INDIA-SERBIA WORKSHOP ON SELECTED TOPICS OF ARTIFICIAL INTELLIGENCE AND INFORMATION TECHNOLOGY TECHNIQUES AND APPLICATIONS

13-15 June 2022, Belgrade

Serbian Academy of Sciences and Arts

Meeting Room 102

PROGRAM

June 13, 2022

OPENING SESSION (10:00 – 10:45)

- Marina Soković, Assistant Minister, Ministry for Education, Science and Technological Development

"**Welcome Address**"

- Zoran Petrovic, Academician, Serbian Academy of Sciences and Arts

"**Welcome Address**"

- Zoran Ognjanovic, Director, Mathematical Institute, Serbian Academy of Sciences and Arts

"**Welcome Address**"

- Prof. Bimal Roy, TCG-CREST

"**Current research activities and scope at TCG-CREST**"

Session I: Artificial Intelligence (1) (10:45 – 12:50)

- Prof. Samiran Chattopadhyay

"**Artificial Intelligence: Present perfect, fast forward**" (10:45 – 11:10)

Abstract: This talk will take us through the evolution of Artificial Intelligence, that has horizontally penetrated through all verticals of life of modern times. A hype in the early 1970s, AI is resurrected in additional avatars of Soft Computing and Machine Learning two dec-ades

later after a silent revolution in computing and networking technologies. This talk will drive through the highways of innovation (like Neural Nets, Transformers, GLPs) in the do-mains of image, audio, video and natural language processing while peeping in the semi-dark lanes and by lanes of applications like healthcare, fin-tech, legal data analytics. Throughout this amazing journey, the talk will look through the window of capabilities of CREST to the expanding meadows of renowned universities like yours for fostering collaborations. Finally, the talk will plunge into the ocean of data, daily created, to unearth pearls of discourses, narratives, emotions and intuitions, not experienced so far.

- Vladan Devedzic (University of Belgrade - School of Management Science)

    Basant Agarwal (Indian Institute of Information Technology Kota (IIIT Kota), India)

    Priyanka Harjule (Malaviya National Institute of Technology, Jaipur, India)

"**Shine a Light – E-Learning initiatives from two EU Projects**" (11:10 – 11:35)

Abstract: This talk presents ideas and initiatives from two ongoing Erasmus + projects funded by the European Commission. Both projects use e-Learning as an enabler for communicating interesting and important learning contents that are believed to increase and improve employability prospects for the targeted groups of learners. The WINnovators project targets young women with reduced opportunities for quality education in different areas of STEM/STEAM and intends to demonstrate how their entrepreneurial skills can gradually grow by providing them with e-Learning incentives in such areas. The YNSPEED project intends to offer free MOOC courses addressing hot topics of modern society – artificial intelligence, sustainable development, and fake news. In the YNSPEED project, the target group of learners are young people (aged 16-29). It is believed that their interest in such important topics can be boosted by communicating the corresponding relevant learning content in a carefully designed way. The *Shine a light* metaphor is a common point and a common approach in both projects – e-Learning technology is used to facilitate informal education for the targeted learners and to indicate directions that often get either omitted or misunderstood in traditional schools.

- Dr. Avishek Gupta

"**Machine Learning under Weak Supervision for Computer Vision and Computational Chemistry problems**" (11:35 – 12:00)

Abstract - Traditional supervised statistical learning setup are ideal for problems where it is easy to obtain labels from experts for each data instance, whereas unsupervised learning setups can be useful to initially examine the problem data at hand before any label information has been provided. For real-world problems it is common to have access to large volumes of data, where each data instance may not have been labelled due to the cost of labelling each instance by an expert. Weak supervision models attained recent success by providing ways to leverage some degree of expert supervision to guide the learning of a statistical model. Different ways in which problem information can be incorporated in the

learning procedure will be discussed (active learning, transfer learning, etc.). Recent approaches towards the weakly supervised training of deep neural networks (contrastive learning, generative active learning, etc.) will be discussed subsequently. Specific applications towards problems in Computer Vision such as scene text recognition and 3D scene understanding will be highlighted. Given the recent success of deep neural networks in Computational Chemistry to predict physical and chemical properties of materials, the potential towards studying weakly supervised deep learning approaches towards the prediction of physical and chemical properties of materials will be approaches towards the prediction of physical and chemical properties of materials will be discussed, with possible applications towards material design for batteries and solar cells.

- Miroslav Trajanovic (University of Nis),

"**Reverse engineering of human bones using artificial intelligence**" (12:00-12:25)

- Milica Petrović (University of Belgrade - Faculty of Mechanical Engineering)

"**Deep learning and optimization of intelligent manufacturing systems within Industry 4.0**" (12:25- 12:50)

Abstract. The proposed research is conducted within the project entitled „Deep Machine Learning and Swarm Intelligence-based Optimization Algorithms for Control and Scheduling of Cyber-Physical Systems in Industry 4.0 - MISSION4.0". The project is financially supported by the Science Fund of the Republic of Serbia within the call "Program for Development of Projects in the Field of Artificial Intelligence". The presentation of research results is divided into two main topics. The first topic covers the development of a reliable, efficient, and optimally scheduled material transport system based on a mobile robot. The proposed methodology is based on biologically inspired optimization algorithms and is aimed to find the optimal solution to the nondeterministic polynomial-hard (NP-hard) scheduling problem. Moreover, a mathematical formulation for the minimization of seven fitness functions is presented. The proposed methodology is extensively experimentally verified on different benchmark problems and tested by Khepera II mobile robot within a laboratory model of the manufacturing environment. The second topic covers semantic segmentation-based mobile robot perception system based on deep learning. The proposed system uses a Fully Convolutional Neural Network with ResNet18 backbone architecture. The perception system is integrated with the Nvidia Jetson Nano development board and two Basler dart cameras and configured as a standalone-edge device. The proposed model is trained on a custom-developed dataset of a laboratory model of manufacturing environment and implemented on the mobile robot RAICO (Robot with Artificial Intelligence based COgnition).

Lunch Break 12:50 – 14:30

Session II: Miscellaneous Topics   (14:30 – 17:15)

- Dr. Abhik Banerjee

"Developing Safe, Cost Effective, and High Energy Density Next Generation Storage Systems" (14:30 – 14:55)

Abstract.   With the popularity of next-generation high-end electronic devices and the promotion of electric vehicles (EV), the cutting-edge lithium-ion battery (LIB) technology has continuously run into one bottleneck or another. Its main performance metrics (including energy density, power density, cycle life, safety, cost, etc.) have been unable to meet the ever-tightening demands for electrified transportation as well as renewable integration into the electricity grid. For electric vehicles, the most important application field of LIBs, it is necessary to reach an energy density of at least 400 Wh/kg at scale. After more than 25 years of commercialization, especially after large-scale production and applications in recent years, many components of LIBs (such as current collector, separator, packaging, and the like) have remained unchanged. Therefore, the important performance metrics of LIBs are mainly determined by the electrode material and electrolyte. And more importantly, next-generation LIBs need reasonable matching of electrode and electrolyte to achieve the best performance, including longer cycling and better safety. Here are the following underlying causes for cost-effective, sustainable, safe, high energy density Li-ion battery.

• Next generation high energy and power density battery materials.

• Cost-effective cobalt-free Li-ion battery technology.

• Solid state (safe) battery technology.

• Advanced battery diagnostic tests and remanufacturing techniques.

• Advanced recycling systems that aim at expensive battery elements which include lithium, cobalt, nickel, manganese, etc.

These contributions are critical if energy storage technologies are to reach their full sustainability potential. Such studies will also enable Clean Technologies and Environmental Policy to continue its trajectory of growth in impact and global reach. I look forward to presenting these contributions in my talk.

Reference:

1. Nature Energyvolume3,pages267–278(2018)

2. Nature Materialsvolume19,pages1339–1345(2020

3. Chem. Rev.2020, 120, 14, 6878–6933

4. Nature Nanotechnologyvolume15,pages170–180(2020)

- Zoran Lj. Petrović (Serbian Academy of Sciences and Arts, Ulster University), Amit Kumar, Nevena Puač, Nikola Škoro, Gordana Malović, Dragana Marić (Institute of Physics Belgrade)

"Non-Equilibrium Plasmas: From Kinetic Theory And Atomic And Molecular Collisions To Kinetic Phenomena And Numerous Applications" (14:55 – 15:20)

Abstract. Non-equilibrium plasmas provide a facility to control separately mean energies of light charged particles, heavy charge particles and neutrals thus allowing applications of plasma on living tissues, thermally unstable materials and in nano-electronics. The foundations of all such applications may be described as kinetic phenomena where fundamental understanding of charged particle transport and overall kinetics, defined by the pertinent collisional processes allows us to modify the energy distribution functions as desired.

Most importantly, having in mind applications on living tissues one needs to ascertain non-equilibrium in atmospheric pressure plasmas that has always been difficult. We have covered applications such as: plasma etching in nano-electronics, plasma cleaning and plasma modification of surfaces, breakdown as a foundation for gaseous dielectrics, plasma induced processes in seeds and plants, plasma sterilization including biofilms with antibiotic resistant microorganisms, stem cell differentiation, induced apoptosis and DNA damage, selective cancer cell immune response activation, treatment of water and medium, purification and activation and many more.

Complex interplay between plasma properties with numerous non-linear processes requires vertically integrated modeling and diagnostics of such plasma sources in order to maintain the desired properties. In that respect elements of AI may be used to allow real time control and obtaining elementary data for numerous relevant processes.

- Slobodan Vukosavic (School of Electrical Engineering, University of Belgrade and Serbian Academy of Sciences and Arts)

"Computer-assisted design ofelectromechanical converters and electronic power converters --The use of evolution algorithms" (15:20 – 15:45)

Coffee Break (15:45 – 16:00)

- Predrag A. Janjic (Research Centre for Computer Science and Information Technologies, Macedonian Academy of Sciences and Arts)

"Computational approaches in studies of white matter in health and disease" (16:00 – 16:25)

Abstract. With the dramatical proliferation of machine learning (ML) applications in disease research, studies report that depending on the features and the level of detail very often resulting tools and their performance is very much data-dependent with close to a marginal capacity of generalization. Such observations seem not to be disease-specific or reflecting specific imaging modalities, but rather reflect the wealth of detail and impossibility to control the overfitting. We present a study approach in the biology of psychiatric or neurological disease where computational science employs a rather wide spectrum of techniques from multiple methods of histological imaging to statistical models of different molecular expressional data of the brain white matter. The critical assumption is that the complexity of neural structure and function essentially limits each and every single technique to insufficient confidence when we look for very subtle alterations.

- Dr. Apratim Chakraborty

"On Elser's conjecture and the topology of U nucleus complex An application of Discrete Morse Theory" (16:25 – 16:50)

Abstract: Abstract: Dorpalen-Barry et al. proved Elser's conjecture about the sign of Elser's number by interpreting them as certain sum of reduced Euler characteristic of an abstract simpli-cial complex known as U-nucleus complex. We prove a generalized conjecture posed by them about the topology of the U-nucleus complex of a graph using discrete Morse theory.

- Dr. Kuldeep Saha

"Explicit constructions of smooth embedding s of 3 and 4 manifolds in small co-dimensions" (16:50 – 17:15)

Abstract: With the popularity of next-generation high-end electronic devices and the promotion of electric vehicles (EV), the cutting-edge lithium-ion battery (LIB) technology has continuously run into one bottleneck or another. Its main performance metrics (including energy density, power density, cycle life, safety, cost, etc.) have been unable to meet the ever-tightening demands for electrified transportation as well as renewable integration into the electricity grid. For electric vehicles, the most important application field of LIBs, it is necessary to reach an energy density of at least 400 Wh/kg at scale. After more than 25 years of commercialization, especially after large-scale production and applications in recent years, many components of LIBs (such as current collector, separator, packaging, and the like) have remained unchanged. Therefore, the important performance metrics of LIBs are mainly determined by the electrode material and electrolyte. And more importantly, next-generation LIBs need reasonable matching of electrode and electrolyte to achieve the best performance, including longer cycling and better safety. Here are the following underlying causes for cost

- Nenad Filipovic (University of Kragujevac)

"Applied machine learning and computational modelling for cardiovascular disease prediction" (17:15 – 17:40)

Session III: Information Security (10:00 – 11:40)

- Dr. Arpita Maitra

"Linear Cryptanalysis Through the Lens of Clauser Horne Shimony Holt Game" (10:00 – 10:25)

Abstract: In this talk, we present the Boolean version of Clauser-Horne-Shimony-Holt (CHSH) game and show how this Boolean circuit can be exploited in Linear Cryptanalysis against thelightweight cipher "SIMON". Till date, the known usage of CHSH game in Quantum Cryptology is to verify the device independence of the protocols. We observed that the game can be viewed as a Boolean circuit and can be exploited to improve the bias of some ciphers. This observation opens a new direction of research in quantum cryptography.

- Dr. Nilanjan Datta

"Light-weight Authenticated Cipher Design based on Hybrid Feedback" (10:25 – 10:50)

Abstract: In recent years, lightweight symmetric cryptography or lightweight authenticated encryption with associated data (AEAD) has seen a sudden surge in interest due to the advent of Internet of things (IoT). The present AEAD standards are not suitable in the spectrum of lightweight applications as they are designed for more general use-cases. In this regard, we will discuss two area-efficient light-weight AEAD schemes: HyENA and its tweakable variant tHyENA. These schemes are based on hybrid feedback and they are state-of-the-art most area efficient online designs with optimal state size, rate, and xor-count. The construction HyENA had qualified for the second round of NIST LwC Competition and tHyENA is the winner of the national light-weight cipher design challenge 2020 organized by DSCI.

- Dr. Shion Samadder Chaudhury

"On some aspects of Low Complexity Secret Sharing and Differential Privacy" (10:50 – 11:15)

Abstract: Secret Sharing refers to methods of distributing a secret among a group in such a way that no individual holds holds any intelligible information about the secret, but when a sufficient number of individuals combine their 'shares', the secret maybe reconstructed. Secret sharing is an important cryptographic primitive and reducing its computational complexity is an important problem. In this talk I shall survey some digital forensics aspects of secret sharing like framing participants, resilience and give a brief description of our work in this area. Differential Privacy is a system for publicly sharing information about a dataset by

describing the patterns of groups within the dataset while withholding information about individuals in the dataset.The idea is that the effect of making an arbitrary single substitution in the database is small enough, the query result cannot be used to infer much about any single individual, and therefore provides privacy. A recent work considers the problem of differential privacy for data lying on a Riemannian manifold. Due to some restrictions on the data in this paper we extend this work in two directions: 1. A combinatorial geometry approach, 2. Differential privacy for data lying on CAT(0) spaces. I shall briefly describe these works and mention some of the ongoing works.

- D. Nedeljković (University of Belgrade - Faculty of Mechanical Engineering)

"**Machine learning based detection of cyber-attacks in systems for manufacturing resources control**" (11:15 – 11:40)

Session IV: Artificial Intelligence (2)   (11:40 – 12:50)

- Dragisa Zunic (Institute for AI, Novi Sad)

"**Financial Exchange and Symbolic AI**" (11:40 – 12:05)

Abstract: We explored the way to represent the archetypal core of financial exchanges declaratively, and then to prove some of its fundamental properties. This core guides the matching of buy and sell orders, i.e., supply and demand, and considering it as an infinite state space system, represents a challenge for modern day financial institutions to certify its properties. We use symbolic AI theory and tools, based on formal logic, to both represent and reason about the system properties. In the domain of fundamental market design, considering that present day exchanges operate sequentially, we proceed to explore the elements of parallelism in order matching. We also mention when machine learning may be required, namely in making sure that he game of exchange is played in a regular way.

- Milan Stojković (Institute for AI, Novi Sad)

"**Assessing Water Resources System Dynamic Resilience Under Hazardous Events using Artificial Neural Networks**" (12:05 – 12:25)

Abstract: The objective of this research is to propose a novel framework for assessing the consequences of hazardous events on a water resources system using dynamic resilience. Two types of hazardous events were considered: a severe flood event and an earthquake. Given that one or both hazards have occurred and considering the intensity of those events, the main characteristics of flood dynamic resilience were evaluated. The framework utilizes an Artificial Neural Network (ANN) to estimate dynamic resilience. The ANN was trained using a large, generated dataset that included a wide range of situations, from relatively mild hazards to severe ones. A case study was performed on the Pirot water system (Serbia).

Dynamic resilience was derived from the system dynamics model alongside the hazardous model implemented. The most extreme hazard combination results in the robustness of 0.04, indicating a combination of an earthquake with a significant magnitude and a flood hydrograph with a low frequency of occurrence. In the case of moderate hazards, the system robustness has a median value of 0.2 and the rapidity median value of 162 hours. The ANN's efficacy was quantified using the average relative error metric which equals 2.14% and 1.77% for robustness and rapidity, respectively.

- Dubravko Ćulibrk (Institute for AI, Novi Sad)

"The Quest for Emotional AI" (12:25 – 12:50)

Abstract: Emotional intelligence is a big part of human success. Transferring the ability to understand deep human emotions to computers, however, is a daunting task. This talk will focus on select results of research done on developing "Emotional Artificial Intelligence" in the last decade and inferring human states of mind from multimodal data (sound, video and images).

Lunch Break (12:50 – 14:30)

Session V: Blockchain Technology (14:30 – 17:00)

- Miodrag Mihaljevic (Serbian Academy of Sciences and Arts)

"**Advances in Techniques for Blockchain Technology and Encryption**" (14:30 – 14:55)

Abstract: This talk points out to certain approaches for developing blockchain consensus protocols with reduced energy consumption and security enhancement of lightweight encryption schemes. We discuss blockchain consensus puzzle solvable employing time-memory trade off technique for inverting one-way cryptographic functions. The addressed security enhancement of encryption is based on employment certain results from coding and information theory. Some applications of the considered techniques are pointed out as well.

- Milica Knezevic (Mathematical Institute of the Serbian Academy of Sciences and Arts)

"**Security Evaluation of Certain Blockchain Based Systems - An Illustrative Example**" (14:55 – 15:20)

Abstract: Over the years, blockchain surpassed the initial application solely related to cryptocurrencies and finance, and it is seen today as a general-purpose technology that can be used in many other use-cases. The key enabler for blockchain widespread usage is the concept of smart contracts, which brought the programmability potential into blockchains. One of the fruitful research directions on blockchain applications is in the subject area of

authentication, authorization and access control, where the blockchain technology is used, on the one hand, to fortify the security and, on the other hand, to overcome the need for a central authority. However, when designing blockchain-based systems, we have to carefully take into consideration inherent characteristics and limitations of blockchains. On the example of a recently published authentication protocol for wireless medical sensor networks, we will show how inappropriate employment of the blockchain technology can undermine the system and can cause multiple vulnerabilities of the protocol.

- Milan Todorovic (Mathematical Institute of the Serbian Academy of Sciences and Arts)

"**Blockchain based Smart Grid**" (15:20 – 15:45)

Abstract: In recent years, increasing climate change intensified the research of utilizing green and renewable sources of energy, which imposes the need of transforming and upgrading the existing power grids. Standard consumers of electrical energy are starting to transform in so called prosumers that represent consumers that can now produce electrical energy by using various renewable sources such as sunlight or wind. The appearance of prosumers drastically increases the complexity of power grids, because these users can now sell the excess energy they have produced to other consumers within the grid. On the other hand, local communities can form their smaller electrical grid, known as micro grid, in order to trade energy efficiently between themselves. It is clear that this more complex power grid requires new mechanisms that would manage energy trading, and that would preserve privacy of the consumers and prosumers. For this, we propose blockchain based platform that is based on utilizing smart contracts within Ethereum blockchain network with modified consensus protocol.

- Nemanja Zdravković (University Metropolitan),

"**Information Security and Blockchain - Healthcare use-cases and challenges**" (15:45 – 16:10)

Abstract: Blockchain technology (BCT) imposes fundamental changes to the way personal data, especially medical records, are currently being processed, and can improve current data security solutions. One significant advantage of using BCT is that it can reform interoperability of healthcare databases, providing authorized access to patient medical records, device tracking, prescription databases, and hospital assets. In this talk, Dr. Nemanja Zdravković, the Head of the Blockchain Technology Laboratory at Belgrade Metropolitan University, will discuss the Laboratory's activities regarding implementing blockchain in healthcare, use-cases and challenges.

- Milan Todorovic, Luka Matijevic; D. Ramljak; Tanja Davidovic; Dragan Urosevievic; Tanja Jaksic Kr\uger, Djordje Jovanovic

"Proof-of-Useful-Work: BlockChain Mining by Solving Real-life Optimization Problems" (16:10 – 16:35)

Abstract: BlockChain (BC) is a distributed data storage structure, maintained without any third party of absolute trust by the so-called consensus protocol. As the main issues in maintaining BC, security, privacy, consistency, and energy consumption are identified. According to the recent literature, some of these issues can be formulated as the Combinatorial Optimization (CO) problems and this fact motivated us to consider BC as an interesting research topic. In this talk we propose new consensus protocol based on Proof-of-Useful-Work (PoUW) concept that assumes solving instances of some real-life optimization problems. Due to the complexity of the underlying problems, we develop various types of heuristic methods that are utilized in the proposed PoUW consensus protocol.

- Zoran Ognjanović (Mathematical Institute of the Serbian Academy of Sciences and Arts)

"An approach to analyzing distributed protocols based on formal logic" (16:35 – 17:00)

Abstract: We present a modal logic that formalizes probabilistic, epistemic and temporal reasoning and formulate the main statements about the logic. We show how the logic can be used to describe distributed protocols (e.g. blockchain, zero-knowledge protocol) and to prove their correctness.

June 15 (12:00 – 18:00)

Sightseeing of Belgrade