBF kernel on monthly admissions based on 10 consecutive time steps.

TREATMENT OF NON-PHYSICAL SOLUTIONS OF THE OXYGEN DIFFUSION IN SOIL BY PHYSICS-INFORMED NEURAL NETWORK

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Abstract

The diffusion of oxygen in the soil in one dimension is investigated by the finite difference method (FDM) and the physics-informed neural network (PINN). By solving the diffusion equation using either method, we determine the oxygen concentration profiles in time within the soil column. However, while respecting specified Dirichlet and Neumann boundary conditions, the concentration profiles at certain times become negative, which is non-physical per se. In the finite difference scheme, we can resolve this situation by proclaiming these negative concentration values as 0 as a post-processing step. In the case of PINN, we propose an innovative solution with a custom loss function, tailored to avoid such non-physical behavior. Two different cases are investigated, with constant and daily periodically changing air oxygen concentration. We have shown that the PINN with a customized loss is effective and accurate. The proposed method for avoiding non-physical solution regions shows potential for generalization to other similar problems, either forward or reverse.

Keywords: oxygen diffusion, diffusion equation, physics-informed neural networks, finite difference method.

EDGE INTELLIGENCE FOR CYBERSECURITY: AI-POWERED THREAT DETECTION IN HARDWARE INFRASTRUCTURE

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Abstract

In today's interconnected world, the vulnerability of hardware infrastructure to cyberattacks poses a significant threat to the stability and security of various systems. These attacks not only have the potential to disrupt operations but also to compromise sensitive data and result in substantial financial losses. Addressing this challenge requires innovative approaches that leverage emerging technologies to enhance cybersecurity defenses. A promising direction for fortifying hardware infrastructure against cyber threats is the integration of artificial intelligence (AI) models. By harnessing AI algorithms trained on comprehensive datasets encompassing hardware energy consumption and network performance metrics, it becomes feasible to detect anomalies indicative of potential cyberattacks. This proactive approach not only enables the timely identification of security breaches but also empowers organizations to take preemptive measures to mitigate their impact. The research adopts a proactive stance toward cybersecurity by employing the Design of Experiment approach. This methodology facilitates the demonstration of the viability of implementing AI-driven cyberattack prevention directly on edge devices such as microcontrollers (MCUs) and Raspberry Pis and similar IoT devices or systems. Central to this is the analysis of energy consumption and network data, which serves as the foundation for training robust AI models capable of detecting and thwarting cyber threats. By collecting and analyzing energy consumption data from diverse hardware devices, this research seeks to elucidate the efficacy of AI-based cyberattack detection mechanisms. Through the systematic training of AI models on this rich dataset, the experiment aims to equip edge devices with the intelligence necessary to autonomously identify anomalies indicative of cyber threats. Ultimately, the deployment of these trained models holds the promise of bolstering cybersecurity defenses at the hardware level, thereby safeguarding critical systems against malicious intrusions. In essence, this research endeavors to bridge the gap between AI-driven cybersecurity and hardware infrastructure resilience. By leveraging advanced technologies and methodological rigor, it strives to pave the way for a more secure and resilient digital ecosystem in the face of evolving cyber threats.

Keywords: edge devices, AI-driven cybersecurity, hardware infrastructure, anomaly.

DEEPTECH-2M SEARCH API FOR RESEARCH FUNDING

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Abstract

This paper presents a DeepTech2M web-based search tool, aimed to provide young researchers with a simplified funding search tool, related to the EU Funding and Tender Portal. DeepTech2M search API follows the standard structure, starting with user input sent to the API at the local website page where API is functioning in the background. The query can input different keywords along with search filters, to produce more accurate results, which, in a form of the list of links to the relevant Calls for funding, are displayed at the local webpage. The developed API solution represents the foundation for upgrading it further with AI functionality, such as semantic similarities in data and results ranking, as planned for the next steps toward the search tool that can provide a list of funding opportunities throughout the world.

Keywords: search API, research funding, Deep Tech, DEEPTECH-2M project, EIT HEI Initiative, Calls for proposals, Horizon Europe.

Acknowledgment

EVALUATION OF MAGNETIZED MICRO- AND NANO-OBJECT PARAMETERS USING ARTIFICIAL INTELLIGENCE

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Abstract

The development of magnetic micro- and nano-objects (MOs) holds significant potential in biotechnology and medicine, but there is a need for fast and efficient methods to measure a range of physical parameters. Our study proposes the use of artificial intelligence (AI) to assess the magnetization and hydrodynamic radius of MOs using a microfluidic chip. The methodology involves the use of a microfluidic chip and standard microscopy techniques to track the movement of MOs under the influence of an external magnetic field. The evaluation of cell magnetization using the AI application allows better prediction of average MOs values exceeding 10^5 MOs/cell than in the case of simulation using finite element analysis. Furthermore, the application of the neural network "U-Net" and the corresponding AI analysis offers the possibility to improve the evaluation of the hydrodynamic radius for MOs larger than 500 nm and for cells magnetized with MOs in the range of 10-100µg/ml culture medium.

Keywords: machine learning, neural network, magnetic nanoparticles, magnetic field, artificial intelligence, biomedical application.

AI-BASED INTELLIGENCE VERSUS INDIVIDUAL INTELLIGENCE: REGARDING DESIGNING BETTER ENVIRONMENTAL POLICIES

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Abstract

This research explores the complex and diverse problems associated with environmental regulations at the governmental level, focusing on two different methods: human judgment and AI-generated system suggestions. The principal objective of the research is to evaluate the impact of human expertise on environmental policies and ascertain the importance of expertise provided by artificial intelligence. Mind Genomics, a collection of intricate statistical models, data mining, and clustering technologies provided as a web-based application service, is the study methodology used.

Mind Genomics, a collection of intricate statistical models, data mining, and clustering technologies provided as a web-based application service, is the study methodology used.

A thorough examination of the literature was done to decide what the investigation's focus would be.

Thus, four topics were selected: climate change mitigation and adaptation, biodiversity conservation, pollution control and waste management, sustainable resource use, and energy efficiency. In general, the results obtained by researchers and AI differed. The experiment designed by researchers scored higher than the one designed by AI. Several binary dependent variables were created to gain more insights into the differences between AI-generated and human-generated elements. The Index of Divergent Thought is used to evaluate the performance of each study. Ordinary least squares regression is used to link the newly created binary variables and response time to the presence or absence of elements. The AI-generated elements performed less well but demonstrated much better differences among mindsets. The results show that AI can provide input that gives results similar to those of a human researcher, if not extraordinarily strong. A novelty of this study is the use of the AI summarizer. Summarizers provide a rich set of recommendations when analyzing an input set, and they present points of view that are not always visible to the human eye, thus essentially completing the human arguments.

COMPARING DIFFERENT APPROACHES FOR MODELLING SOIL PROPERTIES FROM NEAR INFRARED SPECTROSCOPY DATA

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Abstract

Measuring and tracking the changes in soil chemical properties is important for maintaining soil health. Recent decades have brought a shift towards using spectroscopy measurements for estimating these properties, as an alternative for costly and time consuming traditional (chemical) methods for soil analysis. Today, there is a wide range of spectrometers, utilizing different parts of the EM spectrum, differing in size, mobility (stationary and hand-held), accuracy and price. Here we analyse the possibilities of one such instrument, Neospectra, to measure different soil properties (pH, Al, Ca, K, C, N, OC...). Paired spectral and chemical measurements from soil samples are downloaded from the Open Soil Spectral Library. Data is then used for developing models for translating spectral reflectances into chemical properties. Several modelling approaches are tested: Cubist algorithm, Random Forest, and deep learning algorithms such as CNN and ANN. Performance metrics are reported from 10-fold cross validation.

Keywords: soil properties, soil spectroscopy, machine learning, deep learning.

Acknowledgement

ARTIFICIAL INTELLIGENCE-BASED DECISION SUPPORT SYSTEM FOR EARLY AND ACCURATE DIAGNOSIS OF HEART FAILURE

Nowadays, Heart failure (HF) is recognized as a modern epidemic and despite advances in therapy and research, HF still carries an ominous prognosis and a significant socioeconomic burden[1]. Many novel agents that emerged as promising HF drugs failed to reduce residual morbidity and mortality[2]. Since developing and testing new agents has become increasingly costly[3], the concept of repurposing existing drugs for new indications has gained considerable importance. The past decade has seen many advances in the management of HF that have improved survival rate and quality of life for patients living with this condition. Many gaps remain in understanding the pathophysiology of HF, and the application of emerging treatment strategies is an exciting but daunting challenge. Advances in genetic evaluation of cardiomyopathy may provide a more refined, patient-specific, approach to characterizing HF syndromes, whereas large-scale clinical trials on the horizon should further clarify the role of novel pharmacologic agents and invasive therapies. Despite considerable advances in the management of HF, the gold standard for the treatment of end-stage HF patients remains heart transplantation. But there is only a small percentage of patients who could benefit from a new heart due to the limited availability of donor organs. Improving awareness of the very end stages of HF is emerging as a major need for the clinical community.

The aim of INTELHEART[4] project titled "Artificial INTELligence-based Decision Support System for Early and Accurate Diagnosis of HEART Failure" is to combine the expertise from clinical practice with excellence in the computer, biomedical engineering, health technology assessment and implementation sciences to develop and implement the finite element and AI-based computerized digital platform for early and accurate diagnosis of HF for primary and secondary care clinical needs (i.e. outpatient, inpatient, and emergency departments). The INTELHEART platform will uniquely integrate patient-specific demographic and clinical data using existing and novel technologies and develop an AI-driven intelligent decision support system (DSS) and mobile app for patient stratification and HF prediction using machine learning, computational modeling, voice characteristics and vocal biomarkers. Voice characteristics will also be used to assess the emotional disturbance and physiological resilience which have been associated with cardiovascular diseases.

The specific objectives of the project are to:

- Perform clinical study for heart failure diagnosis in tertiary care to collect and integrate various diagnostic data (WP1);
- Develop AI tools for risk stratification and early diagnosis of heart failure (WP2);
- Design, develop and validate a breakthrough AI technology (WP3);
- Develop a finite element model for the patient-specific whole cardiac working cycle (WP4);
- Develop, evaluate and refine a cloud computational platform and mobile app for early diagnoses of heart failure based on artificial intelligence, computational modelling and voice biomarkers (WP5);
- Implement a pilot of the diagnostic platform in participating clinical centers and inform the Serbian regulatory body for medical device class 2b (WP6);
- Disseminate and exploit the project results and communicate the INTELHEART project (WP7);

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[4] http://intelheart.kg.ac.rs/

- Manage the project and the developed innovations based on the project management methods (WP7).

Existing research on the patient perspective of HF is limited and many untested assumptions are made about what we think is best for people with HF and what matters to them most – with little confirmation that these are meaningful or correct. Our overall ambition is to improve the quality and length of life for patients and to reduce the economic burden of HF on health care systems. The strategy on how to approach this goal is to offer primary and secondary care with novel technology-based computational tools finite element and AI which will allow early and accurate diagnosis of HF. The concept, ambition and impact assessment of INTELHEART project are presented in following Figure.
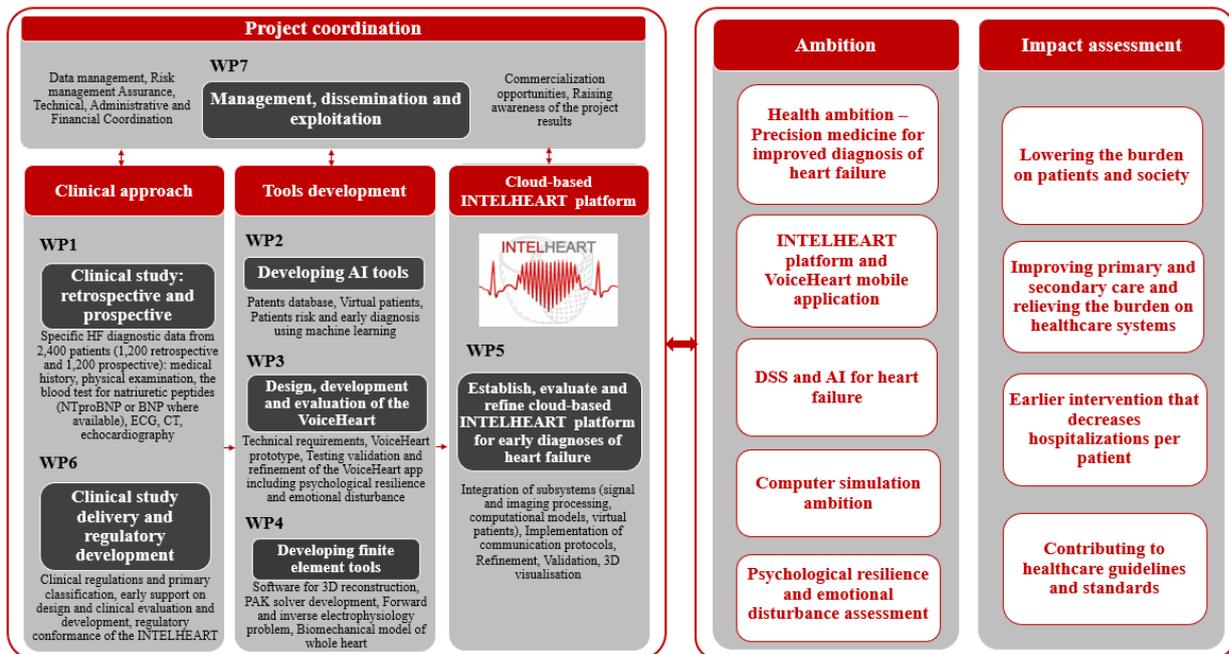

Figure 1 The concept, ambition and impact assessment of INTELHEART project.

Healthcare systems face roadblocks such as lack of appropriate tests and equipment and limited resources at various levels of care that delay diagnosis and treatment for HF in general. **The INTELHEART platform presents a new and innovative AI-DSS solution, which needs fewer resources to diagnose HF accurately and provides patient-centric treatment advice to its primary and secondary care users.**

The INTELHEART project started in January 2024 with a lifetime of three years. It is implemented within the *Prisma* program of the Science Fund of the Republic of Serbia, and within the Artificial Intelligence subprogram. The leading institution is the Faculty of Engineering of the University of Kragujevac, and the project coordinator is prof. Nenad Filipović. Members of the project team are members of nine technical and clinical Institutions located in Kragujevac, Novi Sad, Belgrade, Novi Pazar and Nis. Faculty of Engineering, University of Kragujevac (FINK), Institute for Information Technologies Kragujevac (IITKG) and Faculty of Medical Sciences, University of Kragujevac (FMSUKG) are located in Kragujevac. The Institute for Artificial Intelligence Research and Development of Serbia (IVI) and Faculty of Medicine, University of Novi Sad (MFUNS) are located in Novi Sad. Faculty of Medicine (School of Medicine), University of Belgrade (MFUB) is located in Belgrade. State University of Novi Pazar (SUNP) is located in Novi Pazar. Faculty of Medicine, University of Nis (MFUN) is located in Nis. The project has also a clinical expert from diaspora that is Coventry University, Faculty of Health and Life Sciences, UK (COVU).

The FINK together with technical institutions (IITKG, IVI, SUNP) will bring the expertise in computer science (FE modelling, multiscale modelling, AI, signal processing) and achieve common project objectives with clinical partners (FMSUKG, MFUNS, MFUB, MFUN) and clinical expert from diaspora (COVU) in development of cloud-based computational platform and mobile app for early and accurate diagnosis of heart failure.

The project's activities and objectives are in accordance with the mission and vision of the Science Fund of the Republic of Serbia and with the objectives of the *Strategy of Scientific and Technological Development of the Republic of Serbia for the period from 2021 to 2025*, *Strategy of smart specialization in the Republic of Serbia for the period from 2020 to 2027* and *Strategy for the development of artificial intelligence in the Republic of Serbia for the period 2020-2025* in the following manner:

- Societal needs and priorities;
- Multidisciplinary and interdisciplinary research;
- Ensuring competitiveness, quality, practical value, transparency, and the functionality of the results;
- Professional development of researchers;
- Cooperation with the scientific diaspora.

The INTELHEART clinical study is a non-sponsored and non-interventional, clinical research study which will be done in four clinical centres (Kragujevac, Nis, Novi Sad and Belgrade), in accordance with national legislation and institutional procedures in the field of academic research in medicine. The INTELHEART AI-powered DSS will be designed to fulfill a set of seven requirements to prove its trustworthiness in terms of compliance with the four ethical principles[5]: (i) respect for human autonomy (the AI systems should be designed to empower human congestive and social skills), (ii) prevention of harm (the AI systems should be designed to protect the human dignity by being safe and secure), (iii) fairness (the AI systems must be developed and deployed in such a way to increase societal fairness), and (iv) explicability (the processes that are implemented by the AI system must be transparent in terms of traceability and auditability).

By developing and integrating AI-based tools and analytics within DSS and mobile app, collecting patient data, we will create a unique knowledge database, facilitating implementation of new trustworthy risk stratification, diagnostic and prognostic, privacy-preserving AI tools to improve the quality of healthcare for both clinicians and patients. This approach ensures use of evidence-based preventive and treatment strategies, data management and curation with their easy access within DSS at primary and secondary care. Our approach will reduce errors, delays and costs associated with current HF care pathway.

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[5] Ethics guidelines for trustworthy AI, High-Level Expert Group on Artificial Intelligence, 2019.

140

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