



John Atanasoff



"I am now amazed and pleased to find that each of my four decisions relates to structures that are in use in modern computers" (1971)



JOHN ATANASOFF
SOCIETY OF AUTOMATICS
AND INFORMATICS



OCTOBER 4th - PROFESSIONAL DAY OF BULGARIAN
SPECIALISTS ON COMPUTERS, INFORMATION
TECHNOLOGIES AND AUTOMATICS



ABSTRACT BOOK

INTERNATIONAL CONFERENCE AUTOMATICS AND INFORMATICS 2026, VARNA, BULGARIA

Welcome to ICAI'2026

Dear participants,

It is a great honor and pleasure to welcome you to the International Conference Automatics and Informatics`2026 in the campus of the Technical University in the beautiful city of Varna, Bulgaria.

The International Conference Automatics and Informatics (ICAI) traditionally is held under the patronage of the President of the Republic of Bulgaria during the John Atanasoff days in October every year. The conference has over 55 years of history and has significantly contributed to the development of automation and computer technology in Bulgaria.

The purpose of the conference is to bring together international researchers and industrial practitioners interested in the development and implementation of modern technologies for automation, information, computer science, artificial intelligence and others.

First of all, the congratulations go to the participants who contributed with their papers. Without your high quality articles, we would not be here today.

We would like to express our deepest gratitude to hard working reviewers whose effort contributed for high quality of the paper selection process.

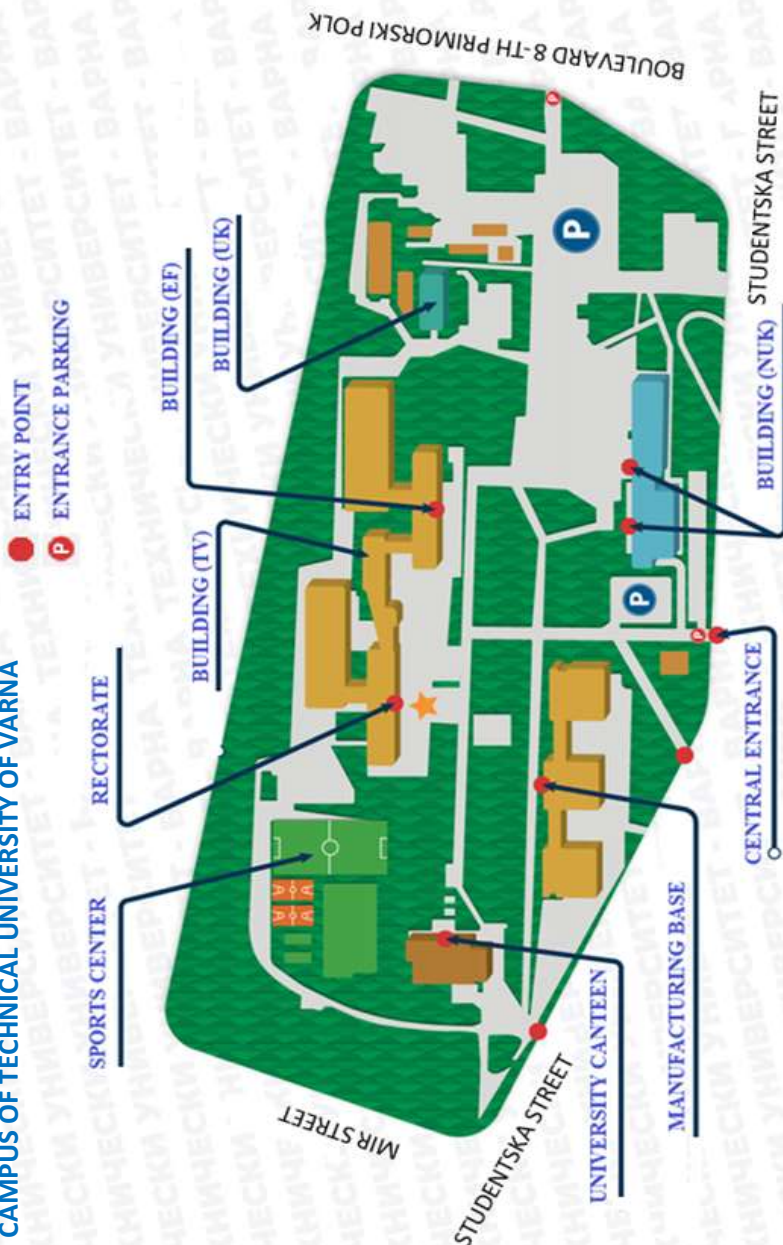
Please, have a look at the conference program to find the most important topics for you.

We wish you a productive meetings and hope you enjoy your stay in Varna!

Through our conference, we want to build bridges between scientists around the world.

The Committees and Chairs of ICAI'2026

CAMPUS OF TECHNICAL UNIVERSITY OF VARNA



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IEEE INTERNATIONAL CONFERENCE AUTOMATICS AND INFORMATICS'2026 (ICAI'26),

08 - 10 October 2026, VARNA (Technical University – Varna)

<http://icai-conf.org>

CONFERENCE PROGRAM – IN PERSON

THE GIVEN TIME IS ACCORDING TO THE BULGARIAN TIME ZONE - SOFIA UTC+3 HOURS

Thursday, October 8th

In the NUK gallery

08:00 – 09:00 REGISTRATION OF PARTICIPANTS

Stream 1 (Conference Hall NUK)

09:00 – 09:20 WELCOME AND OPENING CEREMONY

Stream 1 (Conference Hall NUK)

09:20 - 10:50 PLENARY SESSION 1 (PS)

Chairman: Kosta Boshnakov

1. The Hybrid Intelligence Scenario as a Potential Partnership between Humans and Artificial General Intelligence (AGI)



Arthur Kordon
Kordon Consulting LLC

2. Industrial AI: Unlocking the Next Level of Engineering Productivity



Tomasz Hofler
Siemens

Stream 1 In attendance (In-person)
(Room A – Hall 109TV)

11:00 - 12:30 SESSION A11: Control Theory: Stability and Learning-Based Control of Dynamical Systems

Chair: Kosta Boshnakov

- 1. New Delay-Independent Global Stability Criteria for Linear Neutral Systems Involving Multiple Delays**, Muhammet Mert Ketencigil, Ozlem Faydasicok and Sabri Arik (2950)
- 2. Novel Results for Stability of Neutral Cohen-Grossberg Neural Networks**, Melike Solak Altuntas, Ozlem Faydasicok and Sabri Arik (7762)
- 3. A Biologically Plausible Spiking Actor-Critic for Acrobot Control**, Borislav Markov (8081)
- 4. Optimization of Control Parameters in Cold Nuclear Fusion Systems via Deep Learning Surrogates**, Todor Malchev, Milena Lazarova, Yordan Paunov, Dimitar Alexandrov and Dilyana Gospodinova (0075)

12:30 – 13:30 LUNCH in the UNIVERSITY CANTEEN

13:30 - 15:00 SESSION A12: Advanced Algorithms and Computational Methods

Chair: Kosta Boshnakov

- 1. Gate-Based Quantum Optimization of Lattice Protein Folding: An Efficient NISQ-Compatible Framework**, Ayushi and Madhvi Shakya (5828)
- 2. Fast Linear Iterations for Noise Mitigation in Multi-agent Systems**, Martin Kenyeres, Jozef Kenyeres, Ján Mojžiš, Ján Zelenka and Nayden Chivarov (4543)
- 3. Associative ART: Learning of Weighted Category Relations**, Ilia Atanasov and Romyana Topalova (8540)
- 4. Stratified Specification Search: A Three-Criterion Decision Algorithm under Model Uncertainty**, Mariya Tsoleva (2645)

15:00 - 16:30 SESSION A13: Robotics

Chair: Milena Karova

- 1. Comparative Evaluation of Classical Bug0 Navigation and Deep Reinforcement Learning Using PPO for Mobile Robots**, Vasil Ninov (1035)
- 2. Curriculum learning framework for training a mobile robot for autonomous navigation using Proximal Policy Optimization in ROS2 and Gazebo**, Vasil Ninov, Ivan Chavdarov and Kaloyan Yovchev (4793)
- 3. Conditions for Maintaining the Orientation of a Gripper on a Planar Redundant Robot**, Bozhidar Naydenov, Ivan Chavdarov and Georgi Drenski (8211)

16:30 – 17:00 COFFEE BREAK

17:00 - 18:30 SESSION A14: Measurement, Signal Processing and Monitoring of Technical Systems

Chair: Nikola Nikolov

- 1. Operating-State Classification of Flowmeters Using Time-Domain Signal Signatures**, Pavel Dimitrov, Mariela Alexandrova, Reneta Parvanova, Ivan Grigorov and Radi Dobrev (3961)
- 2. Electrode Shape Reconstruction via a Dual-Channel 1D Convolutional Neural Network**, Murad Redzheb, Plamen Pekov and Dimiter Prodanov (9840)
- 3. Data as a Sensor for Transparent Ranking of Monitoring Positions on the A1 Sofia-Plovdiv Corridor**, Oleg Asenov and Panayot Panayotov (6706)
- 4. Analysis and optimization of power supply modules for data centers**, Elena Nikolova, Nikolay Yordanov, Viktor Dimitrov, Martin Tarlev, Viktoria Hristova and Vassilena Adamova (9134)

18:30 - 19:30 SESSION A15: COMPANY PRESENTATIONS

Chair: Nikola Nikolov

- 1. Siemens, From Data to Decision: Unlocking Industrial AI with Siemens Industrial Edge,** Rostislav Rusev, Nikola Petkov
- 2. Rittal, RITTAL RAS – from the idea to a real product,** Alexander Georgiev

19:30 COCKTAIL in the NUK Gallery

Friday, October 9th

Stream 1 In attendance (In-person)
(Room A – Hall 109TV)

09:00 - 10:30 SESSION A21: Communication Systems and Distributed Architectures

Chair: Mario Angelov

- 1. Architecture and Enabling Technologies for Adaptive Radio Communication Nodes in Multisensor Platforms**, Ivan Ivanov and Mario Angelov (3738)
- 2. Design and Implementation of a DSSS Mode for an SDR-Based Adaptive Radio Link in Multisensor Platform**, Ivan Ivanov and Mario Angelov (3983)
- 3. Provisioning-Assisted Directed Forwarding Initialization for Bluetooth Mesh**, Yordan Yordanov (8672)
- 4. Design, Prototyping, and Preliminary Evaluation of an Event-Driven Microservice Architecture for a Content Management System**, Plamenna Petrova and Juliana Dochkova-Todorova (4733)

10:30 - 12:00 SESSION A22: Machine Learning: Spam Detection and Federated Learning

Chair: Hristo Nenov

- 1. Arbitration Strategies for Hybrid Spam Detection: A Controlled Experimental Comparison**, Stefka Popova, Hristo Bozhidarov Nenov and Velislav Kolesnichenko (5365)
- 2. From Monolingual to Multilingual Spam Detection: Extending Hybrid Machine Learning Models Across Languages**, Stefka Popova, Hristo Bozhidarov Nenov and Velislav Kolesnichenko (6075)
- 3. A Scenario-Driven Framework for Threshold Cheon-Kim-Kim-Song Federated Learning with Phase-Aware Client Availability**, Dinko Dinkov, Veneta Aleksieva and Hristo Valchanov (5354)
- 4. Predictive Quorum Adaptation in Threshold Cheon-Kim-Kim-Song Federated Learning**, Dinko Dinkov, Veneta Aleksieva and Hristo Valchanov (7409)

12:00 - 13:30 SESSION A23: Human Factors and Digital Maturity in the Age of AI

Chair: Ivaylo Tsanov

- 1. Confidence Accuracy Gap in Phishing Detection: An Online Human Factors Study**, Ivaylo Tsanov (2834)
- 2. AI Related Productivity Pressure, Psychological Detachment and Work Related Exhaustion**, Ivaylo Tsanov (9380)
- 3. Linearizing Behavioral Metrics for Scalable User Happiness Assessment**, Svetlana Syarova, Genadiy Gospodinov, Teodora Nikolova, Yoana Hadzhiyska, Miglena Molhova-Vladova and Stefka Toleva-Stoimenova (8570)
- 4. Determinants of Digital Maturity of Small and Medium-sized Enterprises**, Kamen Spassov and Nikolay Netov (9118)

13:30 – 14:30 LUNCH in the UNIVERSITY CANTEEN

14:30 – 16:00 SESSION A24: Generative and Agentic AI

Chair: Ani Epitropova

- 1. Legal and Ethical Boundaries of AI-Based Computer Vision for Water Safety: A Regulatory Analysis of an “AI Lifeguard” System in Bulgaria**, Vasil Zagorchev and Nikolay Netov (6754)
- 2. A Product-Based Framework for Evaluating Visible Human Contribution in AI-Assisted Educational Content Development**, Ani Epitropova (5859)
- 3. Application of Linear Regression Analysis to Predict Global Trends and User Dynamics of ChatGPT**, Desislava D. Angelova and Zheyao I. Zheyayov (6256)
- 4. Systematic literature review on Agentic AI in Business Process Management**, Vanesa Filisyan (8267)

16:00 – 16:30 COFFEE BREAK

16:30 - 18:00 SESSION A25: Applied Software Engineering

Chair: Ventsislav Nikolov

- 1. Good Enough, Until It Isn't: The Debt of Frugal Process Automation**, Mahendrawathi Er, Karina Filza Aafiyah, Kesya Lintang Syawalani, Naila Ramadhani, Nikolaos Nousias, George Tsakalidis and Kostas Vergidis (7422)
- 2. Automating BPMN Model Generation of Public Services through RPA and AI Agents**, Panagiotis Drakopoulos and Kostas Vergidis (8166)
- 3. Interactive Web-Based Exploration of High-Resolution ICON-LAM Precipitation Forecasts Using Client-Side Spatial Filtering**, Catalin-Stefan Rucareanu (8469)
- 4. An empirical and comparative study of Agile and Waterfall approaches to IT project management and their application in corporate organizational structures**, Ivaylo Petrov (7936)

20:00 GALA DINNER in the BM City restaurant
(it is located behind the Festival and Congress Center)

Saturday, October 10th

Stream 1 In attendance (In-person)
(Room A – Hall 109TV)

09:00 - 10:30 SESSION A31: Decision Support Systems under Uncertainty

Chair: Valeriy Kolesnikov

- 1. Favourable Dynamic Change as a Proxy of Difference in Values of Utility**, Mohamed Daboos, Natalia Nikolova, Gabriela Petrova and Kiril Tenekedjiev (0261)
- 2. A Novel Classification Approach for Disasters in Intelligent Decision Support Systems**, Martin Bakardzhiev (7328)
- 3. Hazard-Aware Routing to Civil Protection Shelters Using Dijkstra's Algorithm and Multi-Layer Geospatial Graphs**, Valeriy Kolesnikov, Kateryna Abramova and Maksym Ovcharenko (6861)
- 4. User adoption of AI decision support systems**, Krasimira Georgieva and Iskra Karaivanova (6892)

10:30 - 12:00 SESSION A32: Machine Learning for Finance and Business Analytics

Chair: Yanka Alexandrova

- 1. Modeling Borrower Repayment Performance in Consumer Credit Lending**, Dimitre Tomov, Alexander Efremov and Atanas Atanasov (0475)
- 2. Machine Learning for Corporate Distress Prediction across Information Environments: Evidence from Bulgaria**, Yanka Alexandrova (2170)
- 3. Combining Statistical and Machine Learning Forecasts for Erratic Retail Demand**, Yanka Alexandrova, Yordan Atanasov and Violeta Dimitrova (0651)
- 4. A Business Intelligence-Centered Framework for Explainable and Actionable Machine Learning**, Yanka Alexandrova and Mihaela Muntean (0528)

12:00 - 13:30 SESSION A33: Educational Data Analytics and E-Learning

Chair: Valeria Simeonova

- 1. A Case Study Comparison of Logistic Regression, Random Forest, and Gradient Boosting for Predicting Computer Science Student Placement: Evidence from a Single Institution Dataset**, Ivo Vladimirov Rakitin, Evgeniya Vladimirova Rakitina-Qureshi, Hristo Bozhidarov Nenov, Neli Ananieva Arabadzhieva-Kalcheva, Donika Georgieva Stoyanova and Daniela Ivanova Petrova (0300)
- 2. Impact of Dataset Scale on Predictive Performance in Educational Analytics: A Learning Curve Analysis of Random Forest for Student Placement Prediction**, Ivo Vladimirov Rakitin, Evgeniya Vladimirova Rakitina-Qureshi, Milen Georgiev Angelov, Donika Georgieva Stoyanova, Dimitrichka Zheleva Nikolaeva and Stefka Popova (1490)
- 3. ROTLA: A Temporal Learning Analytics Core Combining Behavioral, Psychological and Affective Indicators in Moodle-Based Courses**, Maria Garbova, Krassen Stefanov, Valeria Simeonova and Dafinca Miteva (7555)
- 4. ACRA-ROTLA: An Integrated Affective-Cognitive Risk Analysis Framework for Early Detection of At-Risk Students in E-Learning**, Maria Garbova, Krassen Stefanov, Valeria Simeonova and Dafinca Miteva (9176)

13:30 – 14:30 LUNCH

14:30 - 16:00 SESSION A34: Image Analysis for Environmental Monitoring

Chair: Monika Bedzheva

- 1. A methodology for studying temperature changes in the marine areas of the Republic of Bulgaria using thermal satellite imagery**, Monika Bedzheva, Daniel Draganov and Yordanka Yordanova (0621)
- 2. A methodology for monitoring of sea beaches using multispectral satellite imagery**, Monika Bedzheva, Tatyana Moneva, Naylyan Salieva, Stanimira Stoyanova and Andriana Ivanova (6873)
- 3. Comparative Assessment of Classical Machine Learning and Temporal Neural Networks for SAR-Based Forest Disturbance Detection in the Burgas Region**, Philipa Aleksandrova, Chavdar Alexandrov and Miroslav Tsvetkov (8372)
- 4. A system for analysis of digital images of underwater objects**, Ventsislav Nikolov and Daniel Hernández-Sosa (1272)

17:00 – 17:15 CLOSING CEREMONY

IEEE INTERNATIONAL CONFERENCE AUTOMATICS AND INFORMATICS'2026 (ICAI'26),

08 - 10 October 2026, VARNA (Technical University – Varna)

<http://icai-conf.org>

CONFERENCE PROGRAM – ONLINE

THE GIVEN TIME IS ACCORDING TO THE BULGARIAN TIME ZONE - SOFIA UTC+3 HOURS

Thursday, October 8th

Stream 1 (Conference Hall NUK)

09:00 – 09:20 WELCOME AND OPENING CEREMONY

Stream 1 (Conference Hall NUK)

09:20 - 10:50 PLENARY SESSION 1 (PS)

Chairman: Kosta Boshnakov

1. The Hybrid Intelligence Scenario as a Potential Partnership between Humans and Artificial General Intelligence (AGI)



Arthur Kordon
Kordon Consulting LLC

2. Industrial AI: Unlocking the Next Level of Engineering Productivity



Tomasz Hofler
Siemens

Stream 2 Online (Virtual) (Room B)	Stream 3 Online (Virtual) (Room C)	Stream 4 Online (Virtual) (Room D)
11:00 - 12:30 SESSION B11: Text Processing Chair: Stanislav Penchev 1. Performance Comparison of Data Structures for Dictionary Lookup in Morphologically Rich Languages, Nikola Vukotić (0926) 2. Grammar-Motivated Annotation Changes in a Serbian Web Corpus: Annotation Quality and Its Cost to Part-of-Speech Taggers, Nikola Vukotić (6002) 3. Parallel Grammar and Spelling Errors Detection, Dragana Petkova, Ilkem Kivanch and Vladimir Zdravski (5421) 4. Uncertainty-Guided Active Learning for Multilingual Sentiment	11:00 - 12:30 SESSION C11: Digital Identity, Authentication and Trusted Records Chair: Aydan Haka 1. Towards Trustworthy and Interoperable Digital Credential Ecosystems: A Structured Literature Review and Conceptual Synthesis of Verifiable Digital Credentials in the Context of eIDAS 2.0, Arbnor Halili, Mariana Atanasova and Eliza Stefanova (5151) 2. Electronic Identification Framework for Digital Academic Repository Systems in Higher Education, Simeon Arnaudov and Boris Stoykov (2716) 3. Graph Neural Network-Based Continuous Keystroke Authentication for Critical	11:00 - 12:30 SESSION D11: Electrical Machines, Power Systems and Thermal Processes Chair: Michail Petrov 1. Comparative Analysis of Surge Arrester Modelling in Switching Transient Studies of Medium Voltage Capacitor Banks, Nisar Basha A and Mahiban Lindsay N (1049) 2. A Hybrid Analytical-Numerical Approach for Investigating the Temperature Distribution in a Variable-Frequency fed Induction Motor, Marin Todorov, Maik Streblau and Marin Marinov (2383) 3. Two linear induction motor drives with a flexible connection between the motors, Bojidar Markov (5055)

Analysis of Tourism Reviews, Aslanbek Murzakhmetov, Mukhan Murotboyev, Arseniy Bapanov, Maxatbek Satymbekov and Nurbol Beisov (1698)	Information Infrastructure, Anna Pyrkova, Nurassyl Kerimbayev and Nazymgul Odanova (5268) 4. Tamper-Evident Compliance Records for EU OSS VAT: An HMAC-Chained Implementation of the Article 63c Ten-Year Record, Marieta Marinova (2014)	4. Design of an Algorithm for Control the Power of Evaporative Condensers in a Cooling System, Antoniy Petrov, Albena Taneva and Michail Petrov (7213)
12:30 – 13:30 LUNCH BREAK		
13:30 - 15:00 SESSION B12: Perception, Autonomous Systems and Robotics Chair: Sevil Ahmed-Shieva	13:30 - 15:00 SESSION C12: Compilers, Software Testing and Source-Code Analysis Chair: Iyavlo Penev	13:30 - 15:00 SESSION D12: Dynamic Modelling, Data Assimilation and Forecasting Chair: Javanshir Mammadov
1. Towards Intelligent Hybrid Systems for 3D Reconstruction of Cultural Heritage: Challenges, Current Methods, and Future Directions, Nikol Manolova, Alexander Penev and Asya Stoyanova-Doycheva (4362) 2. A Declarative Architecture for Perceptual Data Structuring and Anchoring in Autonomous Mobile Robotics, Radoslav Vasilev, Stefan	1. MCLUAC: An Extensible Lua 5.4 Compiler with Token and AST-Level Plugin Points, Georgi Petkov and Martin Vassilev (3180) 2. MutaScore: LLM-Guided, Budget-Aware Mutant Prioritization for End-to-End Web Testing, Mahendra Vardhan Amilineni (4558) 3. Ablation Study of a Hybrid Source-Code Plagiarism Detection Model: Quantifying the Contribution of	1. Development of the architecture of an automated system for monitoring and modeling the process of optimal water consumption, Javanshir Mammadov, Khavar Kerimova and Gulnara Abbasova (0102) 2. Data Assimilation and Probabilistic Water-Level Forecasting in an Open Channel Using EnKF and GPR, Aslanbek Murzakhmetov, Gaukhar

Chivarov, Maya Staikova and Nayden Chivarov (9788) 3. An Explainable Multimodal Framework for Driving-Safety Event Prediction and Grounded Explanation, Karno Sarker (9575) 4. Algorithm for Adaptive Leader Selection in a Drone Swarm, Ivan Garvanov, Magdalena Garvanova, Daniela Borissova, Denislav Kanev, Zdravko Yankov and Evgeni Vasilev (8754)	Individual Components, Daniel Damyanov (1302) 4. Beyond Token Matching: A Controlled-Corpus Study of Graph and Embedding Signals for Detecting Similar and AI-Generated Code, Daniel Damyanov (8094)	Borankulova, Aigul Tungatarova, Samat Bekbolatov, Bakhyt Yeraliyeva, Saltanat Dulatbayeva and Balzhan Turarova (5145) 3. Mamdani Fuzzy Control and Reduced-Order Modeling of Power Supply Fluctuations in the Central Power System of the Karabakh Region of Azerbaijan, Nurali Yusifbayli, Javanshir Mammadov, Huseygulu Guliyev, Lala Najafova and Roya Narimanova (4830) 4. Interlinking Housing Markets and Household Credit: A Dynamic Model of Cyclical Interactions and Long-Term Forecasting, Reepalkumar Patel (2699)
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15:00 - 16:30 SESSION B13: LLM Systems: Retrieval and Model Selection Chair: Ioannis Patias	15:00 - 16:30 SESSION C13: Software Architecture Chair: Ivaylo Penev	15:00 - 16:30 SESSION D13: Optimization and Network Flow Models Chair: Nikola Nikolov
1. CostCompressRAG: Cost-Aware Context Compression for Enterprise Retrieval- Augmented Generation, Sunil Kumar Paidi (2088) 2. Retrieval Quorum: Consensus-Based Evidence Selection for Trustworthy Enterprise RAG, Sai Chaitanya Kumar Paidi (4802) 3. Learning-Based Query Routing with Latency and Cost Constraints in Distributed Search Systems, Sunil Kumar Paidi (9855) 4. Handling Uncertainty in Large Language Model Selection for Public Administration: A Fuzzy Logic Decision Framework, Ioannis Patias (5248)	1. Understanding Software Architecture Evolution: An Analytical Perspective from Monolithic Systems to AI-Oriented Architectures, Hristo Hristov (6562) 2. Serverless React Architectures: A Quantitative Analysis of Scalability, Latency, and Cost Trade-Off, Rand Kouatly and Aiswarya Sajeev (7185) 3. A Layered Architecture for Automated Web Data Extraction on the .NET Platform, Berkant Ismet (4218) 4. Design and Evaluation of a Git-Oriented DVCS Core in Rust, Nicusor Dumitru Sami Barbut-Dica and Mirel Cosulschi (4615) 5. A Rule-Based Algorithm for Software Architecture Recommendation from Requirements Specifications, Nina Asenovska and Asya Stoyanova-Doycheva (7889)	1. Generalized Nonlinear Genomic Network Flow, Draga Toncheva and Vassil Sgurev (0307) 2. Nonlinear Network Flow with Nonlinear Flow Functions, Vassil Sgurev and Draga Toncheva (3508) 3. Management of Building Evacuation through Minimum-Cost Maximum-Flow Optimization, Vassil Sgurev, Lyubka Doukovska and Georgi Tsopanov (8483) 4. A Hybrid Knapsack and Timed-Automata Approach to Energy-Constrained Operation Scheduling, Yordan Belev, Tsvetelina Ivanova and Idilia Batchkova (3816)

16:30 – 17:00 BREAK		
17:00 - 18:30 SESSION B14: Image Processing and Classification Chair: Ivan Grigorov	17:00 - 18:30 SESSION D14: Quantum, Reversible and Memristive Computing Chair: Valeri Mladenov	
1. Multi-Part Plant Disease Detection Using Deep Learning: A Comparative Evaluation of CNN Architectures, Muhammad Hussain Rana, Leong Jo Ee and Muhammad Ehsan Rana (7181) 2. Optimized MobileNetV2 Architecture for Fine-Grained Food Image Classification, Klaus Caka, Usman Akhtar, M. Kamran Asif, Ahmed Hassan, Meerah Karunanithi and Zeeshan Ali (9439) 3. FLACS: Transfer Learning for Facial Skin Type Classification: A Comparative Study of MobileNetV2 and EfficientNetB0, Sri Sandhya Velicheti, Manasa Boyina and Sri Bala Ayyappa Swamy Bezawada (3519) 4. Embedded Implementation of a Segmentation-Guided Flying Pixel Correction Algorithm for Time-of-Flight Images on Raspberry Pi 5, Alexander Lyubenov and Stefan Ivanov (1508)	1. Comparative Analysis of Classical and Quantum Support Vector Machines for Large Hadron Collider Data Classification, Sofia Domracheva, Alexander Penev and Stefan Stavrev (1675) 2. Reversible Peres-Gate Architecture for Two-Input Multiplexers and Cascaded Realization of Three-Variable Boolean Functions, Adriana Borodzhieva (2987) 3. Reversible Implementation of Binary Subtractors Using Fredkin Gates: Logisim-Based Design and Educational Methodology, Adriana Borodzhieva (4963) 4. Logic Gates and Circuits with Memristive Elements, Stoyan Kirilov, Georgi Tsenov, Ivan Trushev and Valeri Mladenov (8309)	

Friday, October 9th

Stream 2 Online (Virtual) (Room B)	Stream 3 Online (Virtual) (Room C)	Stream 4 Online (Virtual) (Room D)
09:00 - 10:30 SESSION B21: Machine Vision Chair: Nikolay Stoimenov	09:00 - 10:30 SESSION C21: Gamification and Learning Analytics Chair: Ventsislav Nikolov	09:00 - 10:30 SESSION D21: Neural Models and Self-Organization Chair: Angel Marchev Jr
1. SDefect-VLM: A Vision–Language Framework for Industrial Surface Defect Detection and Maintenance Advisory, Md Zahidul Islam (0589) 2. A Low-Cost Machine Vision Approach for Real-Time Measurement and Classification of Industrial Parts, Mihail Zagorski, Veselin Marinov, Hristo Karamishev and Radoslav Miltchev (2967) 3. Analysis of Object Detection Stability for Camera-Based Product Monitoring under Different Visual Conditions, Tsvetislava Lavchieva and Delyan Genkov (7333) 4. Non-destructive Inspection of Aircraft Fastener Joints X-Ray	1. A Conceptual Framework for Human-Centered AI Learning Analytics in Gamified Industry 5.0 Education, Neviana Krasteva and Teodor Daskalov (0315) 2. Gamified Incentives and Intrinsic Motivation under Cognitive Overload in a Simulation-Based Study of Engagement and Decision Quality, Neviana Krasteva, Tsvetan Davidkov and Aleksey Potebnya (4573) 3. Explainable Artificial Intelligence for Modeling Invisible Academic Work in Gamified Higher Education Environments, Neviana Krasteva (6671)	1. Different Neural Network models, Georgi Markov, Lyubka Doukovska and Momchil Kiranov (5573) 2. Initial Steps toward Developing a Python Library for Integral Neurons, Emil Hadzhikolev, Kostadin Yotov, Sergey Kubinski and Stanka Hadzhikoleva (8683) 3. Self-Organization in Complex Systems with Evidence from a Multi-Species Particle Simulation, Angel Marchev Jr. (6086) 4. Partificial Life - Particle Simulation Studying Self-organization, Angel Marchev Jr. (8751)

Computed Tomography, Miglena Kyoseva, Nikolay Stoimenov, Peter Panev, Martin Tsvetkov and Svetlana Trifonova (7287)	4. Comparison of Researcher-Selected Models and Automated Model Selection for Student Dropout Prediction, Neli Arabadzhieva-Kalcheva, Maya Todorova, Ivo Rakitin, Evgeniya Rakitina-Qureshi, Antoaneta Ivanova-Dimitrova and Milen Angelov (3467)	
10:30 - 12:00 SESSION B22: Agent-Based and Agentic AI Systems Chair: Plamen Vasilev	10:30 - 12:00 SESSION C22: Digital Technologies in Business, Services and Careers Chair: Stanimir Stoyanov	10:30 - 12:00 SESSION D22: AI Technologies in Photovoltaic Systems Chair: Daniela Borissova
1. A Layered Conceptual Architecture for LLM-Based Agentic Systems, Miglena Stoyanova (4352) 2. A Model-Driven Framework for Agentic AI-Enabled Lean Six Sigma Quality Management, Kalina Garkova, Plamen Vasilev and Daniela Gocheva (2694) 3. Local AI Architecture for an Agent-Assisted Platform, Milen Sotirov and Valentina Petrova (2253) 4. Designing context-driven multi-agent system for corporate training, Lilyana Rusenova and Elena Somova (6091)	1. Experimental evaluation of an AI-based career guidance system, Veneta Tabakova-Komsalova, Evgenia Temelkova, Vaska Baklarova, Ivan Stoyanov and Stanimir Stoyanov (6035) 2. Heterogeneity Among Auditors in Digital Technology Adoption: A Latent Class Analysis, Ilva Isa and Lule Basha (2875) 3. Measuring Store-Level Operational Efficiency: Computational Validation of Weighting Coefficients and a Multidimensional Index Based on MDA, Vasil Marchev (8046)	1. False-Negative Behavior in Thermal-Only CNN-Based Photovoltaic Inspection Under Homogeneous Soiling, Antonio Karaganov (2191) 2. XGBoost–LSTM hybrid framework for fault detection and predictive maintenance of photovoltaic systems, Gabriela-Valentina Olteanu, Ioana Făgărășan, Cristina Nechiforov and Marius Dobrea (5993) 3. Digital-Twin-Informed Machine Learning for Virtual Sensing of Silicon Stress in Photovoltaic Modules, Antonio Karaganov (7705)

	4. Potential innovations for transport and passenger services in the Sofia metro, Mirena Todorova, Zlatin Trendafilov and Vilina Velyova (8392)	4. Entropy-Integrated Decision-Making Model for Photovoltaic Panel Selection, Daniela Borissova, Rossen Mikhov, Gabriela Garvanova-Petkova, Zornitsa Dimitrova, Nesho Garvanov and Vasil Dimitrov (8433)
12:00 - 13:30 SESSION B23: Clinical Prediction and Physiological Signal Analysis Chair: Veneta Aleksieva	12:00 - 13:30 SESSION C23: Generative AI and Ethics in Education Chair: Vladimir Jotsov	12:00 - 13:30 SESSION D23: Parallel and Concurrent Computing Chair: Delyan Genkov
1. An Intelligent Machine Learning Framework for Automated HIV Drug Resistance Prediction and Clinical Decision Support, Pranjali Vaidya, Ktv Reddy, Praful Kamble, Anushka Gopale, Tanmay Barai and Trunal Barai (6286) 2. Evaluation of Audio Features for Noisy Phonocardiogram-Based Heart Sound Classification, Rand Kouatly and Cherry Blossom Garcia (7488) 3. Classification of Physiological States at Rest and During Extreme Gaming in Virtual Reality Using Machine Learning, Penio	1. A Multi-Dimensional Framework for Evaluating Ethical and Pedagogical Dimensions of Artificial Intelligence Integration in Educational Environments, Zhanat Umirzakova, Dana Sakypova, Vladimir Jotsov, Nurassyl Kerimbayev, Raushan Medeuova, Sanimgul Sambayeva and Gulmira Yemzharova (4521) 2. Intelligent Educational Ecosystems of Generative AI: Genesis Learning Model, Nurassyl Kerimbayev, Anna Pyrkova, Rustam Shadiev, Radoslav Yoshinov, Vladimir Jotsov, Zhanbota Menlibay, Aliya Akramova and Vitaly Tshahelny (7852)	1. Scalable Parallel Framework for Recommendation Systems based on User–Item Interaction Graphs, Borjan Dimeski and Vladimir Zdraveski (8610) 2. Researching the parallel operation of computers in a local area network for rendering in Blender, Hristo Kilifarev, Tsvetislava Lavchieva, Delyan Genkov and Miroslav Slavov (8110) 3. Parallel Floyd Warshall Algorithm for Physical and Social Distance between Cities, Jovan Davaliev, Dimitar Peshevski, Dimitar Trajanov and Vladimir Zdraveski (3351)

Lebamovski and Evgeniya Gospodinova (7538) 4. Q-Sepsis: A Lightweight Explainable Quantum Ensemble for Edge-Deployed Sepsis Prediction, Gulshan Katankar, Brajesh Nandan, Arpit Sharma, Saravanan Parthasarathy, Vaishnavi Jayaraman and Selvakumar Ramachandran (1756)	3. A scalable AI-assisted pedagogical model for web design practical courses: empirical validation across diverse university cohorts, Maya Stoeva (0160) 4. A Simulated Multi-Agent Workflow for Differentiated Learning Materials: Design and Pilot Evaluation, Vyara Dukova (0554)	4. Semantic Differential Debugging of Multithreaded Programs, Martin Vassilev and Alexander Penev (5827)
13:30 – 14:30 LUNCH BREAK		
14:30 - 16:00 SESSION B24: Anomaly Detection in Telemetry Chair: Lala Bekirova	14:30 - 16:00 SESSION C24: Learning Platforms and Educational Robotics Chair: Mariyana Todorova	14:30 - 16:00 SESSION D24: Control, Signal Processing and Electronic Chair: Vesela Karlova-Sergieva
1. SENTIS: A Deterministic Anomaly Detection Model Topping the Numenta Anomaly Benchmark, Mahammad Yusifov and Lala Bekirova (0162) 2. Anatomy of a Streaming Anomaly Detector: Channel Ablation, Model Reduction and Cross-Benchmark Adaptation of SENTIS, Mahammad Yusifov (9538)	1. A Reference Architecture for Orchestrating Cognitive Services in Intelligent Learning Platforms, Asya Toskova and Borislav Toskov (2396) 2. Web-based platform for didactic interaction in pedagogical student practice, Lilyana Petkova and Vasilisa Valeova (3014) 3. Educational Robotics: A Systematic Review of Technologies, Pedagogical	1. Adaptive FOPID controller with dynamic integral order for DC motor control, Boris Grasiani, Vesela Karlova-Sergieva and Nina Nikolova (8720) 2. Hall-Effect Sensor Data Processing for Contactless Lever Position Estimation Using Artificial Neural Networks, Ventsislav Simonov and Tanya Titova (7410)

3. RADWIN: Robust Drift-Aware Anomaly Detection for IoT Telemetry Streams at the Edge, Marian Ileana, Pavel Petrov, Vassil Milev and Miroslav Dechev (0289) 4. AROS-S: A Lightweight Onboard Anomaly Detector for Satellite Telemetry, Zlatimir Petrov (9545)	Practices, and Learning Outcomes (2020–2025), Rustam Shadiev, Shugyla Nurserik, Aruzhan Kaldybai, Aierke Nurgali, Nurassyl Kerimbayev, Shakhzada Abdugani, Gulnaz Knyazkhan, Altynshash Bekezhanova, Gulnaz Salgarayeva and Altynshash Bekezhanova (5358) 4. Evaluating Accessibility Evidence in Corporate Learning Systems to Support Inclusive Employment, Radostina Tsvetkova and Lyubka Doukovska (8481)	3. Coupling-Matrix Synthesis of X-Band CMOS Lumped-Element Filters with Unit-Capacitor Design Freedom for Calibration-Aware Design, Marin Nedelchev and Jordan Kechev (7383) 4. Increasing the nonlinearity of Boolean functions by adaptive wavelet spectrum modification, Alla Levina and Nikita Panchenko (6574)
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Saturday, October 10th

Stream 2 Online (Virtual) (Room B)	Stream 3 Online (Virtual) (Room C)	Stream 4 Online (Virtual) (Room D)
09:00 - 10:30 SESSION B31: Deep Learning for Medical Imaging and Clinical Tests Chair: Idilia Batchkova	09:00 - 10:30 SESSION C31: Governance, Standards and Responsible AI Adoption Chair: Sevinch Gulsechen	09:00 - 10:30 SESSION D31: Edge-Cloud, Networking and IoT Data Architectures Chair: Veneta Aleksieva
1. Persistent Homology Meets Deep Learning for Crohn's Disease Lesion Classification , Abbass Rammal, Nadine Chreim, Abbass Harb and Mageda Sharafeddin (4101) 2. Real-Time Brain Tumor Detection and Patient Understanding Using Computer Vision , Derrick Mirindi, Frederic Mirindi and David Sinkhonde (5922) 3. Optimizing Clinical Decision Support: Deep Learning Architectures for Brain Tumor Classification , Klaus Caka, Usman Akhtar, Meerah Karunanithi, M. Kamran Asif, Ahmed Hassan and Zeeshan Ali (7285)	1. AI Adoption in Sensitive Data Environments: Expert Insights from Healthcare and Public Administration , Stefanie Filipczyk and Katia Rasheva-Yordanova (0757) 2. A Governance-Oriented Framework for Privacy-Preserving AI Adoption in Regulated Information Systems , Stefanie Filipczyk and Katia Rasheva-Yordanova (7955) 3. The Adaptive Layered Standardization Model: A Formal and Simulation-Based Approach to Overcoming Standardization Debt in an Era of Exponential Technological Change , Miroslav Mitev (8149)	1. Applying A-MAPSS to an Elixir-Based IoT Sensor Data Processing Platform , Hristo Hristov and Dimitrichka Nikolaeva (7836) 2. Towards Low-Latency Networking: A Hybrid Cloud-Edge Architectural Perspective , Mohammad Al Rawajbeh (4254) 3. Connection and Abstraction Modules for Software Defined Network with Different Controllers , Delyan Genkov, Miroslav Slavov and Hristo Kilifarev (1085) 4. Measuring What Gets Lost: An Empirical Comparison of CRDT-Based and Conventional State

4. Multilingual AI-Powered Medical Report Summarization with Symptom Localization, Aarushi Singh, Nilofer Shaikh, Ritesh Jadhav, Prathamesh Surve and Shan Faiz (4318)	4. The European Cybersecurity Skills Framework as a Basis for Establishing the Cybersecurity Profession and Developing Competence-based Educational Models, Miroslav Mitev and Yassen Tanev (0180)	Synchronization for Digital Twins, Petar Chakalov and Svetoslav Enkov (5080)
10:30 - 12:00 SESSION B32: Speech, Voice and Interaction Technologies Chair: Tzvetomir Vassilev	10:30 - 12:00 SESSION C32: Secure Deployment, Data Protection and Digital Forensics Chair: Plamen Vasilev	10:30 - 12:00 SESSION D32: LPWAN and IoT Sensing Networks Chair: Grisha Spasov
1. A Modular Software Framework for Reproducible Multi-Factor Evaluation of Automatic Speech Recognition Systems, Hasan Gyulyustan and Svetoslav Enkov (4336) 2. Unified Multilingual Web-Based Framework for Bidirectional Speech–Text Conversion Using Intelligent Processing Technologies, Maksat Churiyev, Maral Geldiyeva, Tzvetomir Vassilev, Gadam Akmyradov, Oguljan	1. Origin side penetration testing and remediation framework for Cloudflare fronted self-hosted LLM deployment, Tsvetomir Bogdanov, Nayden Chivarov and Stefan Chivarov (0270) 2. Detection engine constraints and pattern portability across five cloud Data Loss Prevention platforms, Tsvetomir Bogdanov (7940) 3. Comparison of Machine Learning Models at Analysis of Image Files in Digital Forensics, Veselina Vukova and Malinka Ivanova (7763)	1. Simulation study of the applicability of LoRaWAN IoT in an air parameter measurement system, Grisha Spasov (0959) 2. W-Mesh: a Duty-Cycled LoRa Mesh Extension for Windowed Buffered Telemetry, Nikolay Milovanov (1831) 3. IoT LPWAN as the Monitoring and Diagnosis Layer of Smart Water Networks (SWN), Nikolay Milovanov (6106) 4. An AI-driven predictive humidity control architecture for smart greenhouses using distributed

Akmyradova and Ayna Nurmyradova (2462) 3. Toward Voice-Oriented Architectural Styles: A Conceptual Framework for AI-Driven Conversational Systems, Hristo Hristov (9136) 4. The Influence of User-Friendly Interface Design on Technology Acceptance and Continuance Intention in Digital Editing Applications, Yohanes Philip Subekti, Ahmad Sultan Pahlevi and Yanti Tjong (2146)	4. Security Aspects in Multi-tiered Architectural Frameworks for Intelligent Internet of Things Systems, Andon Nenov, Ivaylo Atanasov, Maria Nenova and Georgi Iliev (4702)	LoRaWAN sensor networks in arid climates, Palvan Kalandarov, Shakhnoza Ubaydullayeva and Mariela Alexandrova (8084)
12:00 - 13:30 SESSION B33: Knowledge Representation, Management and Ontologies Chair: Stanislav Penchev	12:00 - 13:30 SESSION C33: Intelligent Assessment and Accreditation Platforms Chair: Todorka Glushkova	12:00 - 13:30 SESSION D33: Materials, Sensors and Manufacturing Technologies Chair: Stefan Ivanov
1. Integrating Artificial Intelligence into Knowledge Management Systems: Trends, Challenges and Future Prospects, Kiril Luchkov and Nadya Velinova-Sokolova (1712) 2. A conceptual framework for using artificial intelligence in digitalization and effective knowledge manage-	1. A local human-in-the-loop system for AI-assisted assessment, Milen Sotirov and Dilyana Dimitrova (2532) 2. Intelligent Programme Accreditation Platform, Milen Sotirov, Valentina Petrova and Donika Nikolova-Sotirova (2811)	1. Experimental Validation of a Simulation-Based Methodology for Quality Improvement in Transparent Polymer Components, Todor Todorov, Georgi Todorov and Mario Semkov (2377) 2. Static Structural Analysis of a 3D-Printed PLA Lattice Structure under

ment, Kiril Luchkov and Nadya Velinova-Sokolova (0428) 3. Protected Plants in Bulgaria: Ontology, Passport Descriptor Pattern and Integration with the GeneBank Ontology, Sebiha Madanska, Asya Stoyanova-Doycheva and Zornica Radeva (3447) 4. Formal, Mathematical, and Computational Interpretation of the “Tree of Life” Motif in Bulgarian Embroidery via Prolog and SVG, Tanya Srebrev, Veneta Tabakova-Komsalova, Stanimir Stoyanov, Srebrin Srebrev, Ivan Stoyanov and Sebiha Madanska (6524)	3. Formal Modeling of an Automated Student Assignment Assessment System Using the Calculus of Context-Aware Ambients, Konstantin Rusev, Todorka Glushkova and Angel Georgiev (7135) 4. Layered-Modular Conceptual Model of a Digital University Information Ecosystem, Vassil Milev, Miroslav Dechev, Marian Ileana, Pavel Petrov and Filipp Safronov (6786)	Multiple Loading Conditions, Vasil Lozanov, Nayden Chivarov and Albena Daskalova (4272) 3. Integrated Automated System for Extraction and Assembly of Injection-Molded Protective Eyewear, Todor Todorov, Yavor Sofronov, Todor Gavrilov and Mario Semkov (9381) 4. Multilayer TiO₂-SiO₂-ZnO Humidity Sensing Element Prepared via a Sol-Gel Method, Stefan Ivanov, Nedyu Nedev, Stephan Kozhukharov, Zvezditzia Nenova, Georgi Avdeev and Toshko Nenov (5034)
13:30 – 14:30 LUNCH BREAK		
14:30 - 16:30 SESSION B34: Enterprise and Industrial Systems: Security, Reliability and Operations Chair: Plamen Vasilev	14:30 - 16:30 SESSION C34: Energy and Context-Aware Smart Environments Chair: Georgi Mihalev	
1. Extension of Conventional Cybersecurity Risk Assessment for	1. Cross-Dataset Consensus Anomaly Detection in Smart Building Energy and Environmental Sensor	

ERP–SCADA Integration, Hristo Hristov and Stela Kostadinova (1552) 2. Design of an ERP–SCADA NIS2 Readiness Framework for Industrial IoT Environments, Hristo Hristov (2226) 3. Fault Injection-Based Timing Robustness Analysis of a Siemens S7-1500V Virtual PLC Runtime, Yavuz Şişkolcu, Görkem İnci and Gökşen Ömekci (2340) 4. A Framework for Integration of Cybersecurity into Project Management Office, Angel Angelov, Daniela Borissova, Ivan Blagoev, Magdalena Garvanova and Ivan Garvanov (9258) 5. Predictive Failure Detection in Oracle SOA and Oracle EBS Ecosystems Using Artificial Intelligence and AIOps, Nagireddy Vasipally (0647)	Streams, Dharmik Champaneri and Shan Faiz (0347) 2. Ontology-Based Energy Monitoring and Context-Aware Anomaly Interpretation Using Hybrid Analytics, Polina Kesova, Tsvetelina Ivanova, Yordan Belev and Idilia Batchkova (8647) 3. Adaptive IoT Controller for Pellet Boilers, Stanimir Yordanov, Georgi Mihalev, Stefan Ivanov and Hristina Stoycheva (5479) 4. Detecting Anomalies in Household Behaviour as an Early Health Signal: A Review and Decision-Support Framework for Unobtrusive Monitoring of Older Adults, Ivo Gergov and Adelina Aleksieva-Petrova (4531)	
17:00 – 17:15 CLOSING CEREMONY		

PLENARY SESSION	Stream 1
Chair: Kosta Boshnakov	University of Chemical Technology and Metallurgy, BG
Thursday, October 08 th 09:20 – 10:50	Conference Hall NUK

1. The Hybrid Intelligence Scenario as a Potential Partnership between Humans and Artificial General Intelligence (AGI)

Arthur Kordon

Kordon Consulting LLC, US

Abstract: Recent exponential growth of the capabilities of frontier AI models raises a realistic expectation of achieving the ambitious goal of Artificial General Intelligence (AGI) in the foreseeable future. The objective of the plenary talk is to discuss the opportunities this major technological breakthrough may offer and to raise warnings about the big challenges that need to be overcome. One of the fundamental issues in this period is developing a reliable long-term strategy of partnership between humans and the growing, dominating cognitive power of AGI. A potential scenario is Hybrid Intelligence, defined as a framework of methods, approaches, and tools to balance the interactions between humans and AI. The key capabilities and advantages of this proposed option will be discussed, along with examples. Of special importance will be emphasizing the need to focus on addressing social issues in the era of highly productive technologies, such as AGI.

2. Industrial AI: Unlocking the Next Level of Engineering Productivity

Tomasz Hofer

Siemens, DE

Abstract: Artificial Intelligence is reshaping the industrial landscape, enabling smarter operations, faster engineering, and more efficient decision-making. This presentation provides an overview of Siemens Industrial AI portfolio, demonstrating how AI is being applied in real industrial environments today. From AI-powered quality inspection and predictive maintenance to advanced engineering copilots, edge-based AI applications, and generative AI integrated into Siemens solutions, attendees will gain insights into how Industrial AI can improve productivity, reduce downtime, and accelerate digital transformation across manufacturing and process industries.

SESSION A11 – CONTROL THEORY: STABILITY AND LEARNING-BASED CONTROL OF DYNAMICAL SYSTEMS	Stream 1
Chair: Kosta Boshnakov	University of Chemical Technology and Metallurgy, BG
Thursday, October 08 th 11:00 – 12:30	Hall 109TV
New Delay-Independent Global Stability Criteria for Linear Neutral Systems Involving Multiple Delays	
<i>Muhammet Mert Ketencigil</i>	<i>Istanbul University, TR</i>
<i>Ozlem Faydasicok</i>	<i>Istanbul University, TR</i>
<i>Sabri Arik</i>	<i>Istanbul University-Cerrahpasa, TR</i>
Abstract: The present work addresses the challenging problem of global asymptotic stability analysis for linear neutral systems involving multiple delays affecting both the states and their derivatives. By using a suitably constructed Lyapunov functional and analysing its time derivative, new delay-independent sufficient conditions are obtained. The derived criteria are stated directly using the entries of the system matrices together with some auxiliary scalar parameters, making them easy to apply in establishing the stability of the considered system through straightforward algebraic computations. A numerical example illustrates how these criteria can be applied, while simulations performed for various delay configurations and initial functions show that the state trajectories approach the equilibrium point in a manner consistent with the analytically derived stability conclusion.	
Novel Results for Stability of Neutral Cohen-Grossberg Neural Networks	
<i>Melike Solak Altuntas</i>	<i>Istanbul University, TR</i>
<i>Ozlem Faydasicok</i>	<i>Istanbul University, TR</i>
<i>Sabri Arik</i>	<i>Istanbul University-Cerrahpasa, TR</i>
Abstract: This paper studies global stability of neutral Cohen–Grossberg neural networks containing a single time delay and a single neutral delay. A Lyapunov functional of the quadratic form is established to derive novel criteria for global asymptotic stability of such neutral systems. The stability criteria are expressed in some algebraic inequality forms, that mainly depend on the elements of system matrices, and structural characteristics of system functions. These conditions do not depend on delay terms and can be directly verified by testing some sets of algebraic inequalities. A representative numerical example together with the simulation results is considered to demonstrate the efficiency of the obtained stability conditions.	
A Biologically Plausible Spiking Actor-Critic for Acrobot Control	
<i>Borislav Markov</i>	<i>Institute of Information and Communication Technologies, BAS BG</i>

Abstract: This paper presents a biologically plausible spiking actor-critic network that learns to control the Acrobot benchmark from the raw -1/step Acrobot reward, without backpropagation and without hand-crafted reward shaping. The actor implements Go/NoGo striatal channels, action selection arises from the opponent activity of D1 and D2 populations, and a two-layer spiking critic estimates state value using a continuous-time temporal-difference rule. Learning is mediated by dopamine-modulated spike-timing-dependent plasticity, a three-factor rule in which a global dopaminergic signal gates local eligibility traces. The network learns within 500 training episodes, reaching a mean return of about -152 over 100 frozen-policy episodes ($M = 10$ seeds). Under matched symmetric scaling, potential-based shaping did not improve performance; the raw Acrobot reward is sufficient. The results demonstrate gradient-free, biologically grounded reinforcement learning on a standard control benchmark.

Optimization of Control Parameters in Cold Nuclear Fusion Systems via Deep Learning Surrogates

Todor Malchev

Technical University of Sofia, BG

Milena Lazarova

Technical University of Sofia, BG

Yordan Paunov

Technical University of Sofia, BG

Dimitar Alexandrov

Lakehead University, CA

Dilyana Gospodinova

Technical University of Sofia, BG

Abstract: Optimization of operating conditions in Cold Nuclear Fusion (CNF) experiments is frequently challenged by the non-linear dynamics of metal-hydrogen systems and the high resource cost associated with exploring high-dimensional parameter spaces. This paper presents a data-driven methodology for identifying optimal control parameters by leveraging historical experimental time-series data. We introduce a specialized Deep Long Short-Term Memory (LSTM) neural network architecture [1] capable of modelling the complex temporal correlations between system inputs, impulse features, and thermodynamic responses. To derive optimal operating conditions, we implement an optimization algorithm that utilizes the trained LSTM network as a differentiable surrogate model. By defining target performance metrics—characterized by specific statistical moments such as the mean, standard deviation, and extrema of the system's response—we employ gradient-based optimization techniques [2] to iteratively refine the input parameter space. This process minimizes the loss function between the model's predicted output and the desired target metrics, effectively retrieving the optimal configuration of control variables. The proposed framework demonstrates that optimal parameter sets can be mathematically derived from existing datasets, providing

a systematic and scalable approach to enhance experimental reproducibility and reaction stability. This method reduces reliance on heuristic trial-and-error procedures, enabling more efficient exploration of the CNF reaction environment.

SESSION B11 – TEXT PROCESSING

Stream 2

Chair: Stanislav Penchev

University of Ruse “Angel Kanchev”, BG

Thursday, October 08th 11:00 – 12:30

Online

Performance Comparison of Data Structures for Dictionary Lookup in Morphologically Rich Languages

Nikola Vukotić

*Academy of Applied Technical and Preschool
Studies, RS*

Abstract: This paper presents an empirical comparison of seven data structures for word lookup in a Serbian morphological dictionary containing 1.86 million entries: HashMap, sorted array with binary search, trie, ternary search tree, directed acyclic word graph (DAWG), Bloom filter, and cuckoo filter. Each structure is implemented in both Python and C, and evaluated across lookup time, memory consumption, build time, and false positive rate using 30 independent runs validated with paired Wilcoxon signed-rank tests. Results show that hash maps provide the fastest deterministic lookup, while DAWG achieves the best memory efficiency among deterministic structures, compressing 1.86M words into 6.1 MB. A scalability analysis and cross-language comparison with English reveal how morphological richness affects performance. Evaluation with out-of-vocabulary queries shows that most structures answer a miss 10 to 25 percent faster than a hit, a property not specific to the tree-based ones. These findings provide practical guidance for selecting data structures in NLP systems targeting morphologically complex languages.

Grammar-Motivated Annotation Changes in a Serbian Web Corpus: Annotation Quality and Its Cost to Part-of-Speech Taggers

Nikola Vukotić

*Academy of Applied Technical and Preschool
Studies, RS*

Abstract: Automatically annotated web corpora contain systematic tagging errors that deterministic rules can correct, but every correction also changes the label distribution and may make the classification task harder. Reported accuracy then falls, and it becomes unclear whether the model has become worse or the task has become more demanding. This paper measures that cost under a strictly paired design. Eight grammar rules were applied to the Serbian web corpus srWaC, a shard of 100,000,116 tokens, yielding an original and a rule-modified arm of 100,000,116 tokens that differ only in the tags of 1,563,418 of them. A manually annotated sample of the most frequent rule finds that 60.1 percent of its firings are conjunctions, which the particle label

contradicts, and a further 36.7 percent are constructions to which the grammar assigns no independent part of speech, leaving 3.2 percent that it supports. Five taggers were trained separately on each arm and evaluated on the corresponding held-out split of 19,991,017 tokens. The cost depends on the tagger architecture: exact-match accuracy of the averaged perceptron fell by 0.02 percentage points and that of the trigram tagger by 1.07, and on the tokens whose reference tag actually changed the gap widened from 0.57 to 17.05 points. The cost is therefore an interaction between the annotation scheme and the tagger architecture rather than a property of either alone, and a single aggregate figure conceals it.

Parallel Grammar and Spelling Errors Detection

Dragana Petkova

Ss. Cyril and Methodius University in Skopje, MK

Ilkem Kivanch

Ss. Cyril and Methodius University in Skopje, MK

Vladimir Zdraveski

Ss. Cyril and Methodius University in Skopje, MK

Abstract: Grammar and spelling error detection is a common task in natural language processing, yet its computational performance characteristics are rarely analyzed. This paper presents a parallel grammar and spelling error detection system designed to be language-agnostic and extensible through rule-based validation, with concrete implementations for English, Turkish, and Macedonian. The proposed system applies configurable grammar and spelling rules adapted for each supported language. It exploits sentence-level independence to improve execution efficiency and supports both sequential and process-based parallel execution models. The results show that parallel execution introduces overhead for small workloads, but substantially reduces execution time for medium and large datasets. The system achieves considerable speedup while exhibiting diminishing returns as the number of workers increases. Cross-language evaluation confirms consistent parallel scalability across all three supported languages, with minor differences attributable to variation in rule-set complexity and per-sentence processing speed.

Uncertainty-Guided Active Learning for Multilingual Sentiment Analysis of Tourism Reviews

Aslanbek Murzakhmetov

M.Kh. Dulaty Taraz University, KZ

Mukhan Murotboyev

M.Kh. Dulaty Taraz University, KZ

Arseniy Bapanov

*Zhambyl branch of the Academy of Public Administration
under the President of Republic of Kazakhstan, KZ*

Maxatbek Satymbekov

School of STEM education Shakarim University Semey, KZ

Nurbol Beisov

Al-Farabi Kazakh National University, KZ

Abstract: Online tourism platforms contain large volumes of multilingual user feedback, but reliable sentiment labels for regional settings are expensive. This paper presents uncertainty-guided active learning for three-class analysis of tourism reviews from Taraz, Kazakhstan. The cleaned corpus contains 10,641 Google Maps and 2GIS records for 25 locations, including 8,140 text reviews. Initial experiments used 279 manually validated Russian, Kazakh, and mixed-language reviews. Logistic regression reached 66.5% Macro-F1 in five-fold cross-validation, whereas rating-derived weak-label training produced 56.1% on the manual test set. We then audited the 200 least-confident predictions and obtained 173 new independent labels. On held-out difficult cases, a hybrid word-and-character support vector machine improved Macro-F1 from 44.9% to 54.6% and accuracy from 56.1% to 68.2%. Cross-validation on all 452 unique manual labels yielded 66.8% Macro-F1 and 74.3% accuracy. Targeted annotation therefore improves robustness on ambiguous multilingual tourism feedback while controlling labelling effort.

SESSION C11 - DIGITAL IDENTITY, AUTHENTICATION AND TRUSTED RECORDS		Stream 3
Chair: Aydan Haka		Technical University of Varna, BG
Thursday, October 08 th 11:00 – 12:30		Online
Towards Trustworthy and Interoperable Digital Credential Ecosystems: A Structured Literature Review and Conceptual Synthesis of Verifiable Digital Credentials in the Context of eIDAS 2.0		
<i>Arbnor Halili</i>		<i>Sofia University “St. Kliment Ohridski”, BG</i>
<i>Mariana Atanasova</i>		<i>Sofia University “St. Kliment Ohridski”, BG</i>
<i>Eliza Stefanova</i>		<i>Sofia University “St. Kliment Ohridski”, BG</i>
Abstract: The increasing digitalization of public and private services has made digital identity an essential part of today’s information systems, especially where services operate across institutions or national borders. However, many identity systems remain fragmented and still rely on national electronic identification schemes or service-specific authentication mechanisms. As a result, cross-border recognition is often difficult, while selective disclosure, user control, and long-term trust management remain limited. Verifiable Digital Credentials offer a way to handle identity-related claims in a digitally verifiable form. Through this model, claims can be issued, stored, presented, and verified using digital wallets, cryptographic mechanisms, and trusted issuer information. The review draws on academic publications, technical standards, and European regulatory material addressing Verifiable Digital Credentials in the context of eIDAS 2.0. It starts from the shift in digital identity from centralized and federated arrangements to models where credentials are stored		

and presented through user-controlled wallets. Within this transition, the paper examines W3C Verifiable Credentials, Decentralized Identifiers, Public Key Infrastructure, trust registries, credential lifecycle processes, and selective disclosure. The European Union Digital COVID Certificate is treated as a reference case rather than a direct template, showing that digitally signed credentials can be verified offline and recognized across national systems when data formats, verification rules, and trust infrastructure are agreed in advance. The paper also discusses the relevance of eIDAS 2.0 and the European Digital Identity Wallet for future credential-based identity systems. The review identifies open issues such as trust registry governance, credential revocation, wallet security, privacy-preserving presentation, semantic consistency, and legal coordination for cross-border recognition. Based on the literature, the paper develops a conceptual model that integrates regulation, governance, security, privacy, interoperability, ecosystem actors, trust infrastructure, and credential lifecycle processes. The analysis suggests that Verifiable Digital Credentials have moved beyond experimentation, but their wider deployment depends on coordinated standards, reliable governance, privacy-oriented design, and interoperable trust infrastructures.

Electronic Identification Framework for Digital Academic Repository Systems in Higher Education

Simeon Arnaudov

*Georgi Benkovski Bulgarian Air Force
Academy, BG*

Boris Stoykov

*Georgi Benkovski Bulgarian Air Force
Academy, BG*

Abstract: The digital transformation of higher education institutions requires a fundamental transition from traditional paper-based academic documentation toward secure, interoperable, and accountable electronic information systems. Academic books, student records, examination documentation, and diploma registration systems represent critical institutional assets that require reliable identification of trusted framework including controlled access management, data integrity protection, and complete traceability of administrative operations. Regulatory requirements are created to maintain academic books and diploma registers in electronic form and replace traditional references handwritten signatures with electronic identification mechanisms for academic staff and administration. This paper proposes a conceptual framework for electronic identification in digital academic repository systems based on the principles of identification, authentication, authorization, and auditability. The proposed model introduces a layered architecture integrating digital identity management, authentication mechanisms, role-based access control, academic databases, and audit logging services.

Graph Neural Network-Based Continuous Keystroke Authentication for Critical Information Infrastructure

Anna Pyrkova

Al-Farabi Kazakh National University, KZ

Nurassyl Kerimbayev

Al-Farabi Kazakh National University, KZ

Nazymgul Odanova

Al-Farabi Kazakh National University, KZ

Abstract: In the context of the digitalization of critical information infrastructure (CII), ensuring reliable user authentication is a key information security challenge. Traditional one-time authentication methods do not provide continuous verification of user identity after a successful login, increasing the risk of unauthorized access. This paper proposes a continuous user authentication method based on a Siamese Graph Convolutional Network (Siamese GCN). The proposed approach transforms keystroke sequences into graph representations whose node features consist of the temporal attributes Hold Time (HT), Down–Down (DD), Up–Down (UD), and Up–Up (UU). The resulting graph pairs are processed by a shared GCN encoder and classified using the absolute difference between their vector representations. Experimental evaluation was performed using the Aalto Desktop Keystroke Dataset, which contains 1,555 text files and 1,093,448 processed keystroke records. The proposed method was compared with the Manhattan Distance and Sequence Siamese LSTM methods using Accuracy, Area Under the ROC Curve (AUC), and Equal Error Rate (EER). The Siamese GCN model achieved an Accuracy of 77.10%, an AUC of 0.8562, and an EER of 22.90%, significantly outperforming the Manhattan Distance method while demonstrating performance comparable to that of the Sequence Siamese LSTM model.

Tamper-Evident Compliance Records for EU OSS VAT: An HMAC-Chained Implementation of the Article 63c Ten-Year Record

Marieta Marinova

Sofia University “St. Kliment Ohridski”, BG

Abstract: Micro-enterprises trading across the European Union under the One-Stop-Shop scheme must keep a twelve-field value-added tax record for ten years and present it electronically on demand. Commercial tools store this record but rarely let the taxpayer verify that it has not been altered. This paper presents a tamper-evident design for the Article 63c record. Each transaction, payment, return and correction enters an append-only chain secured by an HMAC-SHA256 tag that links every entry to its predecessor. A sequence number exposes omissions, a key epoch supports rotation, and a stored dataset version makes each figure reproducible. Corrections reapply the rate of the original supply, as Article 91(2) requires. The signing key stays on the server, so a client without it cannot forge or rewrite the chain. The record maps field by field to the twelve statutory items and exports as CSV and JSON with retention metadata. A monorepo prototype carries 141 automated tests. Tamper injection against the implemented verifier detects deletion, reordering, field mutation and use of the wrong key epoch, while truncation of the tail returns a valid shorter prefix and is detected

only once an independently retained chain head or terminal sequence number is supplied. An in-process benchmark shows constant per-entry append cost and linear verification, with ten thousand entries verified in 804 ms. Verifiability and legal explainability are primary design goals, so the record moves from stored data toward provable evidence, suiting the wider One-Stop-Shop introduced by the VAT in the Digital Age reform from 2028.

SESSION D11 - ELECTRICAL MACHINES, POWER SYSTEMS AND THERMAL PROCESSES		Stream 4
Center of competence "Smart mechatronic, eco- and energy-saving systems and technologies"		
Chair: Michail Petrov		Plovdiv, BG
Thursday, October 08 th 11:00 – 12:30		Online

Comparative Analysis of Surge Arrester Modelling in Switching Transient Studies of Medium Voltage Capacitor Banks

Nisar Basha A

Hindustan University, IN

Mahiban Lindsay N

Hindustan University, IN

Abstract: Accurate modeling of surge arresters is crucial for achieving reliable results during electromagnetic transient (EMT) studies, especially in 33 kV capacitor banks used extensively in large-scale PV solar power plants. This paper compares two surge arrester modeling methods, the traditional nonlinear resistance method and the more advanced frequency-dependent model. Although simple models can give a rough idea of how a surge arrester will perform in response to lightning, switching and resonance transients, they cannot reproduce accurately the frequency-dependent characteristics of metal-oxide varistors (MOVs). The frequency dependent model, on the other hand, is more accurate in the representation of traveling wave effects, oscillatory transients and absorption characteristics which are critical in order to correctly assess insulation coordination and reliability. By means of case studies and simulation results, this paper highlights the importance of frequency dependency in surge arrester modeling for the adequate evaluation of insulation stresses on capacitors and, therefore, for the proper design of protection schemes for capacitor banks at a photovoltaic solar plant. It was concluded that surge arrester frequency dependent models should be used in EMT simulations in order to meet international standards and trends in power system studies.

A Hybrid Analytical-Numerical Approach for Investigating the Temperature Distribution in a Variable-Frequency fed Induction Motor

Marin Todorov

Technical University of Varna, BG

Maik Streblau

Technical University of Varna, BG

Marin Marinov

Technical University of Varna, BG

Abstract: Accurate prediction of the thermal state of variable-frequency induction motors is of critical importance for their reliability. Variable-frequency drives introduce higher harmonics, causing additional electromagnetic losses and increased thermal loading. However, full numerical simulations of these processes require enormous computational resources. In this work, an efficient hybrid methodology for determining the temperature field is proposed and investigated. In the first stage, an electromagnetic T-equivalent circuit, adapted to the specifics of frequency control, is applied. It is used to analytically calculate losses in the windings and the core steel. In the second stage, these losses are introduced as heat sources into a detailed numerical model within the COMSOL Multiphysics environment. For verification of the approach, a real experimental study of a variable-frequency motor was conducted. The results show very good agreement between the simulation and the experiment, proving the practical applicability of the proposed methodology as early as the design phase.

Two linear induction motor drives with a flexible connection between the motors

Bojidar Markov

University of food technology of Plovdiv, BG

Abstract: This article deals with the control of a dynamic system consisting of two linear induction motors connected to each other by a flexible connection. For the control of this system of linear motors is used the method named Direct Thrust Control. The article also discusses additional losses in linear induction motors, and the influence of the flexible connection on the system under consideration.

Design of an Algorithm for Control the Power of Evaporative Condensers in a Cooling System

Antoni Petrov

*Technical University of Sofia, Plovdiv branch,
BG*

Albena Taneva

*Center of competence "Smart mechatronic, eco-
and energy-saving systems and technologies"
Plovdiv, BG*

Michail Petrov

*Center of competence "Smart mechatronic, eco-
and energy-saving systems and technologies"
Plovdiv, BG*

Abstract: Industrial cooling systems based on evaporative condensers are one of the most widespread in practice. The purpose of this work is to describe the power control algorithm in evaporative condensers in ammonia cooling systems. The basis of the control algorithm is the use of a fuzzy logic controller and a multi-stage fuzzy control algorithm of the evaporative condensers. The combination of fuzzy logic and PID control of electric drives with frequency control allows for the implementation of a flexible algorithm, through which to achieve smooth switching and optimal use of power depending on the seasonal needs of the

cooling system. The proposed solution is close to the real application in cooling system.

SESSION A12 – ADVANCED ALGORITHMS AND COMPUTATIONAL METHODS		Stream 1
Chair: Kosta Boshnakov	University of Chemical Technology and Metallurgy-Sofia, BG	
Thursday, October 08 th 13:30 – 15:00		Hall 109TV

Gate-Based Quantum Optimization of Lattice Protein Folding: An Efficient NISQ-Compatible Framework

<i>Ayushi</i>	<i>Maulana Azad National Institute of Technology Bhopal, IN</i>
<i>Madhvi Shakya</i>	<i>Maulana Azad National Institute of Technology Bhopal, IN</i>

Abstract: Protein folding is the biological process through which a polypeptide chain transitions from its linear amino-acid sequence into a specific three-dimensional conformation that is essential for its stability, biological activity, molecular interactions and cellular functions. On the other side, protein misfolding can cause serious neurological illnesses such as Alzheimer’s, Parkinson’s and cystic fibrosis. The traditional protein folding methods, such as knowledge-based and statistical methods, are generally restricted in terms of their scalability and physical correctness. To solve these challenges, the problem has been framed as a combinatorial optimization problem and it is classified as NP-hard. In this work we employ the Miyazawa-Jernigan (MJ) model to capture more realistic residue interactions. We then construct the QAOA method in a gate-based quantum computing framework to address a 2-dimensional square lattice protein folding encoding framework. We show that this approach provides significant reduction in qubit and reduces the exploration of infeasible states compared to previous quantum annealing approaches, thereby enabling more efficient and practical implementations on noisy intermediate-scale quantum (NISQ) devices. We also benchmarked our results against classical optimization using IBM CPLEX and observed that the suggested quantum technique offers high-quality solutions for many peptide instances.

Fast Linear Iterations for Noise Mitigation in Multi-agent Systems

<i>Martin Kenyeres</i>	<i>Institute of Informatics, Slovak Academy of Sciences, SK</i>
<i>Jozef Kenyeres</i>	<i>Frequentis AG, AT</i>
<i>Ján Mojžiš</i>	<i>Institute of Informatics, Slovak Academy of Sciences, SK</i>
<i>Ján Zelenka</i>	<i>Institute of Informatics, Slovak Academy of Sciences, SK</i>
<i>Nayden Chivarov</i>	<i>Institute of Information and Communication Technologies, BAS, BG</i>

Abstract: This paper investigates the efficacy of Optimized Weights (OW) in mitigating the deleterious effects of negative factors represented as Gaussian noise within Multi-Agent Systems (MASs). In distributed environments, the precision of collective state estimation is frequently compromised by stochastic interference. Consequently, the presence of such pervasive noise entails a substantial degradation of network performance, rendering the development of sophisticated mitigation strategies imperative to counteract the detrimental effects on the operational integrity of decentralized systems. Therefore, the past several decades have witnessed a proliferation of diverse mitigation strategies, as experts across a multitude of disciplines have sought to devise robust solutions to counteract these systemic vulnerabilities. To address these challenges, we evaluate the applicability of OW across diverse operational contexts. The approach is validated through simulation on a random geometric graph with 200 vertices. Our methodology entails a rigorous comparative analysis in which the OW framework is benchmarked against two state-of-the-art concurrent methodologies, alongside a baseline control scenario characterized by the absence of formal aggregation mechanisms. Within the experimental framework, we systematically manipulate Gaussian noise and the precision of the applied stopping criterion to rigorously evaluate the operational efficacy of the selected algorithms, specifically focusing on the trade-off between numerical precision and convergence rate. The empirical findings demonstrate that the implementation of OW yields a substantial attenuation of Gaussian noise, significantly outperforming traditional linear consensus protocols in terms of convergence rates, while maintaining comparable levels of precision. Consequently, the results suggest that OW is exceptionally well-suited for noise mitigation in MAS, offering a superior alternative to existing concurrent approaches.

Associative ART: Learning of Weighted Category Relations

Ilia Atanasov

Sofia University St. Kliment Ohridski, BG

Rumyana Topalova

Sofia University St. Kliment Ohridski, BG

Abstract: We introduce Link ART, an extension of the fuzzy ART neural network that, in a single pass over a stream of inputs, accumulates evidence of association between categories, yielding a directed weighted graph over the F2 field. The edge weights allow the detection of broader structures emerging from the committed nodes by applying measures from graph theory. We illustrate the method on a retail dataset, where the learned categories represent customer profiles and the weights reveal how these profiles relate.

Stratified Specification Search: A Three-Criterion Decision Algorithm under Model Uncertainty

Mariya Tsoleva

Sofia University St. Kliment Ohridski, BG

Abstract: Regression analysis requires choosing which variables to include, but this choice is rarely unique. Flexible model-building inflates false positives, a problem known as p-hacking. Bayesian model averaging helps by weighting many specifications instead of picking one, but researchers still judge informally which variables the evidence supports. We propose a reproducible procedure that converts this evidence into an inclusion decision. It combines a stratified Monte Carlo sampling design with a conservative three-criterion vote. This vote requires agreement between a sampled-model inclusion probability, a sign-stability statistic, and a within-model significance rate. Together, these criteria classify each candidate as selected, borderline, or rejected. A mandatory block of theory-based variables anchors the search, so evidence and theory work together rather than separately. Applied to Bulgarian reservation-wage data, the procedure adds 5 of 26 candidates (6 more borderline) to a theory-based mandatory set of 5. A benchmark against LASSO, Elastic Net, forward stepwise selection, and a conventional $PIP > 0.5$ threshold alone shows that the stratified three-criterion vote (STCV) procedure described in this paper achieves fewer false-positive selections and a more parsimonious empirical specification. Independent reruns show individual-variable inclusion-probability ranges as wide as 0.000-0.999 for borderline and rejected candidates. This suggests that inclusion probability alone may not be a fully reliable guide. Requiring only a dependent variable and a candidate pool, the procedure is directly applicable beyond the labour economics context.

SESSION B12 – PERCEPTION, AUTONOMOUS SYSTEMS AND ROBOTICS		Stream 2
Chair: Sevil Ahmed-Shieva		Technical University of Sofia, Plovdiv branch, BG
Thursday, October 08 th 13:30 – 15:00		Online
Towards Intelligent Hybrid Systems for 3D Reconstruction of Cultural Heritage: Challenges, Current Methods, and Future Directions		
Nikol Manolova		University of Plovdiv "Paisii Hilendarski", BG
Alexander Penev		University of Plovdiv "Paisii Hilendarski", BG
Asya Stoyanova-Doycheva		University of Plovdiv "Paisii Hilendarski", BG
Abstract: Digital preservation of cultural and historical heritage increasingly depends on accurate and semantically enriched 3D models, now recognized as a strategic priority by both UNESCO and the European Union. These models support scientific documentation, structural analysis, virtual tourism, and long-term preservation, creating demand for advanced reconstruction methods. Existing workflows often rely on Heritage Building Information Modeling (HBIM), but current implementations remain limited in automation, scalability, and semantic integration. Research in this field is primarily driven by three		

technological directions: ontology-based knowledge representation, deep learning, and photogrammetry. Although each of these methods is beneficial individually, their separate application reveals important limitations. While ontologies provide semantic consistency and interoperability, they do not reconstruct geometry directly; deep neural networks enable depth estimation and automated object recognition but often lack metric reliability; and photogrammetry provides high geometric precision but strongly depends on image quantity, quality, and coverage. This paper presents a focused review and comparative analysis of these approaches, highlighting the need for hybrid intelligent systems extending the HBIM paradigm. A novel framework integrating semantic, learning-based, and geometric methods for cultural heritage digitization is proposed.

A Declarative Architecture for Perceptual Data Structuring and Anchoring in Autonomous Mobile Robotics

Radoslav Vasilev

*Institute of Information and Communication
Technologies, BAS, CN*

Stefan Chivarov

*Institute of Information and Communication
Technologies, BAS, CN*

Maya Staikova

*Institute of Information and Communication
Technologies, BAS, CN*

Nayden Chivarov

*Institute of Information and Communication
Technologies, BAS, CN*

Abstract: Perceptual data obtained from sensors such as RGB-D, LiDAR, IMU and others contains rich yet unstructured information about the surrounding environment. For an intelligent mobile robot to be effective, it must not only perceive perceptual data but also use it within a logical context for decision-making. This raises the question of structuring these data in a way that is easy to understand and process. We propose a declarative approach to structuring information using universal formats (YAML, JSON) that provide portability, visualization, and opportunities for logical interpretation. The presented architecture enables scenes to be described in a human-readable and machine-valid form suitable for diverse client programs—from 3D visualization to logical inference. This structuring serves as a basis for perceptual anchoring, which associates objects with semantic concepts and rules and supports intelligent behavior and decision-making by the robot.

An Explainable Multimodal Framework for Driving-Safety Event Prediction and Grounded Explanation

Karno Sarker

Technische Universität Chemnitz, DE

Md Maruf Hosen

Technische Universität Chemnitz, DE

Md Zahidul Islam

Technische Universität Chemnitz, DE

Md Hasibul Islam

Technische Universität Chemnitz, DE

Jonayed Hossen Antor

Schmalkalden University of Applied Sciences, DE

Al Mamun

Technische Universität Chemnitz, DE

Abstract: Perception models for driving have become highly accurate, yet they usually output opaque predictions that are difficult to trust in safety-critical settings. We present a multimodal, interpretable framework that predicts driving-safety events from a single image and, crucially, exposes every intermediate representation to the user. Road participants are localized with a YOLOv8n detector and summarized into transport-aware spatial descriptors (lateral corridors, ego proximity, traffic density); a lightweight convolutional network predicts scene context (weather, time-of-day, road type, visibility); and the two modalities are fused into a compact, prediction-only feature vector that never sees the ground-truth annotations from which the labels are derived. Tree-based classifiers then estimate six multi-label safety events, which are aggregated into a normalized risk score and turned into a human-readable justification using a template-grounded generator and an instruction-tuned large language model served through Groq. On a 10,000-image BDD100K-derived benchmark, the event predictor reaches up to 0.63 macro F1 and 0.85 macro ROC-AUC, while scene classification reaches up to 0.87 accuracy and 0.72 macro F1. A comparison against single-signal baselines shows that the multimodal fusion contributes the most for context-dependent events such as intersections and dense traffic. Generated explanations are highly faithful: all state the correct risk band and score and 96% contain no fabricated numerical values. A working web interface demonstrates the end-to-end system, underscoring its suitability for transparent driver-assistance applications.

Algorithm for Adaptive Leader Selection in a Drone Swarm

Ivan Garvanov

University of Library Studies and Information
Technologies, BG

Magdalena Garvanova

University of Library Studies and Information
Technologies, BG

Daniela Borissova

Institute of Information and Communication
Technologies, BAS, BG

Denislav Kanev

University of Library Studies and Information
Technologies, BG

Zdravko Yankov

University of Library Studies and Information
Technologies, BG

Evgeni Vasilev

University of Library Studies and Information
Technologies, BG

Abstract: The paper proposes and studies an algorithm for dynamic selection of a new leader in a swarm of unmanned aerial vehicles (UAVs) under a centralized control architecture (Leader-Follower). The algorithm solves the problem of losing the leading drone due to jamming, physical obstacles or battery depletion. The selection criterion is a combined function of the radio

channel quality (signal-to-noise ratio – SNR), its stability over time, the minimum quality of the connection to the swarm periphery and the remaining battery capacity. A hysteresis threshold is added to prevent parasitic leadership switching.

SESSION C12 – COMPILERS, SOFTWARE TESTING AND
SOURCE-CODE ANALYSIS

Stream 3

Chair: Ivaylo Penev

Technical University of Varna, BG

Thursday, October 08th 13:30 – 15:00

Online

**MCLUAC: An Extensible Lua 5.4 Compiler with Token and AST-Level
Plugin Points**

Georgi Petkov

University of Plovdiv “Paisii Hilendarski”, BG

Martin Vassilev

University of Plovdiv “Paisii Hilendarski”, BG

Abstract: Lua is widely embedded in games, tools, and embedded systems, yet its reference compiler luac exposes no interface for inspecting or transforming a program during compilation: it emits bytecode in a single pass and never materializes a syntax tree. LuaJIT diverges from Lua 5.4 semantics, and source-level linters such as luacheck never touch the compilation pipeline or the resulting bytecode. We present MCLUAC, an extensible Lua 5.4 compilation infrastructure written in C23 that deliberately departs from the reference architecture by building a full abstract syntax tree (AST) and exposing two stable plugin points—over the token stream and over the AST — as a dynamically loaded application binary interface (ABI). Extensions compiled as shared libraries can analyze, validate, or rewrite a program at either level while the pipeline still emits a chunk that is binary-compatible with luac. We formalize the pipeline as a composition of total functions and the extension model as transformations inserted between stages. MCLUAC is verified against the official Lua 5.4.8 test suite; we report compilation-time and bytecode-size measurements against the reference compiler and trace the cost of AST materialization to a single, fixable allocation strategy rather than to the design itself. Two example extensions—a token-level bracket validator and an AST-level dead-code eliminator—demonstrate the mechanism.

MutaScore: LLM-Guided, Budget-Aware Mutant Prioritization for End-to-End Web Testing

Mahendra Vardhan Amilineni

University of Massachusetts Lowell, US

Abstract: However, even with end-to-end (E2E) web testing, the use of mutation testing is still limited due to the expensive cost of execution: testing many mutants on a browser-driven test suite is already very expensive since the cost of executing the mutants may involve launching the browser, rendering the pages, and wait for asynchronously occurring UI events. This means that practitioners do not sample or don’t want to do mutation analysis for E2E suites

to lose the diagnostic benefit. To address this problem, this paper introduces Muta Score, a framework which uses a large language model (LLM) as a pre-execution oracle to direct the execution of mutants and maintain the integrity of the mutation score estimated several fixing budgets. While approaches that simply prioritize the mutants most likely to be lethal based on their likelihood of killing tend to overestimate the partial mutation score, Muta Score prioritises the mutants that give the most information on the true mutation score under a budget, and combines LLM-based scoring with a calibrated, model-assisted partial mutation estimator that also leverages non-equivalent, surviving mutants. There are static code-diff features, features of the DOM used during interaction, and context features related to the test-oracles that are used to determine the Behavioural Impact Score (BIS), which is formally-defined by Muta Score for each given mutant. Our evaluation of Muta Score is conducted on a collection of open source web apps that have well-established E2E suites for application-level metrics, and we compare against a set of baselines: random, coverage-based, predictive-mutation-testing, change-aware, and cost-aware, using fidelity-oriented: Error@k, Fidelity@k, ROC/PR-AUC, and rank correlation. BIS-guided prioritization maintains fidelity with mutation-score, but runs only a small subset of the mutants set with a significant model-agnostic capability to estimate behavioral impact using LLMs, making it a great model-agnostic signal for cost-aware E2E mutation testing.

Ablation Study of a Hybrid Source-Code Plagiarism Detection Model: Quantifying the Contribution of Individual Components

Daniel Damyanov

*St. Cyril and St. Methodius University of Veliko
Tarnovo, BG*

Abstract: Hybrid models for source-code plagiarism detection typically combine several analytically distinct signals lexical metrics, graph-based structural representations, semantic embeddings, and a probabilistic estimate of AI-generatedness without it always being clear what the actual contribution of each individual component is to the final result. This paper presents an ablation study of a six-component hybrid model for detecting similar and AI-generated code, in which each component is removed in turn and the effect is measured via F1-score on a real corpus of student and AI-generated solutions across six programming assignments. The results show that the full model ($F1 = 0.931$) significantly outperforms both the classical token-based baseline ($F1 = 0.742$) and the external baseline JPlag ($F1 = 0.741$), and that the contribution of individual components is not uniform: graph-based structural features (AST/PDG) have the strongest effect on hard tasks with few algorithmically distinct solutions, while task-specific fine-tuning and the AI-detector component contribute measurable but differently distributed improvements. The results support the thesis that the added value of the hybrid approach stems

from the integration of its components rather than from the complexity of any single module.

Beyond Token Matching: A Controlled-Corpus Study of Graph and Embedding Signals for Detecting Similar and AI-Generated Code

Daniel Damyanyov
St. Cyril and St. Methodius University of Veliko Tarnovo, BG

Abstract: This paper examines the notorious problem of detecting similar and artificially generated source code in the context of the widespread adoption of large language models (LLMs) in programming education. We formalize program comparison through a five-component representation space $\Phi(p) = (T(p), A(p), C(p), D(p), E(p))$ spanning token, AST, control-flow, program-dependence, and embedding signals, each preceded by a provably idempotent and semantics-invariant normalization stage. Paper analyzes the limitations of classical token-based tools (MOSS, JPlag) when applied to semantically equivalent but syntactically different solutions, and we review alternative graph-based code representations together with suitable comparison algorithms: bipartite-matching approximations of graph edit distance and the Weisfeiler-Lehman graph kernel. The five resulting partial distances are fused through a weighted harmonic mean into a single pseudometric risk score, a deliberate departure from a simple arithmetic average that is motivated and justified. Results from a direct comparative experiment against JPlag on real and AI-generated solutions are reported, together with a dedicated controlled corpus, CommandUndo, that isolates pairs of semantically equivalent but structurally distinct solutions for which JPlag reports near-zero similarity while the hybrid model detects strong structural closeness. The computational cost of the hybrid pipeline and the optimizations that reduce it are discussed with reference to a companion study reporting the full quantitative results. Further discussion covers the architectural organization of the hybrid pipeline and the practical trade-offs that arise when combining lexical, structural, and semantic similarity signals in a single production system.

SESSION D12 – DYNAMIC MODELLING, DATA ASSIMILATION AND FORECASTING		Stream 4
Chair: Javanshir Mammadov		Sumgayit State University, AZ
Thursday, October 08 th 13:30 – 15:00		Online

Development of the architecture of an automated system for monitoring and modeling the process of optimal water consumption

Javanshir Mammadov
Khavar Kerimova
Gulnara Abbasova
Sumgayit State University, AZ
Sumgayit State University, AZ
Sumgayit State University, AZ

Abstract: This article solves a problem of development of the architecture of an automated system for monitoring and modeling optimal water consumption in a distributed water supply network for residential buildings. The proposed system is designed using a multi-tiered approach and integrates measuring devices, IoT/RTU gateways, communication infrastructure, a database, a SCADA system, an intelligent analysis module, a fuzzy decision-making model, and actuators. The main monitored parameters include water flow, pressure, water level in tanks, temperature, energy consumption, pumping equipment status, and potential leak indicators. A closed-loop information and control loop has been developed that ensures the continuous collection, transmission, processing, and analysis of measurement data, followed by the generation of adaptive control actions. To account for the uncertainty of measurement data and the nonlinearity of water supply processes, the use of fuzzy logic is proposed. Linguistic variables for Pressure, Flow, and Tank are generated. Level, Energy Consumption and Pump Speed, as well as a fuzzy rule base for regulating pumping equipment performance. The developed approach allows for the simultaneous consideration of multiple process parameters and the generation of control actions without relying solely on strict thresholds. A demonstration scenario is presented for the water supply system in the 30th quarter of Sumgait, including the control of three pumping stations and ten buildings. It is demonstrated that the centralized SCADA system monitors flow rate, pressure, tank level, valve status, and energy indicators, and enables the detection of pressure drops and localization of fault areas. The proposed architecture provides the foundation for the further integration of artificial intelligence methods, consumption forecasting, leak detection, digital twin, and energy optimization in water supply network operation.

Data Assimilation and Probabilistic Water-Level Forecasting in an Open Channel Using EnKF and GPR

Aslanbek Murzakhetov

Gaukhar Borankulova

Aigul Tungatarova

Samat Bekbolatov

Bakhyt Yeraliyeva

Saltanat Dulatbayeva

Balzhan Turarova

M.Kh. Dulaty Taraz University, KZ

M.Kh. Dulaty Taraz University, KZ

M.Kh. Dulaty Taraz University, KZ

*Kazakh National University of Water Management and
Irrigation, Taraz, KZ*

L.N. Gumilyov Eurasian National University, KZ

M.Kh. Dulaty Taraz University, KZ

M.Kh. Dulaty Taraz University, KZ

Abstract: The paper proposes an approach to processing water level monitoring data in an open irrigation channel, which combines filtering of noisy measurements, searching for anomalies and forecasting for the future. The basis is a dataset of 180 daily observations collected in one season on a channel located in southern Kazakhstan using an IoT system. To clear the data and jointly estimate the level and flow, an ensemble Kalman filter is used, which gives a smoothed condition estimate with an error of RMSE 5.83 cm, MAE 3.88 cm and correlation with measurements of $\mathbf{0.9824}$, and also identifies seven abnormal points and restores the hydraulic characteristics of the flow, corresponding to a calm subcritical regime. Anomalies are identified in two stages, first by simple statistical rules, and then by the magnitude of the discrepancy between the point and the model. To predict the level, a Gaussian regression with a Matern core in combination with the smoothing of the Holt and the trend component, which makes it possible to make forecasts for 7, 21 and 60 days ahead not only in the form of the expected value, but also with an interval of probable deviation.

Mamdani Fuzzy Control and Reduced-Order Modeling of Power Supply Fluctuations in the Central Power System of the Karabakh Region of Azerbaijan

Nurali Yusifbayli

Sumgayit State University, AZ

Javanshir Mammadov

Sumgayit State University, AZ

Huseygulu Guliyev

Sumgayit State University, AZ

Lala Najafova

Sumgayit State University, AZ

Roya Narimanova

Sumgayit State University, AZ

Abstract: This paper presents a Mamdani fuzzy-control model for intelligent management of power supply fluctuations in the central power system of the Karabakh region of Azerbaijan. The proposed approach evaluates voltage deviation, frequency deviation, transformer loading, reactive power, and related operating conditions and converts them into a normalized control signal. Triangular and trapezoidal membership functions are used to represent linguistic operating states, while a nine-rule Mamdani inference system and centroid defuzzification determine the required control intensity. A reduced-order model of the controlled power-system section is introduced to describe the response of voltage and transformer loading to load and generation disturbances. Representative scenarios for mountainous areas of Lachin and Kelbajar are used to test the controller under load increase, transformer overload, generation reduction, reactive-power increase, line outage, and renewable-generation variation. The results show that the fuzzy controller provides graded control actions according to disturbance severity and can reduce voltage and transformer-loading deviations in the simulated control

object. The main contribution is the explicit integration of a Mamdani fuzzy controller with a reduced-order power-system model and a SCADA-based closed-loop control structure.

Interlinking Housing Markets and Household Credit: A Dynamic Model of Cyclical Interactions and Long-Term Forecasting

Reepalkumar Patel

Independent Researcher, IN

Abstract: Financial stability is affected by the interrelationship of housing market and household credit. Nonetheless, the nontrivial interplay between these two series has not been previously investigated. In this paper, a new unobserved components vector autoregressive (UC-VAR) model is proposed. It jointly models the four series that make up the house prices and credit. Also, the model is used to allow for both short- and long-run interactions. The suggested framework enables the house price and credit series to be expressed as the sum of permanent and transitory components. The permanent and transitory components give significant information regarding the boom and bust cycles in these two markets. More specifically, the study found that shortrun shocks to household credit move house prices above or below their long-run trend. The separation of permanent and transitory components is useful because using cross-correlation coefficients it shows that cyclical components of household credit predict future house prices. The components would be more fully elaborated upon later. The coupled 4-dimensional UC-VAR system's importance is relative to the more standard HP filtered and the uncoupled univariate VAR decompositions. The proposed model exhibited better efficiency to capture boom-bust dynamics, especially during financial crises. The author thesis takes a look at financial crises and macroeconomic fluctuations. The spread of financial crises significantly depends on financial and macroeconomic situation, according to data. The thesis presented by the author further demonstrates that the.

SESSION A13 – ROBOTICS

Stream 1

Chair: Milena Karova

Technical University of Varna, BG

Thursday, October 08th 15:00 – 16:30

Hall 109TV

Comparative Evaluation of Classical Bug0 Navigation and Deep Reinforcement Learning Using PPO for Mobile Robots

Vasil Ninov

Sofia University "St. Kliment Ohridski", BG

Abstract: Autonomous navigation of mobile robots requires reliable obstacle avoidance whilst simultaneously moving purposefully through an unknown environment. This thesis compares the classic Bug0 algorithm with a navigation strategy trained using Proximal Policy Optimization (PPO) under identical conditions. The investigation is carried out using a simulated differentially driven mobile robot equipped with 180° LiDAR in a ROS 2 and Gazebo

simulation environment. Both methods are tested on the same 100 predefined scenarios with identical start and destination positions and obstacle settings. Navigation results, route length, navigation efficiency, and trajectories are examined for evaluation. The results show that Bug0 achieves a success rate of 96%, whilst PPO completes 58% of the scenarios. The analysis reveals significant differences in the navigation behavior of the two methods and demonstrates that Bug0 is more reliable under the benchmark conditions examined.

Curriculum learning framework for training a mobile robot for autonomous navigation using Proximal Policy Optimization in ROS2 and Gazebo

Vasil Ninov

Sofia University "St. Kliment Ohridski", BG

Ivan Chavdarov

Sofia University "St. Kliment Ohridski", BG

Kaloyan Yovchev

Sofia University "St. Kliment Ohridski", BG

Abstract: This paper presents the development of a curriculum training framework for a mobile robotic navigation system based on Proximal Policy Optimization (PPO), implemented with ROS2 Humble, Gazebo, and Stable-Baselines3. In contrast to traditional rule-based navigation approaches, the approach presented here is based entirely on reinforcement learning and learns autonomously from interactions with a simulated environment. The curriculum training framework consists of several training stages that progressively increase the complexity of the navigation task. Starting with simple goal navigation, the system progresses through obstacle avoidance, waypoint navigation, and random scenarios to the final-stage environment, with generalization, dynamic timeouts, and mirroring augmentation. The results show that curriculum learning contributes significantly to the stability of the training and enables robust navigation capabilities.

Conditions for Maintaining the Orientation of a Gripper on a Planar Redundant Robot

Bozhidar Naydenov

Sofia University "St. Kliment Ohridski", BG

Ivan Chavdarov

Institute of Robotics, BAS, BG

Georgi Drenski

Institute of Robotics, BAS, BG

Abstract: This paper proposes an approach to determine the conditions for maintaining the orientation of a planar robot gripper, taking into account its joint constraints. An algorithm is proposed to determine the regions of constant orientation in the robot workspace (COW). These regions are also interpreted in the configuration space. Possible applications for constant orientation motion are considered. The approach is applicable to various planar robots and helps in planning constant orientation motions. The application is demonstrated using a 3D-printed planar redundant robot. Computational experiments have been conducted with this robot to validate the proposed approach and the kinematic characteristics

of the robot's motion. The proposed approach and the obtained experimental results are visualized and presented in detail.

SESSION B13 – LLM SYSTEMS: RETRIEVAL AND MODEL SELECTION		Stream 2
Chair: Ioannis Patias		Sofia University “St. Kliment Ohridski”, BG
Thursday, October 08 th 15:00 – 16:30		Online
CostCompressRAG: Cost-Aware Context Compression for Enterprise Retrieval- Augmented Generation		
Sunil Kumar Paidi		Lead Software Engineer, US
Abstract: Retrieval-Augmented Generation (RAG) is a key component of many corporate question-and-answer systems, enabling large language models to draw on external sources to justify their answers. The way RAG retrieves content from other sources can be very inefficient. Even though it may retrieve all the relevant content at some point, there will be redundant, out-of-date, or low- quality content that floods the LLM’s context space with too much “stuff,” increasing token usage and slowing down inference times, but does so without providing equal increases in response quality. Most techniques used today to reduce the volume of content retrieved by compressing it with summary-based methods, such as extracting only the most important sentences, summarizing longer documents into shorter ones, etc., make no consideration for how expensive the original retrieval was; they assume all retrievals are free. In contrast, our technique focuses on reducing the number of tokens used per response while also ensuring high-quality answers. Specifically, we describe a new technique, CostCompressRAG, to improve the efficiency of RAG (retrieval-augmented generation). It reduces the amount of data retrieved when answering questions by evaluating each piece of data found to see whether it would add value to the answer. If adding value would require fewer tokens than what we currently have left, then we keep it; otherwise, we remove it. This method evaluates whether each piece of data (which could be a sentence or paragraph) adds value to the final answer based upon four factors: how well aligned it is to the user’s intent, how important the data is to understanding the final answer, how fresh the data is regarding time, and how confident the model is about its correctness. Once all these factors have been evaluated, CostCompressRAG assigns the remaining token budget to data items in order of decreasing marginal value (the benefit of each piece divided by its cost). When compared to the four methods described above (full context, top-K retrieval, RECOMP extractive, and LLMingua), CostCompressRAG demonstrated significant improvements in terms of efficiency while retaining performance — reducing the average number of tokens required to respond to a question by 54.7%, and the estimated API cost associated with responding by 54.8%. CostCompressRAG also maintained an average increase of less than 2.2%		

in terms of unfaithfulness to the final answer compared to the full-context baseline, and a decrease in EM score of approximately 1.9%. Regarding estimated API cost reductions, the experimental results are placeholder values until code execution.

Retrieval Quorum: Consensus-Based Evidence Selection for Trustworthy Enterprise RAG

Sai Chaitanya Kumar Paidi

University of the Cumberland, US

Abstract: Retrieval-Augmented Generation (RAG) has become the most commonly used architecture to ground the responses from Large Language Models (LLMs) in verified Enterprise Knowledge. Although there are many successful applications using RAG, one major, but largely ignored, failure mechanism exists within individual retrieval components. Individual retrieval components frequently present conflicting or partial information regarding the query being asked. In essence, hallucinations are not eliminated during the retrieval component; they are simply delayed until after the generation process. This paper proposes Retrieval Quorum (RQ-RAG), a Pre-Generation Consensus Mechanism that requires all independent retrieval paths to agree on a single document before any documents are passed to the LLM as evidence. RQ-RAG uses four retrieval mechanisms— BM25 Sparse Retrieval, Dense Vector Search, Metadata Filtered Search, and Cross Encoder ReRanker—each operating independently, aggregated via a Weighted Voting Procedure subject to a Minimum Support Threshold τ . RQ-RAG improves F1 Scores by an average of 13.3 points, increases Faithfulness Scores by 14.0 points, and decreases Hallucination Rates by 11.8 percentage points versus single-retriever baselines. Against strong ensemble baselines, RQ-RAG achieves an additional 6.9 points in faithfulness with no latency overhead beyond parallel retrieval.

Learning-Based Query Routing with Latency and Cost Constraints in Distributed Search Systems

Sumil Kumar Paidi

Lead Software Engineer, US

Abstract: Distributed search systems use shards that divide large collections of documents into multiple shards, each with a different access latency and cost. In-memory shards return results in single-digit milliseconds, whereas archival shards on compressed disk storage may require hundreds of milliseconds per query. The standard production approach is to fan out to each shard, which maximizes recall but consumes most of the compute on shards that don't have any documents relevant to most queries. The existing solutions are either not generalizable across query types or do not guarantee latency or cost. There are hand-coded routing heuristics and learning-to-rank shard selectors that do not generalize across query types or do not guarantee latency or cost. This paper proposes a constrained reinforcement learning framework, called CLaRO (Cost-Latency-aware Routing Optimizer), to learn a per-query shard selection

policy with an explicit latency budget and a cost budget, both of which are enforced using Lagrangian dual variables updated online. CLaRO models shard selection as a sequential decision process: a lightweight policy network estimates the marginal relevance contribution of each shard for a given query and greedily adds shards while the Lagrangian adjusted utility of each shard is positive. We tested CLaRO on four standard information retrieval benchmarks: MS MARCO passage ranking, TREC-DL 2019, TREC-DL 2020, and the NFCorpus subset of BEIR, all of which were tested on a three-tier shard architecture (hot/warm/cold) using only local commodity hardware. CLaRO achieves 96.1% fan-out NDCG@10 with a 71.3% reduction in the average query cost and a 64.6% reduction in P95 latency compared with exhaustive fan-out. CLaRO also provides an additional 19.2% cost savings and 17.0% latency savings compared with a strong learning-to-rank shard selector at a similar or higher ranking quality.

Handling Uncertainty in Large Language Model Selection for Public Administration: A Fuzzy Logic Decision Framework

Ioannis Patias

Sofia University "St. Kliment Ohridski", BG

Abstract: The increasing adoption of Large Language Models (LLMs) in public administration has introduced a fundamental decision challenge in selecting the most appropriate model for a specific governmental use case. While multilingual LLMs provide broad linguistic coverage and strong general reasoning capabilities, localized LLMs often achieve superior performance in national languages, administrative terminology, and country-specific regulatory contexts. Existing recommendations are primarily qualitative, relying on expert judgment and decision tables that do not adequately represent the uncertainty and subjectivity of real-world requirements. This paper addresses the following scientific question: How can uncertainty in selecting between multilingual and localized LLMs be formally modeled to support transparent and explainable decision making in public administration? To answer this question, we propose a fuzzy logic decision framework that represents evaluation criteria as linguistic variables rather than fixed numerical values. The framework incorporates key factors, including language diversity, local regulatory specificity, cultural and linguistic nuance, reasoning complexity, coding requirements, organizational document dependency, and scalability. Expert knowledge is encoded through a fuzzy rule base that maps combinations of criterion values to the suitability of multilingual and localized LLMs. Fuzzy inference and defuzzification produce an interpretable recommendation together with a quantitative suitability score. An illustrative case study demonstrates the applicability of the proposed framework across representative public-sector scenarios. The results show that fuzzy logic effectively captures uncertainty in expert assessments while providing

transparent, explainable, and reproducible recommendations. The proposed methodology contributes a practical decision-support tool that can be extended through empirical calibration, adaptive rule learning, and integration with future public-sector AI evaluation frameworks.

SESSION C13 - SOFTWARE ARCHITECTURE

Stream 3

Chair: Ivaylo Penev

Technical University of Varna, BG

Thursday, October 08th 15:00 – 16:30

Online

Understanding Software Architecture Evolution: An Analytical Perspective from Monolithic Systems to AI-Oriented Architectures

Hristo Hristov

Technical University of Varna, BG

Abstract: Software architectures have evolved continuously over the past decades in response to advances in information technologies and the increasing complexity of software systems. Existing studies predominantly describe this evolution from a historical perspective by presenting architectural styles in chronological order. However, relatively little attention has been paid to the underlying mechanisms that drive transitions between successive architectural generations. This paper proposes an analytical perspective on software architecture evolution by interpreting it as a cause-and-effect process rather than a sequence of technological milestones. The study identifies the principal evolutionary drivers of software architectures, analyzes the reasons for the emergence of major architectural styles, the technological enablers that made them possible, the problems they addressed, the new limitations they introduced and the factors that stimulated subsequent architectural transitions. Based on this analysis, a set of recurring evolutionary principles is derived, demonstrating that software architecture evolution follows consistent patterns governed by technological progress, engineering demands and architectural constraints. The paper further outlines likely future directions of architectural evolution, including increasing autonomy, higher levels of abstraction, greater adaptability and AI-oriented software architectures. The proposed analytical perspective contributes to a deeper understanding of software architecture evolution and provides a conceptual foundation for future studies on the evolution of other domains within information technology.

Serverless React Architectures: A Quantitative Analysis of Scalability, Latency, and Cost Trade-Off

Rand Kouatly

University of Europe for Applied Science, DE

Aiswarya Sajeev

University of Europe for Applied Science, DE

Abstract: Serverless has redefined modern cloud application design by eliminating explicit infrastructure management and enabling automatic scalability. This study investigates the scalability, cost efficiency, and operational

trade-offs of serverless architectures for full-stack web applications built with React.js. The design science approach was applied with the creation of a CRUD-style to-do application on the Amazon Web Services (AWS) platform based on the Lambda, API Gateway, DynamoDB, Cognito, and S3. Artillery was used as performance evaluation based on load testing and Dotcom-Monitor used as end-to-end monitoring in the global regions. The performance has shown that the system could scale linearly to 50,000 requests/s with the median latencies being less than 100ms at moderate load. Memory optimization and memory provisioned concurrency reduced cold start delays of 1-1.5s. Serverless model at maximum had 60 percent cost savings on spiky workloads but it lost its merits with constant high throughput. Although it was highly beneficial in terms of operational simplicity and automation, the issues of observability, debugging, and vendor lock-in remained. The findings validate the practical viability of serverless computing for scalable, cost-aware web architectures and highlight hybrid models as a promising direction for latency-sensitive or cost-critical applications.

A Layered Architecture for Automated Web Data Extraction on the .NET Platform

Berkant Ismet

University of Economics - Varna, BG

Abstract: This paper examines what the Microsoft .NET platform provides for building agents that retrieve, parse, and normalize web documents, and presents a prototype organized as four layers: network, parsing, extraction, and normalization. Requests are issued concurrently through a typed HttpClient obtained from IHttpHttpClientFactory; HtmlAgilityPack builds a Document Object Model (DOM); extraction resolves three product fields—brand, name, and price—by reading embedded JavaScript Object Notation for Linked Data (JSON-LD) structured data where a Product block is present and falling back, field by field, to XML Path Language (XPath) selectors. On 215 product pages from 15 retailers the pipeline recovered all three fields on 182 pages—85% coverage, 95% confidence interval (CI) 79–89%—with 180 of them correct against a manually verified ground truth (99% record accuracy). The coverage is unevenly sourced: an embedded Product block is what makes purely client-rendered sites (such as walmart.com and temu.com) reachable without a headless browser; on the ten pages of those two sites where the block omitted a field, the visual selectors recovered nothing in its place. Because the merge is per field rather than per page, a block that omits a field can still be completed from the DOM. Pages carrying no such block, whose data appears only after JavaScript runs, remain out of reach.

A Rule-Based Algorithm for Software Architecture Recommendation from Requirements Specifications

Nina Asenovska

Plovdiv University Paisii Hilendarski, BG

Asya Stoyanova-Doycheva

Plovdiv University Paisii Hilendarski, BG

Abstract: This paper presents in detail the ADSS (Architectural Decision Support System) algorithm - a deterministic, rule-based component for generating software architecture recommendations within a platform called Archescape. The algorithm combines a weighted scoring matrix with two layers of rules for score adjustment and architecture pattern recognition, deriving an architectural style, a technology stack and a quality criteria profile from a structured questionnaire. The weights of the questionnaire categories are derived with the Analytic Hierarchy Process (AHP), the semantic tags are bound to the question to which they are related, and the quality criteria take part in the final choice. The algorithm is evaluated on 36 realistic requirements specifications from 32 domains, labelled independently by three experienced software architects. ADSS agrees with the expert majority in 80.6% of the cases (94.4% if the second-ranked style is also counted), with Cohen's $\kappa = 0.76$ - higher than the agreement among the architects themselves ($\kappa = 0.48$). The output is deterministic and does not change when unrelated answers are added. The results outline the advantages of determinism, transparency and low cost, as well as concrete, verifiable limitations and directions for future work.

SESSION D13 - OPTIMIZATION AND NETWORK FLOW MODELS		Stream 4
Chair: Nikola Nikolov		Technical University of Varna, BG
Thursday, October 08 th 15:00 – 16:30		Online

Generalized Nonlinear Genomic Network Flow

Draga Toncheva *Institute of Information and Communication Technologies, BAS, BG*

Vassil Sgurev *Institute of Information and Communication Technologies, BAS, BG*

Abstract: The present work is dedicated to the results of the development of a generalized nonlinear network model for modeling the behavior of genomic regulatory networks (GRNs). It is proposed to solve this problem by replacing multipliers and arc flow functions with corresponding nonlinear non-negative functions – separable and convex. Dependencies were obtained that characterize the generalized nonlinear network flow. Methods for determining the maximum generalized nonlinear network flow, the minimum one, and the maximum flow with minimum value are described. The described optimization problems are solved using convex programming methods. The main area of application of the method proposed in this work is genomic regulatory networks at the cellular level.

Nonlinear Network Flow with Nonlinear Flow Functions

Vassil Sgurev *Institute of Information and Communication Technologies, BAS, BG*

Draga Toncheva *Institute of Information and Communication Technologies, BAS, BG*

Abstract: The present work is dedicated to an extremely important task for science and practice: the transition from linear network flows to nonlinear ones. A method for solving this problem is proposed by replacing the linear arc flow functions with separable convex nonlinear functions. The dependencies that determine the resulting nonlinear network flow are derived. A condition has been obtained by which one can transition from a nonlinear network flow to a linear one – and vice versa. A method for determining the maximum and minimum nonlinear network flow, as well as the maximum flow with a minimum value, is proposed. For this purpose, convex programming methods are used. Various areas in which the proposed nonlinear network flow can be used are indicated. The most significant of these is genomics – with the study of its cellular regulatory networks.

Management of Building Evacuation through Minimum-Cost Maximum-Flow Optimization

Vassil Sgurev *Institute of Information and Communication Technologies, BAS, BG*

Lyubka *Institute of Information and Communication Technologies, BAS, BG*

Doukovska *Institute of Information and Communication Technologies, BAS, BG*

Georgi Tsopanov *Institute of Information and Communication Technologies, BAS, BG*

Abstract: This article examines the management of evacuation flows in buildings. More specifically, this is understood as the task of routing occupants toward safe exits when every passage has a limited capacity. The study briefly reviews the main categories of evacuation models and argues that the network-flow formulation provides an appropriate basis for a management-oriented analysis. Accordingly, the building is represented as a directed graph, while the evacuation process is modelled as a classical network flow in which the arcs are characterized by capacity and transit time. The evacuation management problem is posed as a two-stage minimum-cost maximum-flow optimization. The first stage determines the maximum sustainable evacuation rate, while the second selects the minimum-cost routing among those that achieve it, with arc transit times as costs. The article then illustrates the approach through a compact numerical example and translates the optimal solution into explicit management decisions. These include the allocation of occupants among available exits, the identification of vulnerable passages, and the prioritization of capacity improvements based on the unique minimum cut. Compared with the intuitive plan in which occupants follow a single route, the coordinated use of both exits reduces the nominal discharge time by about 43%, without requiring any physical modification of the building.

A Hybrid Knapsack and Timed-Automata Approach to Energy-Constrained Operation Scheduling

Yordan Belev

University of Chemical Technology and Metallurgy-Sofia, BG

Tsvetelina Ivanova

University of Chemical Technology and Metallurgy-Sofia, BG

Idilia Batchkova

University of Chemical Technology and Metallurgy-Sofia, BG

Abstract: Furniture micro and small enterprises must schedule heterogeneous orders under limited machine time, legacy automation, shared material buffers, and restrictive electrical contracts. This paper presents a closed-loop hybrid method in which a multidimensional knapsack model selects and provisionally reserves a valuable subset of orders, while a network of timed automata is designed to check temporal and technological feasibility before release. The method is aligned with IEC 62264 Operations Schedule and Operations Capability concepts and is positioned at the MES level between order entry and SCADA/PLC execution. A reproducible case based on an industrial furniture-production system, with explicitly declared illustrative parameters, uses a 50 kW site limit, a 2000 kg waste buffer, an 8000 kg shared product store, four sanding orders, and four pellet orders. An illustrative trace shows why aggregate capacity feasibility is insufficient: the naive sequence is blocked because its next update would overfill the buffer, whereas resequencing a pellet order between sanding orders yields a 1489 min feasible plan, 48 kW peak load, and 970.2 kg final buffer content. The contribution is a transparent optimization-verification workflow that distinguishes candidate selection, timed-model acceptance, and live-state replanning; the reported evidence is an analytically reproducible trace evaluation rather than an exported UPPAAL verifier run.

SESSION A14 - MEASUREMENT, SIGNAL PROCESSING AND
MONITORING OF TECHNICAL SYSTEMS

Stream 1

Chairman: Nikola Nikolov

Technical University of Varna, BG

Thursday, October 08th 17:00 – 18:30

Hall 109TV

Operating-State Classification of Flowmeters Using Time-Domain Signal Signatures

Pavel Dimitrov

Technical University of Varna, BG

Mariela Alexandrova

Technical University of Varna, BG

Reneta Parvanova

Technical University of Varna, BG

Ivan Grigorov

Technical University of Varna, BG

Radi Dobrev

Technical University of Varna, BG

Abstract: Conventional flowmeters provide a standardized 4–20 mA process signal but limited information about operating condition. This study evaluates whether temporal features from this signal enable embedded classification of four technology-specific operating states in electromagnetic, vortex, and transit-time ultrasonic flowmeters. Signals were sampled at 50 Hz, segmented into 10 s windows with 50% overlap, and represented by 16 time-domain features. Three technology-specific decision trees were developed using record-grouped cross-validation on 182 recordings comprising 30 508 labelled windows and implemented on an Arduino UNO R4. Ten held-out physical repetitions per technology were then used for evaluation. Mean validation accuracy, balanced accuracy, and macro F1 were 53.42%, 54.94%, and 44.29% for electromagnetic; 67.63%, 67.13%, and 62.22% for vortex; and 65.40%, 60.86%, and 54.98% for ultrasonic flowmeters. Validation performance was 10.52–37.35 percentage points below development estimates, with errors concentrated in specific state pairs. The results demonstrate proof-of-concept state recognition while highlighting limited repeat-run robustness and the need for cross-device, cross-configuration, and cross-vendor validation.

Electrode Shape Reconstruction via a Dual-Channel 1D Convolutional Neural Network

Murad Redzheb *Institute of Information and Communication Technologies, BAS, BG*
Plamen Pekov *Institute of Information and Communication Technologies, BAS, BG*
Dimitar Prodanov *Institute of Information and Communication Technologies, BAS, BG*

Abstract: Chronically implanted neural electrodes deform within soft, viscoelastic brain tissue, yet this mechanical interaction cannot be observed directly. We present a machine-learning framework that reconstructs the shape of a sensor probe having the form-factor of a deep brain stimulation electrode embedded in a hydrogel brain-phantom from a strain-gauge signal. A flexure transducer couples the probe to a Wheatstone bridge, and a dual-channel 1D convolutional neural network maps the normalized bridge signal to 49 deflection targets. Across 33 dynamic sessions, reconstruction reached a mean RMSE of 20.6 μm , which is about 3.4% of the probe width. An ablation showed that input normalization, rather than temporal architecture, was the dominant driver of accuracy. Generalization was the principal limitation: the worst leave-one-day-out case reached 110 μm , and a dynamically trained model extrapolated poorly to static relaxation holds.

Data as a Sensor for Transparent Ranking of Monitoring Positions on the A1 Sofia-Plovdiv Corridor

Oleg Asenov *National Toll Authority, BG*
Panayot Panayotov *National Toll Authority, BG*

Abstract: Road agencies continuously generate traffic and control data, while field-inspection capacity remains finite. This study asks whether those data can guide where engineers should look first, without mistaking an operational signal for a measurement of physical condition. We propose the Data as a Sensor framework, which converts administrative, traffic, and geospatial data into a transparent pre-inspection ranking. The framework is demonstrated on the A1 Sofia-Plovdiv corridor using hourly monitoring-position data for calendar year 2025. The source archive contains 15 CSV files and 4,998,029 rows; after spatial matching and quality screening, 12 directional units were eligible for analysis. The Monitoring-Position Attention Score (MPAS) combines the 30th-highest observed hourly flow, mean flow per observed hour, and mean recognized heavy-goods-vehicle (HGV) intensity. Cherna Kotka ranks first in both directions, followed by the Trayanovi Vrata Tunnel in the Plovdiv-to-Sofia direction. The leading positions remain stable under alternative high-hour indicators, time supports, normalizations, weights, and a parsimonious formulation that removes the strongly correlated mean-flow component. Replacing absolute HGV intensity with HGV share changes part of the ranking, confirming that the two indicators answer different management questions. The case study establishes analytical feasibility, transparency, and rank robustness; it does not validate physical condition, which requires independent field measurements and labels.

Analysis and optimization of power supply modules for data centers

Elena Nikolova

Technical University of Sofia, BG

Nikolay Yordanov

Technical University of Sofia, BG

Viktor Dimitrov

Technical University of Sofia, BG

Martin Tarlev

Technical University of Sofia, BG

Viktoria Hristova

Technical University of Sofia, BG

Vassilena Adamova

Technical University of Sofia, BG

Abstract: The rapid expansion of cloud services and AI-driven workloads has significantly increased the power requirements of modern data center power supply modules. Ensuring efficient power delivery to server infrastructures has become essential for improving energy efficiency, reducing the carbon footprint, and optimizing operational costs. As server power density continues to rise, traditional silicon-based power devices and AC-48 VDC architectures are reaching their physical limits. This paper examines the transition toward wide bandgap (WBG) semiconductors—specifically Silicon Carbide (SiC) and Gallium Nitride (GaN)—to enhance efficiency, thermal robustness, and power density in next-generation power supply units. Current data center distribution architectures are reviewed, the material characteristics of WBG devices are compared, and their impact on switching losses, cooling requirements, and

overall system efficiency is evaluated. The results demonstrate that SiC and GaN are key enabling technologies for high-voltage DC distribution (800–1500 VDC) and centralized power conversion, leading to substantial reductions in power losses and cooling energy consumption. These improvements directly contribute to lower operational costs and a reduced environmental footprint in large-scale data centers.

SESSION B14 - IMAGE PROCESSING AND CLASSIFICATION

Stream 2

Chair: Ivan Grigorov

Technical University of Gabrovo, BG

Thursday, October 08th 17:00 – 18:30

Online

Multi-Part Plant Disease Detection Using Deep Learning: A Comparative Evaluation of CNN Architectures

Muhammad Hussain Rana

Asia Pacific University, MY

Leong Jo Ee

Asia Pacific University, MY

Muhammad Ehsan Rana

Asia Pacific University, MY

Abstract: Plant diseases pose a significant threat to global agriculture, causing substantial losses in crop yield and quality. Early and accurate detection of diseases is crucial to mitigate these impacts and support sustainable crop management. Recent advances in deep learning, particularly Convolutional Neural Networks (CNNs), have shown promising results in automated plant disease detection. However, existing research often focuses on limited CNN models or specific plant parts, primarily leaves, neglecting other important parts such as stems, roots and fruits. This research aims to fill these gaps by evaluating multiple CNN architectures, including pre-trained models like MobileNet and InceptionV3, a self-built light weight CNN and a hybrid CNN with Random Forest model across diverse plant parts and datasets.

Optimized MobileNetV2 Architecture for Fine-Grained Food Image Classification

Klaus Caka

University of Europe for Applied Sciences, Potsdam DE

Usman Akhtar

Arden University Berlin, DE

M. Kamran Asif

King Saud University, SA

Ahmed Hassan

Arden University Berlin, DE

Meerah Karunanithi

University of Europe for Applied Sciences, Potsdam DE

Zeeshan Ali

Saudi Telecom Company, SA

Abstract: Accurate food image recognition has become an essential task in computer vision with applications in health tracking, nutrition analysis, and smart catering systems. This paper presents a convolutional neural network–based approach trained and validated on the Food-101 dataset to classify food images into 101 categories. The study compares multiple architectures and

evaluates the influence of preprocessing, augmentation, and optimizer selection on model performance. Experimental results demonstrate that the proposed model achieves high accuracy and balanced precision–recall values, confirming its robustness across heterogeneous food classes. The system further illustrates the potential of lightweight CNNs for efficient deployment in mobile or cloud-based environments. Overall, the presented framework contributes to improving automated food classification pipelines and provides a scalable baseline for future multimodal food understanding tasks.

FLACS: Transfer Learning for Facial Skin Type Classification: A Comparative Study of MobileNetV2 and EfficientNetB0

Sri Sandhya Velicheti

University of Europe for Applied Sciences, Potsdam DE

Manasa Boyina

Alliance University, IN

*Sri Bala Ayyappa Swamy
Bezawada*

University of Europe for Applied Sciences, Potsdam DE

Abstract: Facial skin classification plays an important role in personalized skincare applications that can help identify the right care recommendations for different facial skin categories. Manual evaluation will be subjective, and differences in lighting conditions, image quality, and human interpretation can lead to inconsistencies. In this paper, an explainable transfer learning method is proposed for facial skin classification utilizing two pre-trained deep learning models, MobileNetV2 and EfficientNetB0. The facial region is detected by OpenCV and then classified according to four skin categories: ACNE, DRY, NORMAL, and OILY. Both models are tested using confusion matrix analysis, accuracy, recall, precision and F1-score. In order to make the model easier to interpret, Gradient-weighted Class Activation Mapping (Grad-CAM) is used to visualize the areas of the image that contributed to the classification. According to the experimental results, EfficientNetB0 achieved a validation accuracy of 62.82%, better than MobileNetV2, achieved a validation accuracy of 57.69% in the same dataset. The comparative analysis demonstrates the effectiveness of transfer learning for facial skin classification and highlights the importance of explainable AI techniques in improving transparency and user trust

Embedded Implementation of a Segmentation-Guided Flying Pixel Correction Algorithm for Time-of-Flight Images on Raspberry Pi 5

Alexander Lyubenov

Technical University of Gabrovo, BG

Stefan Ivanov

Technical University of Gabrovo, BG

Abstract: Time-of-Flight (ToF) cameras are widely used in 3D robotic perception, but their measurement quality is often degraded by "flying pixels"—depth artifacts at object boundaries caused by mixed optical responses. Conventional local filters frequently fail to repair these boundary errors or inadvertently alter valid depth measurements. This paper presents an

embedded implementation of a segmentation-guided flying pixel correction algorithm running natively in C++ on a Raspberry Pi 5 with a PMD Pico Flexx ToF camera. The proposed method uses k-means clustering on the infrared grayscale channel as a structural region constraint, ensuring that candidate invalid boundary samples are replaced only using depth values from valid neighbors within the same segment. Experimental validation across multiple artifact-heavy scenes shows that the algorithm substantially outperforms standard median and bilateral filters in boundary recovery while strictly preserving original valid depth data. Continuous execution profiling demonstrates real-time algorithmic throughput with low CPU load, stable memory usage, and minimal thermal impact. The results confirm that structure-preserving boundary correction can be efficiently deployed on low-cost edge hardware without dedicated hardware accelerators.

SESSION C14 - QUANTUM, REVERSIBLE AND MEMRISTIVE COMPUTING		Stream 3
Chair: Valeri Mladenov		Technical University of Sofia, BG
Thursday, October 08 th 17:00 – 18:30		Online
Comparative Analysis of Classical and Quantum Support Vector Machines for Large Hadron Collider Data Classification		
<i>Sofia Domracheva</i>	<i>Plovdiv University "Paisii Hilendarski", BG</i>	
<i>Alexander Penev</i>	<i>Plovdiv University "Paisii Hilendarski", BG</i>	
<i>Stefan Stavrev</i>	<i>Plovdiv University "Paisii Hilendarski", BG</i>	
Abstract: This paper presents an analysis of classical and quantum kernel methods for signal-background separation using simulated Large Hadron Collider (LHC) data (ATLAS Open Data, hadronic jets). A binary jet-classification task is constructed from the quality of jet reconstruction; the data pass through a unified preprocessing pipeline (standardization, principal-component dimensionality reduction, and scaling for quantum encoding). A classical support-vector machine with a radial basis function (RBF) kernel is compared against a quantum support-vector machine (QSVM) with a ZZ Feature Map, executed on ideal and noisy simulators as well as on a real IBM Quantum device under a limited compute-time budget. The results show that under current Noisy Intermediate-Scale Quantum (NISQ) technology the advantage remains with the classical method (ROC-AUC of approximately 0.88-0.89 versus up to 0.72 for the quantum one), the main cause being the exponential concentration of the quantum kernel - an algorithmic effect present even under ideal simulation - compounded by hardware decoherence and the quadratic computational cost. The work delineates the conditions of applicability of quantum kernel methods in high-energy physics and outlines promising directions for their future development.		

Reversible Peres-Gate Architecture for Two-Input Multiplexers and Cascaded Realization of Three-Variable Boolean Functions

Adriana Borodzhieva

University of Ruse “Angel Kanchev”, BG

Abstract: This paper presents a reversible design methodology for constructing a two-input multiplexer and synthesizing a three-variable Boolean function using a cascaded multiplexer architecture built exclusively from Peres gates. The approach integrates analytical derivation, modular reversible-logic construction, and simulator-based verification. First, the functional behavior of the Peres gate is examined, and reversible implementations of the fundamental Boolean operations are derived. These primitives are then used to assemble a fully reversible two-input multiplexer whose output matches the classical MUX function while preserving bijective input-output mapping. Finally, a three-input Boolean function is realized through a cascade of Peres-based multiplexers, demonstrating how reversible modules can replicate conventional combinational structures without information loss. The methodology supports educational applications in digital electronics courses and provides a unified framework for comparing reversible multiplexer implementations based on different reversible gates.

Reversible Implementation of Binary Subtractors Using Fredkin Gates: Logisim-Based Design and Educational Methodology

Adriana Borodzhieva

University of Ruse “Angel Kanchev”, BG

Abstract: This paper presents a complete reversible realization of half- and full one-bit subtractors using Fredkin gates, together with an educational methodology tailored for undergraduate Digital Electronics courses. Building on prior work with FPGA-based subtractor implementations and reversible Toffoli- and Fredkin-based modules, the proposed approach guides students from the conceptual understanding of the Fredkin controlled-SWAP gate to the synthesis of reversible subtractor circuits in Logisim. The methodology combines Boolean analysis and modular construction of reversible building blocks. Logisim simulations are used to validate functional correctness across all input combinations and to highlight ancilla and garbage management in reversible designs. Classroom observations indicate that the activity strengthens students' intuition for reversible computation, enhances engagement with energy-efficient logic design, and provides a natural bridge toward quantum-oriented architectures.

Logic Gates and Circuits with Memristive Elements

Stoyan Kirtlov

Technical University of Sofia, BG

Georgi Tsenov

Technical University of Sofia, BG

Ivan Trushev

Technical University of Sofia, BG

Valeri Mladenov

Technical University of Sofia, BG

Abstract: Digital logic gates and circuits are essential functional units in modern computing architectures, traditionally realized with semiconductor elements. Latest advances in nano-electronics have demonstrated that memristor-based logic elements can efficiently complement and replace conventional implementations due to their inherent nonvolatile memory behavior, fast resistance switching, low power consumption, and nanoscale outline. In this article, the operation of several logic gates that are memristor-based, including OR, AND, NOR, is experimentally analyzed. The study employs tungsten-sulfide Knowm memristors, integrated on chips, and using a digital signal generator and an oscilloscope. Numerical analyses are performed together with laboratory measurements, using MATLAB and LTspice simulations. Comparison between experimental and simulated results confirms their correct operation. The study includes several widely utilized standard and modified memristor models for guaranteeing robust analysis. Overall, the obtained results signify an essential contribution to simulations, representation, and validation of memristor-based logic circuits.

SESSION A15 - COMPANY PRESENTATIONS		Stream 1
Chair: Nikola Nikolov		Technical University of Varna, BG
Thursday, October 08 th 18:30 – 19:30		Hall 109TV
Siemens, From Data to Decision: Unlocking Industrial AI with Siemens Industrial Edge		
<i>Rostislav Rusev</i>		<i>Siemens, BG</i>
<i>Nikola Petkov</i>		<i>Siemens, BG</i>
Rittal, RITTAL RAS – from the idea to a real product		
<i>Alexander Georgiev</i>		<i>Rittal, BG</i>

SESSION A21 - COMMUNICATION SYSTEMS AND DISTRIBUTED ARCHITECTURES	Stream 1
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Chair: Mario Angelov

Bulgarian Defence Institute, BG

Friday, October 9th 09:00 – 10:30

Hall 109TV

Architecture and Enabling Technologies for Adaptive Radio Communication Nodes in Multisensor Platforms

Ivan Ivanov

Bulgarian Defence Institute, BG

Mario Angelov

Bulgarian Defence Institute, BG

Abstract: Multisensor platforms generate multiple information products with diverse requirements on the communication system. In a contested and dynamic operational environment, the typical solution — a finite set of waveforms — cannot satisfy these needs. The information-communication profile (ICP) is proposed: a unit binding each class of information products to a communication mode fitted to it, subject to negotiation and verification. An adaptive radio communication node architecture is defined that adapts by switching profiles per the served product and situation. The enabling technologies supporting its realization are described.

Design and Implementation of a DSSS Mode for an SDR-Based Adaptive Radio Link in Multisensor Platform

Ivan Ivanov

Bulgarian Defence Institute, BG

Mario Angelov

Bulgarian Defence Institute, BG

Abstract: This paper presents the results of the design, implementation and experimental evaluation of one of the communication modes of the adaptive radio communication subsystem of a multisensor platform. The communication channel uses direct-sequence spread spectrum (DSSS), and the implementation is based on the software-defined radio (SDR) concept. This mode of the platform serves robust low-rate exchange of sensor information, as well as control, status, alarm and fallback traffic. The mode has been implemented and tested in simulation and over the air: the receiver recovers packets from a signal hidden below the noise floor, and receiver-side processing alone further improves the operating point at no cost in air time.

Provisioning-Assisted Directed Forwarding Initialization for Bluetooth Mesh

Yordan Yordanov

Technical University of Varna, BG

Abstract: Bluetooth Mesh networks increasingly require scalable, low-latency forwarding. This paper proposes a Provisioning-Assisted Directed Forwarding initialization mechanism. Directed forwarding entries are initialized according to the remote provisioning node after admitting a joining node. The result is immediate reachability without periodic path discovery control messages. The author's custom simulator evaluates the method against managed flooding and

standard Directed Forwarding. The results show lower control overhead and lower overall network congestion.

Design, Prototyping, and Preliminary Evaluation of an Event-Driven Microservice Architecture for a Content Management System

Plamenna Petrova *St. Cyril and St. Methodius University of Veliko Tarnovo, BG*
Juliana Dochkova-Todorova *St. Cyril and St. Methodius University of Veliko Tarnovo, BG*

Abstract: The modern content management systems must handle heterogeneous content structures, media assets, editorial decisions, and analytics across independently owned data stores. This study investigates these concerns through the design, implementation, and preliminary evaluation of an event-driven microservice architecture for a prototype of such system, which separates domain functions into capability-aligned services and harnesses HTTP routing, synchronous gRPC validation, and asynchronous RabbitMQ messaging. Schema-driven content modelling is integrated with separation into commands and queries, selective Event Sourcing, transactional outboxes and inboxes, idempotent consumers, and Saga orchestration. The evaluation procedure employed automated unit, functional, and integration tests, actor-oriented scenarios, and a custom benchmark tool covering content operations, media validation, event publication, as well as workflows completions. Ultimately, the results furnish initial evidence that the use of the applied mechanisms can support coherent content-related actions.

SESSION B21 - MACHINE VISION	Stream 2
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Chair: Nikolay Stoimenov	Institute of Information and Communication Technologies, BAS BG
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Friday, October 9 th 09:00 – 10:30	Online
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SDefect-VLM: A Vision–Language Framework for Industrial Surface Defect Detection and Maintenance Advisory

<i>Md Zahidul Islam</i>	<i>Chemnitz University of Technology, DE</i>
<i>Jonayed Hossen Antor</i>	<i>Schmalkalden University of Applied Sciences, DE</i>
<i>Karno Sarker</i>	<i>Chemnitz University of Technology, DE</i>
<i>Md Sohan Sorker</i>	<i>University of Erlangen-Nuremberg, DE</i>
<i>Al Mamun</i>	<i>Chemnitz University of Technology, DE</i>
<i>Md Jiaul Haque</i>	<i>City University, BD</i>

Abstract: Automated surface inspection is a core part of industrial quality control, yet most deep-learning inspection systems output only a class label and leave the operator to interpret it and decide what to do. We present SDefect, a deployed inspection system that passes the output of a convolutional defect

classifier to a large language model (LLM), which then writes maintenance guidance graded by severity. The two stages form a cascade and are not trained jointly as a multimodal model. A ResNet-50 classifier assigns a steel surface image to one of six defect categories. The predicted label and its confidence score are then used to condition a Llama-3.1 model served through the Groq inference API, which returns a description of the defect, a severity assessment, and corrective actions. The language model never sees the image or any visual embedding. Operators use the pipeline through a web application with single-image, batch, and diagnostic modes. On NEU-DET the classifier reaches 99.72% accuracy and a weighted F1-score of 0.9972, in line with published results on this saturated benchmark. We compare it with AlexNet, VGG-16, and MobileNetV2 and state where that comparison is not controlled. We also evaluate the advisory module case by case against hand-written rule-based templates and a locally hosted model, which suggested unsafe remedies for two of the six classes. Our contribution is the integration and deployment of classification and language-based advice in one tool for operators. We do not claim an accuracy gain on a saturated benchmark.

A Low-Cost Machine Vision Approach for Real-Time Measurement and Classification of Industrial Parts

Mihail Zagorski

Technical University of Sofia, BG

Veselin Marinov

Technical University of Sofia, BG

Hristo Karamishev

Technical University of Sofia, BG

Radoslav Miltchev

Technical University of Sofia, BG

Abstract: The present study follows a workflow for the development and testing of a low-cost machine vision system for real-time measurement and classification of industrial parts. For the purposes of the investigation, three parts belonging to the same product family, characterized by different dimensions and numbers of holes, together with their corresponding workpieces, are analyzed. The proposed system is based on a standard USB camera and OpenCV – an open-source computer vision software library. The processing workflow includes image acquisition, camera calibration, region of interest selection, edge detection, contour extraction, dimensional measurement, and hole detection. Part classification is performed using geometric features, including length and number of holes. Experimental tests demonstrate the capability of the system to distinguish between different part and workpiece types in real time while maintaining low implementation costs. The developed approach represents an accessible solution for automated inspection and classification tasks in smart manufacturing environments.

Analysis of Object Detection Stability for Camera-Based Product Monitoring under Different Visual Conditions

Tsvetislava Lavchieva

Technical University of Gabrovo, BG

Delyan Genkov

Technical University of Gabrovo, BG

Abstract: Camera-based product monitoring is strongly influenced by the stability of object detection in consecutive video frames. In fixed-view applications, such as product observation in a vending-machine-like setup, the camera usually observes the products from one main frontal direction. In this case, detection reliability depends not only on the selected model, but also on visual factors such as illumination, image noise, blur, partial occlusion, and changes in the visible product arrangement. This paper presents an experimental analysis of object detection stability in a fixed-view camera-based product monitoring scenario. The study is based on a developed prototype that supports camera and video input, product-specific object detection, visual output, and runtime performance monitoring. The experimental evaluation uses an original video sequence and visually modified variants of the same sequence in order to observe the influence of different visual changes and degradations under comparable scene content. The analysis considers correct detections, missed detections, incorrect class assignments, recognition rate, confidence variation, and processing speed. The purpose of the study is to identify factors that affect detection reliability and to support the further development of more stable camera-based monitoring systems.

Non-destructive Inspection of Aircraft Fastener Joints X-Ray Computed Tomography

Miglena Kyoseva

Institute of Information and Communication Technologies, BAS BG

Nikolay Stoimenov

Institute of Information and Communication Technologies, BAS BG

Svetlana Trifonova

Institute of Mathematics and Informatics, BAS BG

Martin Tsvetkov

Institute of Mathematics and Informatics, BAS BG

Abstract: The article pays attention to fastener joints in the aviation industry, their types and usage. This study purpose is to perform an in-depth analysis of X-ray computed tomography (CT) applicability and effectivity on different types of Al alloys and also to conduct research on materials' integrity around fasteners holes. The conducted research showed that damaged fasteners heads lead to gaps in the joints between the connected plates.

SESSION C21 - GAMIFICATION AND LEARNING ANALYTICS

Stream 3

Chair: Ventsislav Nikolov

Technical University of Varna, BG

Friday, October 9th 09:00 – 10:30

Online

A Conceptual Framework for Human-Centered AI Learning Analytics in Gamified Industry 5.0 Education

Neviana Krasteva

Sofia University "St Kliment Ohridski", BG

Teodor Daskalov

Sofia University "St Kliment Ohridski", BG

Abstract: Artificial intelligence (AI), learning analytics, and gamification are transforming educational systems by enabling adaptive, data-informed, and learner-centered approaches to competence development. However, current research frequently evaluates gamified learning environments through isolated indicators such as engagement, motivation, or performance, while insufficiently explaining how interaction, cognitive adaptation, and institutional recognition jointly contribute to sustainable learning processes. This paper proposes the Interpretive Circulatory Competence Framework (ICCF) as a conceptual analytical model for interpreting competence development in AI-supported Industry 5.0 learning environments. The framework connects Communicative Intensity, Critical Resilience, and Institutional Integration through a Human-Centered Governance Layer. A preliminary expert assessment involving 12 higher education instructors evaluated the ICCF across five criteria. The overall evaluation was positive ($M = 4.42$, $SD = 0.41$), providing initial support for its conceptual clarity and perceived relevance without constituting empirical validation of causal relationships among its dimensions. The ICCF provides a foundation for future empirical research on adaptive learning ecosystems.

Gamified Incentives and Intrinsic Motivation under Cognitive Overload in a Simulation-Based Study of Engagement and Decision Quality

Neviana Krasteva

Sofia University "St Kliment Ohridski", BG

Tsvetan Davidkov

Sofia University "St Kliment Ohridski", BG

Aleksey Potebnya

Sofia University "St Kliment Ohridski", BG

Abstract: This study examines the comparative effectiveness of gamified incentives and intrinsic motivation under conditions of cognitive overload in digital environments. Drawing on Self-Determination Theory and Cognitive Load Theory, the study adopts a combined simulation and experimental design and positions the proposed framework within the context of artificial intelligence-driven adaptive systems. A simulation model based on 250 observations is used to validate hypothesized relationships under low and high cognitive load conditions, while a controlled laboratory experiment with 30 participants provides additional empirical validation in a real-time decision-making context. Cognitive load is manipulated through information density and time pressure, and motivational conditions include gamified incentives, such as points, badges, and leaderboards, and intrinsic motivation support based on autonomy and competence feedback. The results show that gamified incentives increase engagement primarily under low cognitive load, whereas their

effectiveness decreases under high cognitive demand. In contrast, intrinsic motivation demonstrates stronger and more stable effects across both simulation and experimental conditions, particularly under cognitive overload. Engagement further emerges as a central mediating mechanism predicting decision quality and behavioural intention. The study contributes to the literature by identifying cognitive overload as a boundary condition that determines the relative effectiveness of motivational strategies. It also provides implications for adaptive digital environments by conceptualizing cognitive load as a real-time state variable that can guide the dynamic adjustment of motivational mechanisms in human-centred artificial intelligence systems.

Explainable Artificial Intelligence for Modeling Invisible Academic Work in Gamified Higher Education Environments

Neviana Krasteva

Sofia University "St Kliment Ohridski", BG

Abstract: The increasing adoption of Learning Management Systems (LMS) and gamified educational platforms has transformed higher education into a data-intensive environment where student activities are increasingly represented through digital traces. However, observable platform interactions capture only a limited part of academic effort, while substantial components such as cognitive preparation, informal collaboration, and off-platform learning remain invisible. This study proposes an exploratory computational framework for modeling invisible academic work and perceived digital control using synthetic but theoretically informed data. A simulated LMS dataset was generated to represent behavioral, temporal, assessment, and gamification-related patterns. K-Means clustering was applied to identify behavioral profiles, while Random Forest and XGBoost models were used to reconstruct latent constructs associated with workload, stress, and autonomy. SHAP-based interpretation was employed to examine feature contributions and improve model transparency. The framework demonstrates the feasibility of computationally exploring latent educational behavior structures while providing a controlled environment for hypothesis development and future validation. The study contributes to discussions on learning analytics, educational datafication, algorithmic transparency, and human-centered artificial intelligence in higher education.

Comparison of Researcher-Selected Models and Automated Model Selection for Student Dropout Prediction

Neli Arabadzhieva-Kalcheva

Technical University of Varna, BG

Maya Todorova

Technical University of Varna, BG

Ivo Rakitin

Technical University of Varna, BG

Evgeniya Rakitina-Qureshi

Technical University of Varna, BG

Antoaneta Ivanova-Dimitrova

Technical University of Varna, BG

Milen Angelov

Technical University of Varna, BG

Abstract: This study compares machine learning models selected by the authors and a constructed Soft Voting ensemble with automated model and hyperparameter selection using Fast and Lightweight AutoML (FLAML) for student dropout prediction. The models selected by the authors are Logistic Regression, Random Forest, a Support Vector Machine with a radial basis function kernel, XGBoost, LightGBM, and CatBoost; their probabilistic outputs are also combined in a Soft Voting ensemble. All approaches were evaluated using nested stratified cross-validation with five outer folds. Soft Voting achieved the highest mean accuracy, F1-score, and ROC-AUC, at 91.71 percent, 89.12 percent, and 95.79 percent, respectively. FLAML achieved 90.72 percent accuracy, 89.49 percent precision, 86.49 percent recall, 87.95 percent F1-score, and 95.43 percent ROC-AUC. Automated selection produced recall close to the highest value but did not outperform the leading approaches specified by the authors across the combined metrics and required a mean of 300.77 seconds per outer fold. For the analyzed dataset, Soft Voting achieved the strongest overall performance, whereas the support vector machine with a radial basis function kernel provided the most favorable balance between predictive performance and computational time.

SESSION D21 - NEURAL MODELS AND SELF-ORGANIZATION

Stream 4

Chair: Angel Marchev Jr University of National and World Economy, BG

Friday, October 9th 09:00 – 10:30

Online

Different Neural Network models

Georgi Markov Institute of Information and Communication Technologies, BAS, BG

Lyubka Doukovska Institute of Information and Communication Technologies, BAS, BG

Momchil Kiranov Institute of Information and Communication Technologies, BAS, BG

Abstract: The vast selection of different Neural Network methods make it difficult to initially choose the correct one for a certain jobs. Therefore, one has to look at the comparison of the statistics of every single method to choose the most appropriate one for a certain problem. In this paper, we compare the different accuracies, losses and other relative statistics that the most popular NN methods give us and highlights the consensus approach when presented with differing datasets, problems and clarity of input data.

Initial Steps toward Developing a Python Library for Integral Neurons

Emil Hadzhikolev University of Plovdiv "Paisii Hilendarski", BG

Kostadin Yotov University of Plovdiv "Paisii Hilendarski", BG

Sergey Kubinski University of Plovdiv "Paisii Hilendarski", BG

Stanka Hadzhikoleva University of Plovdiv "Paisii Hilendarski", BG

Abstract: This paper presents the initial steps toward the development of IntegralNeuronPy – a modular Python library for modeling, training, and validating integral neurons. An integral neuron implementing the XOR logical function is used as the reference case, for which both an exact analytical solution and an existing MATLAB implementation are available. On this basis, Python implementations generated by five generative AI models are evaluated, together with several variants of the residual-vector computation function. The results show that the generated code can reproduce the underlying mathematical model, but requires additional numerical and implementation-level verification. A vectorized NumPy implementation is selected as a suitable foundation, upon which an initial modular architecture for IntegralNeuronPy is proposed.

Self-Organization in Complex Systems with Evidence from a Multi-Species Particle Simulation

Angel Marchev Jr.

University of National and World Economy, BG

Abstract: Self-organization describes the spontaneous emergence of coherent structure from local interactions among many components, producing robust, decentralized order. This article traces the concept from general systems theory and cybernetics through modern complexity science, emphasizing that self-organization typically requires open systems that exchange energy or information with an environment. Building on Ashby and Wiener's feedback-based regulation, Prigogine's dissipative structures, and Haken's synergetics, the text links macroscopic order to nonlinear amplification near critical thresholds and to information-theoretic notions of entropy reduction. It synthesizes common enabling conditions - strong feedback, many interacting parts, a balance between randomness and stability, and sustained energy flow - and motivates self-organization as a route to adaptability, resilience, and efficient collective problem solving across physical, biological, social, and engineered domains. To ground these ideas in observation, the paper closes with an empirical case drawn from a browser-based multi-species particle simulator, in which an asymmetric coupling matrix produces metastable, organism-like aggregates punctuated by sporadic bursts of reorganization. Measured spatial entropy declines as the structures form while composite volatility spikes at each burst, exhibiting in a controlled and reproducible setting the entropy reduction and edge-of-chaos dynamics described in the theoretical review.

Partificial Life - Particle Simulation Studying Self-organization

Angel Marchev Jr.

University of National and World Economy, BG

Abstract: This paper presents Partificial Life, a browser-based artificial life simulator where multiple particle species interact via a tunable, potentially asymmetric coupling matrix implementing attraction and repulsion. Emergent outcomes include clustering, segregation, chase-escape cycles, and episodic

burst dynamics. A measurement suite combining color-weighted Ripley clustering, k-nearest-neighbor spatial entropy, mean displacement, SSIM-based frame change, and a composite volatility index supports quantitative analysis of these evolving patterns. The system is documented in full: the interaction model and its controllable parameters, the formal definition of each metric, the interactive controls and configuration panel, and a language-agnostic browser API through which configurations are loaded, runs orchestrated, and metrics retrieved programmatically, so that experiments are repeatable and shareable between researchers. A functional demonstration completes the description, loading a saved configuration and reading the resulting behavior directly off the metric dashboard: the field settles into partial aggregation with slow coarsening and no burst activity, a regime the suite separates clearly from the intermittent dynamics observed under other coupling matrices.

SESSION A22 - MACHINE LEARNING: SPAM DETECTION AND FEDERATED LEARNING		Stream 1
Chair: Hristo Nenov		Technical University of Varna, BG
Friday, October 9 th 10:30 – 12:00		Hall 109TV
Arbitration Strategies for Hybrid Spam Detection: A Controlled Experimental Comparison		
Stefka Popova		Technical University of Varna, BG
Hristo Nenov		Technical University of Varna, BG
Velislav Kolesnichenko		Technical University of Varna, BG
Abstract: Hybrid machine learning models have become one of the commonly used approaches for spam detection by combining the strengths of multiple classifiers. Although numerous arbitration strategies have been proposed for aggregating the predictions of the classifiers combined, most existing studies evaluate only a single decision aggregation mechanism within a specific ensemble architecture, making it difficult to evaluate the contribution of the arbitration strategy itself. This paper presents a controlled experimental comparison of three classical arbitration strategies—hard voting, probability-based voting, and weighted probability-based voting—under identical experimental conditions. Two hybrid spam detection ensembles with different levels of performance diversity are evaluated using the same datasets, preprocessing pipeline, feature representation, ensemble classifiers, and evaluation procedure. The experimental results show that the effectiveness of arbitration strategies depends on the performance diversity of the classifiers in the ensemble rather than representing a universally superior solution. By isolating the arbitration mechanism, the study demonstrates that weighted voting is most beneficial for diverse ensembles while simpler approaches are sufficient when classifier performance is relatively similar.		

From Monolingual to Multilingual Spam Detection: Extending Hybrid Machine Learning Models Across Languages

Stefka Popova

Technical University of Varna, BG

Hristo Nenov

Technical University of Varna, BG

Velislav Kolesnichenko

Technical University of Varna, BG

Abstract: Spam detection systems are mostly developed and evaluated using monolingual datasets, although modern email communication involves multiple languages. This paper explores the progressive extension of a hybrid machine learning architecture from monolingual to multilingual spam detection. Instead of designing independent models for different languages, the proposed study follows the gradual adaptation of the same hybrid architecture through few experimental stages and addition of two more languages resulting in a fully trilingual model trained and evaluated on English, Bulgarian and Spanish datasets. Throughout all experiments, the hybrid architecture remains unchanged, allowing the influence of language extension to be isolated from architectural modifications. Classification performance is assessed using accuracy, AUC-ROC, AUC-PR, and stability analysis based on standard deviation. The results demonstrate how language mismatch affects predictive performance and show that retraining the ensemble classifiers for the expanded multilingual environment restores both classification quality and model stability. The proposed methodology provides a systematic framework for evaluating the gradual multilingual adaptation of hybrid spam detection systems.

A Scenario-Driven Framework for Threshold Cheon-Kim-Kim-Song Federated Learning with Phase-Aware Client Availability

Dinko Dinkov

Technical University of Varna, BG

Veneta Aleksieva

Technical University of Varna, BG

Hristo Valchanov

Technical University of Varna, BG

Abstract: Threshold fully homomorphic encryption removes the need for a single decryption-key holder in privacy-preserving federated learning, but successful model aggregation depends on the availability of a sufficiently large decryption quorum. This paper presents a scenario-driven threshold- Cheon-Kim-Kim-Song (CKKS) federated learning framework that models client availability separately during training, encrypted-update delivery, and partial decryption. The framework separates registered shareholders, distributed-key-generation dealers, selected trainers, successful contributors, and decryption-eligible clients. Deterministic immutable traces allow multiple thresholds to be evaluated under identical client behavior.

Predictive Quorum Adaptation in Threshold Cheon-Kim-Kim-Song Federated Learning

Dinko Dinkov

Technical University of Varna, BG

Veneta Aleksieva

Technical University of Varna, BG

Hristo Valchanov

Technical University of Varna, BG

Abstract: This paper proposes a predictive and cost-aware controller for adaptive Threshold Cheon-Kim-Kim-Song (CKKS) reconfiguration in federated learning under dynamic client availability. The method combines discounted Markov availability prediction, chance-constrained threshold selection, and runtime-aware distributed key generation (DKG) switching to balance decryption liveness, quorum size, and reconfiguration overhead. End-to-end experiments with real multiparty CKKS show that the proposed controller can significantly reduce adaptive DKG operations and communication cost, particularly under sudden and volatile availability changes, while revealing the expected trade-off between liveness and conservative reconfiguration.

SESSION B22 - AGENT-BASED AND AGENTIC AI SYSTEMS

Stream 2

Chair: Plamen Vasilev

University of Chemical Technology and
Metallurgy, BG

Friday, October 9th 10:30 – 12:00

Online

A Layered Conceptual Architecture for LLM-Based Agentic Systems

Miglena Stoyanova

University of Economics - Varna, BG

Abstract: Large language models (LLMs) are increasingly used as core components of intelligent systems that go beyond conversational interaction. However, the development of large language model based agentic systems requires more than the integration of a language model into an application interface. Such systems need architectural mechanisms for task decomposition, memory, retrieval, tool usage, orchestration, monitoring, evaluation and human control. This paper proposes a layered conceptual architecture for developing LLM-based agentic systems. The architecture includes six interconnected layers: user and organizational context, orchestration and task management, agent layer, knowledge and memory, tools and integration, and governance, monitoring and evaluation. The paper explains the role of each layer and analyzes the interactions between them. The proposed architecture is assessed through scenario-based testing in knowledge management, document review and business process support, using four qualitative dimensions: task complexity, knowledge grounding, tool and system integration, and governance intensity. The analysis shows that the layered structure provides a systematic basis for designing agentic systems that can support knowledge work, workflow automation and decision-making under appropriate control mechanisms.

A Model-Driven Framework for Agentic AI-Enabled Lean Six Sigma Quality Management

Kalina Garkova

University of Chemical Technology and Metallurgy, BG

Plamen Vasilev

University of Chemical Technology and Metallurgy, BG

Daniela Gocheva

University of Chemical Technology and Metallurgy, BG

Abstract: This paper presents a semi-formal framework for automating industrial quality management through the integration of Agentic Artificial Intelligence (AI) and the Lean Six Sigma (LSS) methodology. The research addresses the critical challenge of transforming the modern manufacturing "data avalanche" into strategic decision-making by systematically moving production data up the Pyramid of Knowledge, from raw metrics to actionable executive wisdom. Utilizing a Model-Driven Architecture (MDA) approach, we define the system's logic and agency through semi-formal Unified Modeling Language (UML) specifications, including Use Case, Class, Activity, and Sequence diagrams. This modular, layered architecture strictly delineates the boundaries between the Brain Layer, powered by a reasoning enabled Large Language Model (LLM), and the Logic Layer, which encapsulates a specialized toolkit of statistical "senses". The proposed framework empowers the LLM to act as an autonomous expert that dynamically invokes high-precision tools—such as ANOVA, OLS Regression, Pareto Analysis, and Process Capability indices (Cp/Cpk)—to interpret complex industrial datasets with mathematical accuracy. By implementing Electronic Poka-yoke mechanisms and Registry Patterns, the system ensures data integrity and allows for the seamless integration of new analytical modules without modifying the core reasoning logic. Furthermore, the framework realizes intelligent feedback loops where the agent performs real-time Root Cause Analysis (RCA), effectively automating the logic of an Ishikawa diagram to isolate disruptive variables and suggest prescriptive set-point corrections. The results provide a scalable, future-proof blueprint for the next generation of Industry 5.0 quality expert systems, capable of evolving alongside advancements in LLM technology to achieve zero-defect production.

Local AI Architecture for an Agent-Assisted Platform

Milen Sotirov

Nikola Vaptsarov Naval Academy, BG

Valentina Petrova

Nikola Vaptsarov Naval Academy, BG

Abstract: This paper presents the architecture of an agent-assisted platform for programme accreditation at Nikola Vaptsarov Naval Academy, developed for professional field 5.3, "Communication and Computer Engineering". It addresses the integration of local artificial intelligence, which keeps institutional data on local hardware, into the formal workflow of programme accreditation in higher education. The architecture combines fixed server-side rules with locally installed

AI models, while authorized users review and approve every result. The authors propose the Rule-Based and Local LLM Workflow Management Method, which assigns control of the workflow to fixed server-side rules and the preparation of proposals to a local AI model. The paper describes a layered architecture that brings together the import of institutional documents, the generation of accreditation reports and the traceability of AI-assisted actions within one local environment. It also compares a local semantic index for Bulgarian free-text questions with keyword matching, measures several local AI models on a local hardware and summarizes the solutions to the main implementation problems found during development.

Designing context-driven multi-agent system for corporate training

Lilyana Rusenova

Sofia University "St. Kliment Ohridski", BG

Elena Somova

University of Plovdiv "Paisii Hilendarski", BG

Abstract: This paper proposes a multiagent-based approach for the organization, delivery, and evaluation of training, grounded in formally defined business processes, organizational roles, and strategic objectives. The study investigates the capabilities of a corporate context model implemented in AI-assisted environments for corporate training and identifies a critical limitation in existing systems, namely the insufficient personalization of training with respect to the employee's specific organizational role and the contextual characteristics of the corporate environment. The primary objective of this research is to develop a conceptual model of the corporate context within an intelligent multi-agent system for corporate training, that integrates BPMN-based business processes, organizational roles, and strategic goals within a closed-loop control framework for dynamic planning, execution, and evaluation of training activities. The corporate instructional design framework, grounded in organizational processes and procedures, is proposed on the basis of corporate context model and conceptual architecture of an intelligent multiagent system. The core of the framework is structured around the triad role – process – context, which serves as a foundational abstraction for modeling the relationships between learning requirements and operational corporate environment. Business processes are formalized using the BPMN standard. The relationships between BPMN process models, organizational roles, and the corporate context are presented. A small experimental prototype of an AI-based multiagent system for corporate training, based on the proposed models, is also shown.

SESSION C22 - DIGITAL TECHNOLOGIES IN BUSINESS, SERVICES AND CAREERS		Stream 3
Chair: Stanimir Stoyanov	Centre of Excellence in Informatics and Information and Communication Technologies, BG	
Friday, October 9 th 10:30 – 12:00		Online

Experimental evaluation of an AI-based career guidance system

Veneta Tabakova-Komsalova *Centre of Excellence in Informatics and Information
and Communication Technologies, BG*
Evgenia Temelkova *University of Plovdiv "Paisii Hilendarski", BG*
Vaska Baklarova *University of Plovdiv "Paisii Hilendarski", BG*
Ivan Stoyanov *Institute of Information and Communication
Technologies, BAS, BG*
Stanimir Stoyanov *Centre of Excellence in Informatics and Information
and Communication Technologies, BG*

Abstract: This paper extends a proposed AI-based career guidance system. It formalizes an experimental methodology, implements a prototype trial, and compares three approaches for scoring candidate–position fit: an expert-weighted baseline model, Random Forest, and a multilayer perceptron. We used a synthetic, anonymized dataset of 2,400 observations. The dataset reflects the main feature groups from the original architecture: technical skills, interests, education, soft skills, experience, location, salary expectations, and digital literacy. Evaluation used a separate test set and five-fold stratified cross-validation. Random Forest achieved the best balance of accuracy, interpretability, and robustness. It outperformed the baseline model on F1 and ROC-AUC. Feature importance analysis confirmed that skill and interest similarity are the leading factors. The results show that the proposed architecture is technologically feasible. Before deployment, however, it needs field validation with real candidates and employers, an algorithmic fairness audit, and explainability mechanisms.

Heterogeneity Among Auditors in Digital Technology Adoption: A Latent Class Analysis

Ilva Isa *European Univeristy of Tirana, AL*
Lule Basha *European Univeristy of Tirana, AL*

Abstract: Digitalization is transforming auditing processes into heterogonic activities between auditing standards and efficiency aim into decision making. Auditing in itself is considered to be a continuous activity and as such research has tested relationships between different variables that affect technology adoption, but it has little research on the heterogeneity among individual auditors. In this research we apply a person-centered approach and aim to investigate the possibility of having distinct types of auditors according to their patterns of digital technology adoption. We estimate a latent class model based on survey data from 93 practicing auditors on 18 binary indicators of digital practice. We validate the resulting structure against an independent, non-model-based classification. Three different and well-separated types are identified: non-adopters, selective adopters and full adopters, with 90.2% agreement between the two methods. The results

suggest that heterogeneity among auditors is real and structured, but not reducible to the organizational and professional variables on which prior research has typically relied.

Measuring Store-Level Operational Efficiency: Computational Validation of Weighting Coefficients and a Multidimensional Index Based on MDA

Vasil Marchev

University of National and World Economy, BG

Abstract: This paper presents a simulation-based validation of methodological architecture for an integrated multidimensional index used for evaluation of the operational efficiency of stores within nationally based retail chains. The multidimensional index is structured across three layers combined into a unified, integrated multidimensional index at the store level. The concept integrates a broad range of indicators aggregated into three structural categories: operational, financial, and external environment. The validation, based on synthetic data, demonstrates the feasibility of constructing a reliable integrated coefficient that holistically reflects the operational and financial performance of stores. The developed system adds managerial value by facilitating comparative analysis, identifying weak

Potential innovations for transport and passenger services in the Sofia metro

Mirena Todorova

University of Transport "Todor Kableshkov", BG

Zlatin Trendafilov

University of Transport "Todor Kableshkov", BG

Vilina Velyova

University of Transport "Todor Kableshkov", BG

Abstract: The Metro systems are at the heart of sustainable urban mobility, but their adaptability is challenged by changing transport models and passenger expectations. As urbanization progresses, constant analysis and implementation of innovations in the fields of automation, digitalization, artificial intelligence (AI) and the telecommunications are needed to ensure the long-term development of metros. The Sofia Metro is one of the most successful infrastructure projects financed by the EU Structural Funds in Bulgaria, and is highly rated by passengers for its quality of service. The study analyzed the existing technical equipment, examining the two main types of automation and train control systems, as well as the functioning of the centralized dispatching control, which plays a key role in the coordination of traffic on the lines. The study covers the various systems for ensuring the operation of the metro, the condition of the rolling stock and activities related to safety and passenger service. Depending on the established levels of automation and information services, the modern information systems and intelligent platforms have been analyzed, which have the capacity to optimize the daily operational activities of the staff in real time, as well as to significantly increase the quality, comfort and security of passenger

services. Based on the analysis, an upgrade and improvement of the passenger information system has been proposed. This solution will allow the implementation of innovative technological solutions for passenger flow monitoring, as well as for timely informing passengers about traffic, intermodal connections and the occurrence of incidents. This research and its results were achieved within the framework of project NEXUS No. 101177985, funded by the EU's Horizon Europe programme.

SESSION D22 - AI TECHNOLOGIES IN PHOTOVOLTAIC SYSTEMS

Stream 4

Chair: Daniela Borissova Institute of Information and Communication Technologies, BAS, BG

Friday, October 9th 10:30 – 12:00

Online

False-Negative Behavior in Thermal-Only CNN-Based Photovoltaic Inspection Under Homogeneous Soiling

Antonio Karaganov

Engineer, BG

Abstract: Infrared thermography is widely used for photovoltaic (PV) inspection, but maintenance-relevant conditions that produce weak spatial thermal signatures may remain difficult to detect. This study investigates homogeneous surface soiling as a potential false-negative condition in thermal-only PV inspection. Two convolutional neural network classifiers, a reconstructed lightweight CNN and a MobileNetV2 transfer-learning model, were evaluated using clean, homogeneous-soiling, and localized-anomaly thermal images. Both models successfully responded to the localized thermal anomalies, while the homogeneous-soiling condition remained classified as \emph{normal}. Complementary electrical measurements indicated reduced module output under the soiling condition. The results are presented as a preliminary two-module field case study and suggest that limitations in the thermal information itself may contribute to false-negative behavior under spatially uniform surface contamination.

XGBoost–LSTM hybrid framework for fault detection and predictive maintenance of photovoltaic systems

Gabriela-Valentina Olteanu

National University of Science and Technology Politehnica of Bucharest, RO

Ioana Făgărășan

National University of Science and Technology Politehnica of Bucharest, RO

Cristina Nechiforov

National University of Science and Technology Politehnica of Bucharest, RO

Marius Dobrea

Technical University of Civil Engineering of Bucharest, RO

Abstract: This paper proposes a three-level architecture for anomaly detection, multiclass fault diagnosis, and predictive maintenance in photovoltaic systems. The first level uses XGBoost to distinguish normal operation from abnormal states based on statistical and dynamic features extracted from sliding time windows. The second level combines a multiclass XGBoost model with an LSTM network through weighted soft voting, with the fusion coefficient optimized on the validation set. The third level estimates the risk of an anomaly occurring one hour, one day, and one week ahead using independent XGBoost models. The outputs of the three levels are integrated into a health index and an automatic alarm system with NORMAL, WARNING, and CRITICAL levels. The methodology was validated on 1,373,798 observations collected from the monitoring of a real photovoltaic system. The binary detector achieved an accuracy of 89.67% and a recall of 74.18%, while the hybrid model increased multiclass diagnosis accuracy from 77.04% to 82.28% and the weighted F1-score from 81.99% to 85.24%. For future anomaly prediction, the one-hour horizon provided the highest recall, whereas the one-day horizon achieved the best accuracy and precision. The results confirm the ability of the proposed method to support early warning, system condition assessment, and prioritization of maintenance interventions.

Digital-Twin-Informed Machine Learning for Virtual Sensing of Silicon Stress in Photovoltaic Modules

Antonio Karaganov

Engineer, BG

Abstract: This paper presents a module-specific, digital-twin-informed virtual sensing framework for estimating the maximum tensile principal stress in the silicon layer of a photovoltaic module from four support reaction measurements. A nonlinear SAP2000 model was used to generate mechanical loading states representing uniform snow and localized human or maintenance loads. Physics-informed reaction features and temporal event information were used to train a gradient boosting regression model. Grouped out-of-fold validation showed that incorporating temporal loading information substantially improved stress-estimation performance compared with a reaction-only formulation. The analysis also demonstrated that similar support reactions may correspond to different internal stress states. The predicted silicon stress can be compared with literature-reported fracture-risk levels to provide a mechanical warning and inspection trigger using only sparse support-force measurements.

Entropy-Integrated Decision-Making Model for Photovoltaic Panel Selection

Daniela Borissova

*Institute of Information and Communication
Technologies, BAS, BG*

Rossen Mikhov

*Institute of Information and Communication
Technologies, BAS, BG*

Gabriela Garvanova-Petkova	Institute of Information and Communication Technologies, BAS, BG
Zornitsa Dimitrova	Institute of Information and Communication Technologies, BAS, BG
Nesho Garvanov	University of Library Studies and Information Technologies, BG
Vasil Dimitrov	Institute of Information and Communication Technologies, BAS, BG

Abstract: Innovations in solar panel materials are pushing the industry towards higher efficiency, lower production costs, and physical flexibility. The large number of photovoltaic panel models available, combined with the interrelationships among different parameters, often makes choosing the right photovoltaic panel difficult. In this regard, the article proposes a model to support decision-making in selecting the most suitable PV panel for a specific engineering project concerning the installation of a photovoltaic system. The model integrates the entropy method to determine objective weights that reflect the relative importance of attributes, thereby ranking the items. The final goal is to select the best option for constructing a photovoltaic installation for a single-family house, as demonstrated by solving a practical problem involving 14 commercially available photovoltaic panels evaluated using four technical and economic criteria. The proposed model provides an objective, reproducible, and practical decision-support approach for the preliminary selection of photovoltaic panels in the design of residential photovoltaic systems.

SESSION A23 - HUMAN FACTORS AND DIGITAL MATURITY IN THE AGE OF AI	Stream 1
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Chair: Ivaylo Tzanov	Technical University of Varna, BG
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Friday, October 9 th 12:00 – 13:30	Hall 109TV
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Confidence Accuracy Gap in Phishing Detection: An Online Human Factors Study

Ivaylo Tzanov *Technical University of Varna, BG*

Abstract: Accuracy only phishing evaluations cannot show whether users recognize the limits of their judgments or verify high consequence messages. This cross sectional online study combined classification correctness, item level confidence, verification intention, cybersecurity fatigue, and previous training in a controlled eight email task (n = 120). Mean confidence exceeded accuracy by 6.4 percentage points, 95% CI [4.30, 8.50], d = 0.55. Fatigue was the strongest predictor of verification intention in the complete-case regression (beta = -.33; model R-squared = .24, f-squared = .32), and trained participants had lower absolute calibration error than untrained participants, g = -0.54. The contribution is a reproducible three-component evaluation of phishing resilience detection, calibration, and verification that maps distinct human

failure modes to training, interface, and reporting controls. Because sampling was non-probability based and verification was measured as intention, the analytical framework supports task-level design implications rather than population prevalence or causal effects.

AI Related Productivity Pressure, Psychological Detachment and Work Related Exhaustion

Ivaylo Tsanov

Technical University of Varna, BG

Abstract: Generative AI can improve task efficiency without reducing total job demands. This cross sectional online study separated AI use frequency from AI related productivity pressure and examined their associations with psychological detachment and work-related exhaustion among 150 working adults. Productivity pressure correlated with lower detachment, $r = -.41$, 95% CI $[-.54, -.27]$. In the hierarchical exhaustion model, productivity pressure (beta = .25) and detachment (beta = -.41) explained variance beyond AI use frequency and weekly hours; the final model accounted for 40% of exhaustion variance, $R\text{-squared} = .40$, $f\text{-squared} = .67$. AI use frequency was not an independent predictor. The contribution is a socio-technical implementation evaluation model that distinguishes tool exposure from the organizational conversion of time savings into output demands and recovery loss. The non probability, same source, cross-sectional design supports associations and implementation hypotheses, not causal mediation or population estimates.

Linearizing Behavioral Metrics for Scalable User Happiness Assessment

Svetlana Syarova

*University of Library Studies and Information
Technologies, BG*

Genadiy Gospodinov

*University of Library Studies and Information
Technologies, BG*

Teodora Nikolova

*University of Library Studies and Information
Technologies, BG*

Yoana Hadzhiyska

*University of Library Studies and Information
Technologies, BG*

Miglena Molhova-Vladova

University of National and World Economy, BG

Stefka Toleva-Stoimenova

*University of Library Studies and Information
Technologies, BG*

Abstract: Measuring user happiness in digital platforms remains challenging due to reliance on subjective surveys that are episodic, biased, and low-response. We propose a framework that translates emotional states into behavioral proxy metrics, grounded in the Google HEART framework and informed by recent systematic reviews in happiness economics. We address the statistical instability of ratio metrics such as click-through rate (CTR),

conversion per session in A/B testing through Delta-method linearization, which stabilizes variance, preserves the sign of the treatment effect, and controls Type I error. A Monte Carlo simulation with one hundred thousand users validates the approach and a distributed implementation (Apache Spark) enables real-time, single-pass computation. Our integration of SWB theory with rigorous statistics offers product teams a scalable, evidence-based way to track user happiness.

Determinants of Digital Maturity of Small and Medium-sized Enterprises

Kamen Spassov

Sofia University "St. Kliment Ohridski", BG

Nikolay Netov

Sofia University "St. Kliment Ohridski", BG

Diana Netova

Sofia University "St. Kliment Ohridski", BG

Abstract: This study analyzes the determinants of Digital Maturity of small and medium-sized enterprises (SMEs) on a sample of 45 companies with complete responses collected through a questionnaire survey. Based on the structure adopted in the current scientific literature, three latent constructs are formulated: Human Capital, AI Readiness and Quality of Management, and Digital Maturity. The results of the questionnaire survey are analyzed using structural equation modeling using the partial least squares method (PLS-SEM). The measurement model demonstrates good reliability and validity (composite reliability above 0.84; average extracted variance above 0.57; highest HTMT value 0.78 below the threshold 0.85). The structural model explains 49.3% of the variation in Digital Maturity ($R^2 = 0.493$; adjusted $R^2 = 0.470$). The two resource constructs have statistically significant effects on Digital Maturity: Human Capital ($\beta = 0.424$; $p = 0.004$) and management quality in the context of readiness for practical application of artificial intelligence in real business practice ($\beta = 0.364$; $p = 0.030$). The results show that the Digital Maturity of SMEs is driven primarily by investment in people and management capital, and not only by the development of the technology itself, and that the maturity for practical business application of artificial intelligence manifests itself as a natural extension of the overall Digital Maturity.

SESSION B23 - CLINICAL PREDICTION AND

PHYSIOLOGICAL SIGNAL ANALYSIS

Stream 2

Chair: Veneta Aleksieva

Technical University of Varna, BG

Friday, October 9th 12:00 – 13:30

Online

An Intelligent Machine Learning Framework for Automated HIV Drug Resistance Prediction and Clinical Decision Support

Pranjali Vaidya

*Datta Meghe Institute of Higher Education &
Research, Wardha, Maharashtra, IN*

<i>Ktv Reddy</i>	<i>Datta Meghe Institute of Higher Education & Research, Wardha, Maharashtra, IN</i>
<i>Praful Kamble</i>	<i>Datta Meghe Institute of Higher Education & Research, Wardha, Maharashtra, IN</i>
<i>Anushka Gopale</i>	<i>Datta Meghe Institute of Higher Education & Research, Wardha, Maharashtra, IN</i>
<i>Tanmay Barai</i>	<i>Datta Meghe Institute of Higher Education & Research, Wardha, Maharashtra, IN</i>
<i>Trunal Barai</i>	<i>Datta Meghe Institute of Higher Education & Research, Wardha, Maharashtra, IN</i>

Abstract: HIV treatment may become less effective when drug resistance develops, making the identification of resistance patterns important for treatment planning. This study develops a machine-learning framework for HIV drug-resistance prediction and computational support for clinical decision-making. The proposed approach uses clinical, demographic, laboratory, and treatment-related attributes from an HIV-1 drug-resistance dataset containing 1,522 records and 38 variables. For the ABC drug-resistance analysis, records with valid resistance categories were selected, resulting in 1,426 observations comprising 808 sensitive and 618 resistant cases. The data were separated into training and testing subsets using a stratified 80:20 split. Categorical variables were transformed using one-hot encoding, while missing numerical values were handled using statistics obtained from the training data. SMOTE was restricted to the training subset to address class imbalance. Random Forest and XGBoost were compared using accuracy, precision, recall, and F1-score. On the independent test set, Random Forest achieved 98.95% accuracy, 97.64% precision, 100.00% recall, and 98.80% F1-score, whereas XGBoost achieved 98.60% accuracy, 97.62% precision, 99.19% recall, and 98.40% F1-score. Five-fold cross-validation gave XGBoost a mean accuracy of $98.88\% \pm 0.41\%$, compared with $97.62\% \pm 0.64\%$ for Random Forest. The results suggest that ensemble learning can support computational HIV drug-resistance assessment, although evaluation on independent datasets and clinical validation are still required before practical healthcare deployment.

Evaluation of Audio Features for Noisy Phonocardiogram-Based Heart Sound Classification

<i>Rand Kouatly</i>	<i>University of Europe for Applied Sciences, Potsdam DE</i>
<i>Cherry Blossom Garcia</i>	<i>University of Europe for Applied Sciences, Potsdam DE</i>

Abstract: Heart disease is among the most common causes of death in all parts of the world, which is one of the reasons that have encouraged the creation of easily available and effective diagnosis devices. Phonocardiogram (PCG) recordings provide a non-invasive and low-cost alternative to the screening cardiac pathology but in practice are frequently corrupted by environmental

and patient-induced noise, which reduces performance in automatic classification. The paper is a comparative analysis of the traditional machine learning algorithms and handcrafted audio features in the classification of heart valve disorders using noisy PCG signals. Heart sounds are preprocessed with the CirCor DigiScope dataset using bandpass filtering, Hilbert- envelop-based segmentation and data augmentation with additive noise, time shifting and pitch shifting to simulate real clinical conditions. Several feature representations are obtained among them Short-Time Fourier Transform (STFT), Mel-frequency cepstral coefficients (MFCC), Mel spectrograms, spectral centroid, zero-crossing rate, autocorrelation, and empirical mode decomposition (EMD). Decision tree, support vector machine (SVM), random forest, K-Nearest Neighbors (KNN), Extreme Gradient Boosting (XGBoost) and Gaussian Naive Bayes classifiers are trained using these features. The models reach relatively low performance, at 54–59 percent and SVM results best in general, across all the configurations. The features based on the EMD and Mel spectrograms are relatively less vulnerable to the noise, compared to MFCC and spectral centroid, which diminish considerably. These results demonstrate the difficulty of heart sound recognition in non-clean noisy environments and the importance of more effective denoising, feature and model architectures to achieve reliable PCG based screenings.

Classification of Physiological States at Rest and During Extreme Gaming in Virtual Reality Using Machine Learning

Penio Lebamovski

Institute of Robotics, Bulgarian Academy of Sciences, BG

Evgeniya Gospodinova

Institute of Robotics, Bulgarian Academy of Sciences, BG

Abstract: The present study evaluates the possibility of automatically distinguishing between two physiological states— rest and participation in an extreme game in virtual reality (VR) using machine learning methods and heart rate variability (HRV) features. HRV is a well-established non-invasive method for assessing changes in the autonomic nervous system and the psychophysiological state of a person. The experiment involved 42 healthy volunteers, in whom electrocardiographic (ECG) signals were recorded in two states - rest and interaction with VR. The RR-interval series were extracted from the recorded ECG signals, based on which ten HRV features were calculated from the time, frequency and nonlinear domains. The Random Forest algorithm was applied for the automated differentiation of the two physiological states, and Leave-One-Subject-Out (LOSO) cross-validation was applied to assess its generalizability. The obtained results showed high classification efficiency, with the model achieving an accuracy of 94.05%, as well as high values of Balanced Accuracy, F1-score, Cohen's Kappa and ROC-AUC. The analysis of the significance of the HRV features showed that the RMSSD, HF and SDNN indicators have the greatest contribution to the classification, while the

nonlinear HRV features also contribute to the distinction between the two states. The obtained results show that the combined use of a limited set of HRV features and the Random Forest algorithm is an effective approach for automated distinction of the physiological state at rest and during gameplay in VR. The scientific contribution of the study consists in the development and validation of a subject-independent approach for binary classification of physiological states by the combined use of ten HRV features and the Random Forest algorithm in a VR environment. The proposed approach has potential for application in objective assessment of psychophysiological load, monitoring of the user's physiological state, and development of adaptive virtual reality systems capable of taking into account the user's physiological response.

Q-Sepsis: A Lightweight Explainable Quantum Ensemble for Edge-Deployed Sepsis Prediction

Gulshan Katankar

SRM Institute of Science and Technology, IN

Brajesh Nandan

SRM Institute of Science and Technology, IN

Arpit Sharma

SRM Institute of Science and Technology, IN

Saravanan Parthasarathy

SRM Institute of Science and Technology, IN

Vaishnavi Jayaraman

SRM Institute of Science and Technology, IN

Selvakumar Ramachandran

University of Oxford, IN

Abstract: Sepsis is a serious condition caused by an uncontrolled immune response by the nervous system, it results in multiple organ failure and has very high mortality rates. The small patterns of physiological changes distributed over a large period makes early detection a difficult task. This study introduces Q-Sepsis, an explainable Quantum Ensemble learning system developed for the early detection of sepsis by utilizing the high dimensional feature mapping capability of the Variational Quantum Circuits (VQC) which enhances the early prediction capabilities while maintaining clinical relevancy via Explainable AI (XAI). Physionet/Computing in cardiology challenge 2019 dataset was used for this study. The proposed Q-Sepsis framework demonstrated its capability to identify pre-septic patterns. By utilizing threshold tuning to maintain a Recall of 85% the model achieved an AUPRC of 0.722 and an AUROC of 0.99. After patient level smoothing the resulting AUPRC was 0.85, the SHAP analysis found Heart rate, shock indexes and respiratory rate as the primary predictors for sepsis risk which aligns with the clinical definition for Sepsis-3. Q-Sepsis shows the efficacy of Quantum Machine Learning (QML), in critical environments, which delivers an edge ready highly sensitive system for predicting sepsis at early stages that helps doctors with transparent risk assessments joining powerful quantum computing with reliable medical diagnosis.

SESSION C23 - GENERATIVE AI AND ETHICS IN EDUCATION		Stream 3
Chair: Vladimir Jotsov		University of Library Studies and Information Technologies, BG
Friday, October 9 th 12:00 – 13:30		Online
A Multi-Dimensional Framework for Evaluating Ethical and Pedagogical Dimensions of Artificial Intelligence Integration in Educational Environments		
Zhanat Umirzakova	West Kazakhstan medical university named after Marat Ospanov, KZ	
Dana Sakypova	L.N. Gumilyov Eurasian National University, KZ	
Vladimir Jotsov	University of Library Studies and Information Technologies, BG	
Nurassyl Kerimbayev	Al-Farabi Kazakh National University, KZ	
Raushan Medeuova	West Kazakhstan medical university named after Marat Ospanov, KZ	
Sanimgul Sambayeva	West Kazakhstan medical university named after Marat Ospanov, KZ	
Gulmira Yemzharova	West Kazakhstan medical university named after Marat Ospanov, KZ	
Abstract: The rapid deployment of artificial intelligence (AI) tools in formal education has created an urgent need for frameworks that jointly assess pedagogical effectiveness and ethical compliance, dimensions typically evaluated in isolation by existing methodologies. This paper proposes the Multi-Dimensional AI Pedagogical Assessment System (MAPAS), a weighted composite scoring framework integrating five orthogonal dimensions: Pedagogical Alignment (PA), Ethical Compliance (EC), Learning Efficacy (LE), Autonomy Preservation (AP), and Inclusivity (IN), underpinned by constraint-based modelling to support deep learning and machine learning applications. Constraint-based modelling methods had been elaborated aiming at more effective deep learning and machine learning applications. The framework was validated on a multi-institutional dataset of 6,814 students and 395 educators across 10 institutions spanning higher education, secondary, vocational, and online/MOOC environments. Seven commercial AI platforms were evaluated using automated bias auditing (Aequitas), xAPI behavioral telemetry, standardized pre/post-test assessments, and a Likert-scale expert survey. MAPAS achieved a composite EPAI-Score of 0.847, classification accuracy of 88.3%, and F1-score of 0.879, outperforming four benchmark frameworks by an average of 16.1 percentage points. The Bias Index decreased to 0.091 versus 0.184 for the next-best baseline. Ablation analysis identified Ethical Compliance as the largest single-dimension contributor (AEPAI = -0.106 upon removal). Statistically significant learning gains (mean +21.3%, $p < 0.001$) were observed across all contexts, confirming MAPAS as a reproducible instrument for institutional AI governance and evidence-based tool selection. In the end, the study proposes a scalable method by which unforeseen AI can be aligned with human values, enabling broader and safer market adoption.		

Intelligent Educational Ecosystems of Generative AI: Genesis Learning Model

Nurassyl Kerimbayev

Al-Farabi Kazakh National University, KZ

Anna Pyrkova

Al-Farabi Kazakh National University, KZ

Rustam Shadiev

Zhejiang University, CN

Radoslav Yoshinov

The Bulgarian Academy of Sciences, BG

Vladimir Jotsov

University of Library Studies and Information Technologies, BG

Zhanbota Menlibay

Al-Farabi Kazakh National University, KZ

Aliya Akramova

Al-Farabi Kazakh National University, KZ

Vitaly Tsahelny

Eurasian Association of Pedagogical Universities, BY

Abstract: The growing adoption of generative artificial intelligence in education has created new opportunities for adaptive learning, personalized support and data-informed instructional decision-making. However, the integration of learning analytics, assessment processes, and AI-supported learning services into a unified educational architecture remains a significant challenge. This study proposes the Genesis Learning Model, an AI-enhanced educational framework that integrates competency-oriented pedagogy, event-based learning analytics, adaptive support mechanisms, and generative AI services into a unified instructional ecosystem. The model was implemented in the NlogN learning environment and evaluated through a six-week pilot study involving 138 learners across five educational levels, ranging from secondary education to doctoral studies. The analysis was based on 18,461 educational events, including 3,914 AI-supported interactions. Quantitative and qualitative analyses examined learning performance, learner engagement, technology acceptance and human–AI interaction patterns. The results demonstrate sustained learner engagement, positive learning outcomes and favourable perceptions of AI-supported educational services. Significant relationships were identified among learning performance, task completion, AI usage frequency, perceived usefulness and perceived ease of use. AI-supported services were used for programming assistance and conceptual explanations for learners, while also enabling teacher-triggered automatic generation of learning tasks for students. Analysis of interaction sequences revealed structured learning trajectories characterized by iterative cycles of explanation, problem solving, assessment and feedback interpretation, suggesting that AI primarily functioned as a cognitive support mechanism rather than a substitute for independent learning. The findings demonstrate the feasibility of integrating learning analytics, competency-based assessment, and generative AI within a unified instructional architecture.

A scalable AI-assisted pedagogical model for web design practical courses: empirical validation across diverse university cohorts

Maya Stoeva

Universiti of Plovdiv "Paisii Hilendarski", BG

Abstract: As Artificial Intelligence becomes an integral part of modern Web/UI/UX design and front-end development, higher education must adapt its practical instruction models. Building upon previous research on enterprise AI workflow integration, this paper introduces a time-scalable, AI-assisted pedagogical framework for Web Design laboratory exercises. The model positions Generative AI as an interactive lab co-tutor that provides prompt-driven code scaffolding, real-time wireframing, design, debugging, and rapid prototyping under human-in-the-loop instructor oversight. The framework was empirically validated across three distinct student cohorts with varying contact hours: Business Information Technologies (BIT) part-time (10 hours), BIT full-time (20 hours), and specialized software engineering/design programs (30 hours). Comparative performance analysis against historical non-AI cohorts demonstrates significant improvements in student completion rates (up to 96%) and grade distributions, proving that AI-assisted practical instruction effectively mitigates strict time constraints while fostering deep technical competence.

**A Simulated Multi-Agent Workflow for Differentiated Learning
Materials: Design and Pilot Evaluation**

Vyara Dukova

Technical University of Varna, BG

Abstract: This paper proposes and evaluates MAS-EDU-6, a simulated six-role large language model workflow for generating differentiated learning materials. The workflow distributes instructional design across learning-objective analysis, learner profiling, activity design, differentiation, pedagogical critique, and ethical-factual review. An exploratory within-subject pilot involved 20 vocational high-school teachers who completed the same instructional-design task with a single LLM chatbot and with MAS-EDU-6. Teacher ratings on eight five-point criteria were higher for MAS-EDU-6 in all cases. The largest descriptive differences concerned differentiation (+1.20), reduced need for editing (+0.85), pedagogical applicability (+0.60), and clarity (+0.50). The results provide initial evidence for the value of structured role-based prompting, while not demonstrating a fully autonomous multi-agent system or improved student learning outcomes.

SESSION D23 - PARALLEL AND CONCURRENT COMPUTING

Stream 4

Chair: Delyan Genkov

Technical University of Gabrovo, BG

Friday, October 9th 12:00 – 13:30

Online

**Scalable Parallel Framework for Recommendation Systems based on
User–Item Interaction Graphs**

Borjan Dimeski

Ss. Cyril and Methodius University in Skopje, MK

Vladimir Zdraveski

Ss. Cyril and Methodius University in Skopje, MK

Abstract: In today's data-rich and time-scarce environment, recommendation systems must provide users with fast, accurate, and personalized results at scale. Random walk-based methods offer a powerful way to capture indirect user-item relationships, but their computational cost has limited their practical deployment. We present a scalable framework for random walk-based recommendation systems that enables efficient personalization on large user-item graphs through parallel execution and demonstrate the framework through a music recommendation case study based on the Last.fm dataset. Experiments on large-scale music interaction data demonstrate that the proposed approach scales effectively while preserving the output distribution of the underlying sequential algorithm, as parallelization affects only execution order, not algorithmic semantics. We evaluate two parallel implementations of the framework: a shared-memory OpenMP version and a hybrid MPI+OpenMP version.

Researching the parallel operation of computers in a local area network for rendering in Blender

Hristo Kilifarev

Technical University of Gabrovo, BG

Tsvetislava Lavchieva

Technical University of Gabrovo, BG

Delyan Genkov

Technical University of Gabrovo, BG

Miroslav Slavov

Technical University of Gabrovo, BG

Abstract: This paper investigates the performance optimization of legacy computer systems aggregated within a Local Area Network (LAN) for distributed animation rendering. Utilizing the open-source Blender framework managed via the Flamenco orchestration platform, a low-budget cluster was deployed across nine identical workstations driven by low-power Intel Celeron CPUs and integrated graphics, operating under Windows 10 Enterprise. The paper delineates the physical and logical infrastructure setup, the network sharing topography, and an automated command-line benchmarking pipeline configured to monitor real-time system metrics at a strict 1-second interval. Empirical results demonstrate that while single-frame rendering of high-complexity static scenes yields zero performance scaling due to network propagation bottlenecks and a lack of frame tiling support, animation rendering scales effectively with the number of compute nodes. Furthermore, a critical rendering engine paradox was identified: while pure CPU-based Eevee rendering is significantly slower than Cycles due to rasterization overhead, triggering the integrated GPU hardware context collapses processing times, achieving a peak cluster speedup of 62.79x under the Eevee engine. The findings prove that legacy hardware can be efficiently repurposed for parallel multimedia computations, providing a scalable and practical framework for educational environments.

Parallel Floyd Warshall Algorithm for Physical and Social Distance between Cities

Jovan Davaliev

Ss. Cyril and Methodius University in Skopje, MK

Dimitar Peshevski

Ss. Cyril and Methodius University in Skopje, MK

Dimitar Trajanov

Ss. Cyril and Methodius University in Skopje, MK

Vladimir Zdraveski

Ss. Cyril and Methodius University in Skopje, MK

Abstract: This work focuses on the Floyd-Warshall's algorithm parallel implementation and applies it in calculating transportation distance as well as social distance between cities. This research compares its performance to the traditional serial implementation, highlighting substantial improvements in execution speed and overall scalability. This study addresses the algorithm's time complexity limitations by leveraging multi-threaded computing, providing a scalable solution that efficiently handles large-scale datasets. The results demonstrate the effectiveness of the algorithm in reducing computational time, improving precision, and significantly contributing to transportation planning and logistics in urban and global networks. Cities social use case explores a new concept of advanced big data based functionalities and reports that might be available in the social networks in real time using this high performance computing approach.

Semantic Differential Debugging of Multithreaded Programs

Martin Vassilev

Universiti of Plovdiv "Paisii Hilendarski", BG

Alexander Penev

Universiti of Plovdiv "Paisii Hilendarski", BG

Abstract: Differential debugging locates a regression by running a working and a failing version of a program side by side and comparing their states. Existing tools compare the debugger's textual output, which breaks down for multithreaded programs: addresses, thread numbers and enumeration order differ between any two processes, so a line-oriented diff reports differences where none exist – and it cannot say which thread in one process corresponds to which in the other. We introduce semantic differential debugging, in which the comparison is performed over a typed model of program state – threads, frames, variables – by a structured diff and a thread-correspondence algorithm, over a capture that follows pointers so that heap-allocated state becomes comparable. Implemented in the open-source IDD debugger, the approach reports zero spurious differences where a text diff reports up to 230 lines, pairs 282 of 282 threads correctly under permuted spawn order, remains invariant as the thread count grows from 6 to 48, and, on memcached, attributes a seeded regression to the exact heap field of each affected worker thread.

SESSION A24 - GENERATIVE AND AGENTIC AI

Stream 1

Chair: Ani Epitropova

Universiti of Plovdiv "Paisii Hilendarski", BG

Friday, October 10th 14:30 – 16:00

Hall 109TV

Legal and Ethical Boundaries of AI-Based Computer Vision for Water Safety: A Regulatory Analysis of an “AI Lifeguard” System in Bulgaria*Vasil Zagorchev**Sofia University “St. Kliment Ohridski”, BG**Nikolay Netov**Sofia University “St. Kliment Ohridski”, BG*

Abstract: The deployment of artificial intelligence–based computer vision for detecting persons in distress in the water lies at the intersection of personal data protection law and the emerging European regulatory framework for artificial intelligence. This article analyses the legal and ethical conditions under which an “AI Lifeguard” system may be developed, trained, and operated on guarded beaches, at public-use swimming pools, and at unguarded inland water areas in Bulgaria. The project “AI-Based Computer Vision for Advanced Lifesaving Services and Water Safety Management in Bulgaria” is used as a case study, and the analysis is conducted against three legal instruments: Regulation (EU) 2016/679 (GDPR), Regulation (EU) 2024/1689 (AI Act), and the Bulgarian Personal Data Protection Act (PDPA). We show that the applicability of the GDPR depends entirely on whether the trained model can be qualified as genuinely anonymous under the two-step test formulated by the European Data Protection Board, and that the system’s risk classification under the AI Act is determined not by its sensor hardware, but by its decision-making architecture: an assistive notification system operating under full human oversight remains outside the high-risk regime, whereas a system that prioritises or dispatches emergency response falls fully within the scope of Annex III. Two compliance hypotheses are derived, together with the implementation steps and legislative amendments required under each of them.

A Product-Based Framework for Evaluating Visible Human Contribution in AI-Assisted Educational Content Development*Ani Epitropova**Universiti of Plovdiv "Paisii Hilendarski", BG*

Abstract: The increasing adoption of generative artificial intelligence in higher education has created a growing need for reliable approaches to assess visible human contribution in AI-assisted educational products. While existing Human–AI evaluation frameworks primarily focus on interaction processes or system performance, educators in authentic higher education settings rarely have access to students' prompt histories, interaction logs, or intermediate AI-generated versions unless learners voluntarily provide them. Consequently, the final submitted product often represents the only available evidence for evaluating human contribution. This study proposes a product-based

framework for evaluating visible human contribution in AI-assisted educational content development. The framework operationalizes human contribution through three complementary dimensions—Knowledge Transformation, Contextualization, and Decision-Making—comprising twelve measurable indicators. The framework was pilot-tested on AI-assisted educational products developed by 54 master's students. The findings demonstrated consistently high levels of visible human contribution and strong positive associations between the three framework dimensions and expert evaluation, providing preliminary evidence of convergent validity. Qualitative analysis further identified Local Contextualization as the least consistently represented dimension, suggesting that adapting AI-generated content to authentic local educational settings remains one of the most distinctive manifestations of human contribution. Beyond its research contribution, the proposed framework offers a practical and scalable approach for evaluating AI-assisted educational products in authentic higher education settings, where access to AI interaction histories is typically unavailable, and may be adapted to different academic disciplines, educational contexts, AI platforms, and learner-generated artefacts.

Application of Linear Regression Analysis to Predict Global Trends and User Dynamics of ChatGPT

Desislava D. Angelova

Technical University of Varna, BG

Zheyuo I. Zheyunov

Technical University of Varna, BG

Abstract: This paper presents a quantitative analysis and forecasting of user dynamics in Large Language Models (LLMs) using linear regression methodologies. Based on aggregated statistics reported for approximately 1.1 million ChatGPT interactions through mid-2025, the research benchmarks linear and exponential approximation models to define market diffusion trends for the 2023–2026 period. Results indicate a significant shift in the user paradigm—from task automation to the integration of AI as a cognitive assistant. The analysis documents the "commoditization" of the technology, where "Asking" type queries predominate over specialized text generation. The paper identifies demographic adoption anomalies and outlines three integration scenarios, addressing risks of cognitive dependency and professional productivity shifts.

Systematic literature review on Agentic AI in Business Process Management

Vanessa Filisyan

Sofia University "St. Kliment Ohridski", BG

Abstract: This study aims to investigate the research landscape regarding the application of Agentic AI in Business Process Management (BPM) adopting the systematic literature review method. It analyzes publications indexed in Google Scholar and identifies a publication peak in 2025. Despite the rising

interest in the topic, there is high fragmentation, and the focus is only on publication devoted to Agentic AI in BPM. Three clusters emerged from the thematic analysis: evolution towards Agentic AI oriented business systems, architectures and frameworks of Agentic AI, and AI considerations. The first covers fundamental research that sets the foundations for the transition from static processes to flexible, autonomous agents. The second focuses on the technological stack that enables AI to act as an autonomous agent. The last covers how implementing Agentic AI impacts the employees and the business value. The review summarizes the existing AI architectural approaches and implementation considerations and further gives a future research outline.

SESSION B24 - ANOMALY DETECTION IN TELEMETRY

Stream 2

Chair: Lala Bekirova

Azerbaijan State Oil and Industry University, AZ

Friday, October 9th 14:30 – 16:00

Online

SENTIS: A Deterministic Anomaly Detection Model Topping the Numenta Anomaly Benchmark

Mahammad Yusifov

Azerbaijan State Oil and Industry University, AZ

Lala Bekirova

Azerbaijan State Oil and Industry University, AZ

Abstract: System outages in distributed software architectures cause immediate financial losses, yet most production monitoring tools remain reactive, triggering alerts only after Service Level Agreement thresholds have already been breached. This paper presents SENTIS (Sensor Enabled Tactical Intelligence System), a lightweight proactive anomaly detection model designed for real-time streaming metrics in Kubernetes and JVM environments. SENTIS fuses six deterministic signals - a running min/max envelope, a deviation score against an adaptive baseline, a memory of value-transition sequences, a time-of-day expectation model, a stuck-value detector, and a dual shape memory with fixed and adaptive vigilance — into a single continuous anomaly score, computed fully online with no training phase and no external dependencies. We validate SENTIS on the full Numenta Anomaly Benchmark (NAB v1.1). We demonstrate that SENTIS achieves a standard NAB score of 75.19, the highest of all detectors evaluated on the benchmark, surpassing the previous leader ARTIME (74.9), and the highest Reward Low FN score of 81.16 — while still detecting gradual level-shift anomalies, such as memory leaks and configuration drift, that shape-based detectors structurally miss.

Anatomy of a Streaming Anomaly Detector: Channel Ablation, Model Reduction and Cross-Benchmark Adaptation of SENTIS

Mahammad Yusifov

Azerbaijan State Oil and Industry University, AZ

Abstract: SENTIS is a deterministic, dependency-free detector for streaming operational metrics that fuses six independent channels — a spatial envelope, a

deviation index over an adaptive baseline, a sequence memory, a temporal context model, a flatline sentinel and a dual-vigilance shape memory — into a single anomaly score, and which currently leads the Numenta Anomaly Benchmark (NAB). This paper reports a component-level analysis of that detector and two consequences of it. First, an ablation in which each channel is silenced in turn and the complete benchmark re-run establishes what each component contributes: fusion by maximum rather than by mean accounts for 21.88 points of standard score, the spatial envelope for 10.59, and the shape memory for 1.33, while the deviation index is shown to reduce performance. Removing that channel yields SENTIS-5C, a five-channel model scoring 75.89 / 64.54 / 81.63 on the standard, Reward Low FP and Reward Low FN profiles, which improves on the six-channel model on all three and establishes a new best result on the benchmark. Second, the architecture is transferred to two corpora published after NAB. On the Server Machine Dataset — 28 production servers and 1,064 metric streams — SENTIS-5C identifies 90.5% of labelled anomaly segments for a point-adjusted F1 of 0.906, without training and at 0.14 ms per record. On the UCR Anomaly Archive, whose protocol requires a ranking rather than an alert, the NAB-shaped output is shown to be the limiting factor rather than the channels themselves; a ranking-mode variant, SENTIS-R, raises top-1 accuracy from 3.2% to 18.4%.

RADWIN: Robust Drift-Aware Anomaly Detection for IoT Telemetry Streams at the Edge

Marian Ileana *National University of Science and Technology Politehnica of Bucharest, RO*

Pavel Petrov *St. Cyril and St. Methodius University of Veliko Tarnovo, BG*

Vassil Milev *St. Cyril and St. Methodius University of Veliko Tarnovo, BG*

Miroslav Dechev *Institute of Robotics, Bulgarian Academy of Sciences, BG*

Abstract: Internet of Things (IoT) deployments generate continuous telemetry that must be screened for anomalies close to the source, under tight memory and latency budgets and in the presence of concept drift, where the statistics of normal behaviour shift over time. Heavyweight deep models do not fit edge nodes, batch detectors such as Isolation Forest or One-Class SVM cannot adapt online once trained, and simple zscore rules are corrupted by anomalies inside their calibration window and by drift, producing large numbers of false alarms. We present RADWIN (Robust ADaptive WINdow), a lightweight detector that combines a sliding robust estimator of location and scale (median and median absolute deviation) with an adaptive windowing drift monitor that resets the calibration window when the regime changes, enabling fast recalibration without retraining. On nine real telemetry series from the Numenta Anomaly Benchmark (about 72000 points, 21 labelled anomaly windows), RADWIN attains a point-adjusted F1 of 0.933, matching the strongest baseline (Isolation

Forest) while using about 2 KB of state instead of roughly 1 MB, a reduction of two to three orders of magnitude. Against comparably lightweight detectors it lowers false-alarm events by 39 percent relative to a windowed Gaussian, and the ablation without drift adaptation confirms the contribution of the windowing reset. Per-sample latency stays below 100 microseconds, well within real-time edge constraints. The results position RADWIN on the accuracy-versus-cost Pareto frontier for on-device anomaly detection.

AROS-S: A Lightweight Onboard Anomaly Detector for Satellite Telemetry

Zlatimir Petrov

Nikola Vaptsarov Naval Academy, BG

Abstract: Responding to a satellite anomaly from the ground is slow, because the link has a long round trip and contact lasts only part of each orbit, while classical onboard fault protection relies on fixed limit checks aimed at anticipated failures rather than attacks. AROS-S (Autonomous Real-time Onboard Security for Satellites) instead checks every telemetry packet on the payload computer. Because no public dataset of in-orbit attacks exists, it does not train a classifier but learns normal spacecraft state and treats any departure as suspicious. Three layers with different blind spots run in parallel: two Isolation Forests on partitioned feature groups catch out-of-range points, a 38-parameter autoencoder catches packets that break the learned feature relationships, and a window autoencoder catches slow drift. All models train on one class over two disjoint synthetic normal regimes, the second patterned on the statistics of NASASMAP scientific fields, and are served as SHA-256-verified ONNX graphs with thresholds set at the 99th percentile of the normal score. AROS-S raises no false alarms on the baseline regime, cuts the second regime’s false alarm rate from 100 percent to about 6percent, and separates normal from attack reconstruction error by about three orders of magnitude; the slow memory leak is caught only by the window layer. On the real NASA SMAP benchmark the autoencoder reaches an F1 of 0.70, on par with the strongest classical one-class baseline at the smallest model size and lowest per-window latency. A simulated, signed response loop completes the design.

SESSION C24 - LEARNING PLATFORMS AND EDUCATIONAL ROBOTICS

Stream 3

Chair: Mariyana Todorova

Technical University of Varna, BG

Friday, October 9th 14:30 – 16:00

Online

A Reference Architecture for Orchestrating Cognitive Services in Intelligent Learning Platforms

Asya Toskova

Universiti of Plovdiv "Paisii Hilendarski", BG

Borislav Toskov

Universiti of Plovdiv "Paisii Hilendarski", BG

Abstract: Artificial intelligence has rapidly transformed the architecture of modern learning platforms, enabling functionalities such as personalized recommendations, learner modeling, competency inference, automatic feedback generation, and intelligent assessment. However, in most existing architectures, these functionalities are implemented as application-specific components, limiting their reusability, reducing interoperability, and increasing dependence on particular AI technologies. This paper extends the ITU-T F.742.2 functional architecture by introducing a Cognitive Service Layer that decouples cognitive processing from the business logic of learning applications. The proposed architecture organizes cognitive functionalities as reusable Cognitive Services managed by a Cognitive Orchestrator, which is responsible for service discovery, policy-based service selection, workflow generation, execution monitoring, result aggregation, and failure handling through fallback mechanisms and Human-in-the-Loop verification. The component architecture of the Cognitive Orchestrator and a representative service interaction workflow are presented to illustrate the interaction among the main architectural components. The proposed architecture provides a technology-independent foundation for orchestrating cognitive services and integrating heterogeneous AI models into intelligent learning platforms while preserving the system's modularity, extensibility, and adaptability.

Web-based platform for didactic interaction in pedagogical student practice

Lilyana Petkova

LiLuzeNet Ltd, BG

Vasilisa Valeova

South-West University "Neofit Rilski", BG

Abstract: The digital transformation of pedagogical practice necessitates the creation of an integrated educational environment that supports the effective planning, organization, implementation, and analysis of pre-service teachers' practical training. This study presents and evaluates a web-based platform designed to facilitate didactic interaction during the pedagogical practice of pre-service teachers in Technology and Entrepreneurship Education. The proposed conceptual model structures pedagogical practice as an interconnected five-stage cycle: preparation and planning, development of didactic materials, implementation of pedagogical activities, feedback and assessment, and reflection and sharing. The platform serves as a unified digital environment for interaction among pre-service teachers, university lecturers, and mentor teachers by supporting activity coordination, communication, access to educational resources, and the monitoring of professional development. The integration of an electronic portfolio, a digital repository of effective pedagogical practices, feedback tools, and facilities for sharing educational and methodological resources creates conditions for active collaboration, reflective learning, and the exchange of innovative pedagogical ideas. The primary objective of the study is to determine the platform's potential to enhance the

quality and effectiveness of pedagogical practice and to support the development of pre-service teachers' methodological, didactic, digital, and professional competencies. The findings indicate positive trends in the organization of practical training, interaction among participants, the timeliness of feedback, and professional reflection. These findings support considering the web-based platform as a promising instrument for the technologically and pedagogically grounded enhancement of pre-service teacher education.

Educational Robotics: A Systematic Review of Technologies, Pedagogical Practices, and Learning Outcomes (2020–2025)

Rustam Shadiev

Zhejiang University, CN

Shugyla Nurserik

Kazakh National Women's Teacher Training University, KZ

Aruzhan Kaldybai

Kazakh National Women's Teacher Training University, KZ

Aierke Nurgali

Kazakh National Women's Teacher Training University, KZ

Nurassyl Kerimbayev

Al-Farabi Kazakh National University, KZ

Shakhzada Abdugani

Kazakh National Women's Teacher Training University, KZ

Gulnaz Knyazkhan

Kazakh National Women's Teacher Training University, KZ

Altynshash Bekezhanova

Kazakh National Women's Teacher Training University, KZ

Gulnaz Salgarayeva

Kazakh National Women's Teacher Training University, KZ

Altynshash Bekezhanova

Kazakh National Women's Teacher Training University, KZ

Abstract: Abstract— Educational robotics has become an increasingly important component of teaching and learning, particularly in STEM and STEAM education. Although empirical research has expanded rapidly, evidence remains fragmented across different robotics technologies, educational contexts, pedagogical approaches, and learning outcomes. This study presents a systematic literature review of empirical research published between 2020 and 2025 to synthesize current evidence on the use of educational robotics in teaching and learning. Following PRISMA guidelines, studies were identified through searches of the Google Scholar and MDPI databases. After applying predefined inclusion and exclusion criteria, 40 empirical studies were included in the qualitative synthesis. The studies were analyzed according to robotics technologies, educational contexts, pedagogical approaches, learning outcomes, and implementation challenges. The findings show that construction-based robotics kits, Arduino platforms, and programmable robots were the most frequently used technologies, primarily in STEM and higher education. Across the reviewed studies, educational robotics was consistently associated with improvements in computational thinking, problem-solving, motivation, engagement, collaboration, and programming skills. However, challenges related to limited resources, teacher preparedness, and technical constraints remain. Overall, this review provides a comprehensive synthesis of recent

empirical evidence and offers implications for educators, researchers, and future implementation of educational robotics.

Evaluating Accessibility Evidence in Corporate Learning Systems to Support Inclusive Employment

Radostina Tsvetkova

Institute of Information and Communication Technologies, BAS, BG

Lyubka Doukovska

Institute of Information and Communication Technologies, BAS, BG

Abstract: Corporate learning systems have become important workplace infrastructure for mandatory training, professional certification, competency development, and career progression. When these systems are inaccessible, employees with disabilities may face barriers to professional development and employment. Organizations therefore often rely on vendor accessibility statements, Voluntary Product Accessibility Templates (VPATs), Accessibility Conformance Reports (ACRs), and related documentation during procurement. This paper evaluates publicly available accessibility evidence for eight corporate learning systems using comparative documentary analysis. The study examines the availability, scope, currency, specificity, methodology, and limitations of vendor evidence. The findings show that product-level conformance documentation can provide a useful baseline but cannot establish the accessibility of a configured workplace learning environment, which is also shaped by content, integrations, authentication, configuration, and organizational processes. Accessibility documentation should therefore support procurement evaluation and verification rather than be treated as proof of complete accessibility. Linking vendor evidence with employee tasks, acceptance testing, remediation, and ongoing monitoring can reduce the risk of inaccessible learning systems becoming barriers to inclusive employment.

SESSION D24 - LEARNING PLATFORMS AND EDUCATIONAL ROBOTICS

Stream 4

Chair: Vesela Karlova-Sergieva

Technical University of Sofia, BG

Friday, October 9th 14:30 – 16:00

Online

Adaptive FOPID controller with dynamic integral order for DC motor control

Boris Grasiani

Technical University of Sofia, BG

Vesela Karlova-Sergieva

Technical University of Sofia, BG

Nina Nikolova

Technical University of Sofia, BG

Abstract: This paper proposes an adaptive Fractional-Order Proportional–Integral–Derivative (FOPID) controller for DC motor speed control, in which the fractional integral order is dynamically adjusted according to the instantaneous control error. To compensate for the residual steady-state error,

an additional fractional-order integrator is incorporated into the control structure. The proposed approach is compared with a conventional adaptive PID controller using the integral performance indices IAE, ISE, and ITAE, as well as transient response analysis and load disturbance evaluation. Simulation results demonstrate improved control accuracy, reduced steady-state error, smoother control action, and enhanced robustness to external disturbances, confirming the effectiveness of the proposed adaptive FOPID controller.

Hall-Effect Sensor Data Processing for Contactless Lever Position Estimation Using Artificial Neural Networks

Ventsislav Simonov

University of Food Technologies - Plovdiv, BG

Tanya Titova

Technical University of Sofia, branch Plovdiv, BG

Abstract: This paper investigates artificial neural network (ANN)-based processing of three-dimensional Hall-effect sensor data for contactless lever position estimation. Experimental data were acquired from 98 mechanical test mechanisms in which a lever carrying a permanent magnet was moved to predefined angular positions by an automated robotic arm. The magnetic-field components along the X, Y, and Z axes were sampled at 1 ms intervals and used as inputs to regression and classification ANN models. Two feedforward regression networks trained with Levenberg-Marquardt and Bayesian regularization algorithms were evaluated for angle approximation, while a feedforward classifier trained with the scaled conjugate gradient algorithm was evaluated for direct position classification. The Levenberg-Marquardt and Bayesian regularization networks achieved best validation mean squared errors of 0.022602 deg^2 and 0.022969 deg^2 , respectively, corresponding to validation RMSE values of approximately 0.150 deg and 0.152 deg. The classifier achieved 97.7% accuracy on the test set with a validation cross-entropy of 0.039769. The results show that compact feedforward ANNs can provide accurate interpolation of Hall-effect sensor m

Coupling-Matrix Synthesis of X-Band CMOS Lumped-Element Filters with Unit-Capacitor Design Freedom for Calibration-Aware Design

Marin Nedelchev

Technical University of Sofia, BG

Jordan Kechev

Technical University of Sofia, BG

Abstract: This paper presents a synthesis method for X-band CMOS lumped-element bandpass filters. The key idea is simple: every capacitor in the filter is built with the same unit capacitor, connected in small series-parallel networks. Process variation then moves all capacitors together, and one single calibration loop can correct the whole filter. The method starts from a generalized Chebyshev filtering function with two transmission zeros. It extracts an inline $N+2$ coupling matrix, where the zeros come from frequency-dependent (resonant) couplings, and turns this matrix into an LC ladder with capacitive

and inductive couplings. It is shown that the resonant coupling branches load the resonators strongly; a self-consistent slope-parameter model describes this loading and gives a limit on how close the zeros may sit to the passband. The soft specifications (return loss, zero positions, and bandwidth) then serve as free variables of a quasi-Newton loop that moves all coupling and I/O capacitors onto the unit-capacitor grid, and a final inductor-only optimization removes the small remaining error. As an example, a fourth-order 10-GHz filter is designed in which all capacitors are made from a 580-fF unit cell (18 cells in total). The circuit matches the ideal coupling-matrix response within 0.0015 in $|S_{21}|$. It reaches 19.3-dB return loss, 1.02-GHz equiripple bandwidth, and transmission zeros at 8.64 and 11.33 GHz. Monte Carlo analysis with $3\sigma = 20\%$ capacitor tolerance shows that matching turns process variation into a pure frequency shift of about ± 0.8 GHz. A single-parameter SAR calibration then reduces this shift to a 67-MHz window and keeps the bandwidth within 12 MHz.

Increasing the nonlinearity of Boolean functions by adaptive wavelet spectrum modification

Alla Levina

LETI University, RU

Nikita Panchenko

LETI University, RU

Abstract: Boolean functions are fundamental components of modern cryptographic systems. Their resistance to linear cryptanalysis is largely determined by nonlinearity, making the construction of highly nonlinear Boolean functions an important research problem. This paper aims to develop an adaptive method for increasing Boolean-function nonlinearity through selective modification of wavelet-spectrum coefficients. The proposed method transforms a Boolean function into a bipolar representation, performs multilevel Haar wavelet decomposition, adaptively modifies selected detail coefficients, and reconstructs the function using the inverse wavelet transform. The effectiveness of the proposed method was evaluated through computational experiments on Boolean functions with 8, 10, and 12 variables. For each function, the initial nonlinearity was compared with the nonlinearity obtained after adaptive wavelet-spectrum modification using the Walsh–Hadamard transform as the evaluation criterion. The experimental results demonstrated consistent improvements in nonlinearity across all considered function dimensions, with average increases of 11.8%, 17.8%, and 16.1% for 8, 10, and 12-variable Boolean functions, respectively. The obtained results indicate that adaptive wavelet-spectrum modification can be applied to improve the cryptographic properties of Boolean functions and may be useful in the design of nonlinear components for modern cryptographic systems.

SESSION A25 - APPLIED SOFTWARE ENGINEERING

Stream 1

Chair: Ventsislav Nikolov

Technical University of Varna, BG

Friday, October 9th 16:30 – 18:00

Hall 109TV

Good Enough, Until It Isn't: The Debt of Frugal Process Automation

<i>Mahendrawathi Er</i>	<i>Institut Teknologi Sepuluh Nopember, Surabaya, ID</i>
<i>Karina Filza Aafiyah</i>	<i>Institut Teknologi Sepuluh Nopember, Surabaya, ID</i>
<i>Kesya Lintang Syawalani</i>	<i>Institut Teknologi Sepuluh Nopember, Surabaya, ID</i>
<i>Naila Ramadhani</i>	<i>Institut Teknologi Sepuluh Nopember, Surabaya, ID</i>
<i>Nikolaos Nousias</i>	<i>University of Macedonia, Thessaloniki, GR</i>
<i>George Tsakalidis</i>	<i>University of Macedonia, Thessaloniki, GR</i>
<i>Kostas Vergidis</i>	<i>University of Macedonia, Thessaloniki, GR</i>

Abstract: Due to limited resources and Information Technology (IT) capabilities, many firms, especially those in the Global South characterized by low business process management maturity, implemented Business Process Automation (BPA) in a “frugal” manner. While this approach appears to solve some immediate issues, it often results in the accumulation of technical and business process debts. This study explores two questions: (1) How do organizational resource constraints and process maturity levels influence the adoption of BPA? and (2) How does the implementation of frugal BPA affect the accumulation of technical and business process debt? To address these questions, we conducted two case studies of Indonesian companies that automated their procure-to-pay processes. Data collection was conducted through semi-structured interviews with staff directly involved in automation initiatives, complemented by observation and document analysis. Using open and axial coding, two key themes emerged: efficiency-driven automation and the emergence of technical and business process debts. The findings have several implications. From a practical side, they emphasize the importance of aligning automation strategies with long-term process governance and IT capability development to mitigate future debts. The study contributes to the discourse on frugal innovation and digital transformation in low-maturity and resource-constrained BPM contexts by highlighting the trade-offs between short-term efficiency and long-term sustainability.

Automating BPMN Model Generation of Public Services through RPA and AI Agents

<i>Panagiotis Drakopoulos</i>	<i>University of Macedonia, Thessaloniki, GR</i>
<i>Kostas Vergidis</i>	<i>University of Macedonia, Thessaloniki, GR</i>

Abstract: Digital transformation in the public sector relies heavily on business process modeling to understand and optimize administrative workflows. In practice, however, public administrations face two persistent obstacles: procedural knowledge fragmented across legal texts and heterogeneous sources, and the high cognitive overhead of manual BPMN modeling, which restricts it to a small pool of experienced modelers. This paper introduces

MITOS Modeler, an application developed within the UiPath Cloud ecosystem that automatically translates administrative documentation from the Greek National Registry of Administrative Public Services (MITOS) into editable BPMN 2.0 diagrams. The system combines Robotic Process Automation (RPA) for structured data retrieval from the MITOS API with a specialized dualagent AI architecture that separates semantic parsing from model synthesis. Five randomly sampled administrative processes were modeled and assessed by an expert panel using the established 3C evaluation framework (clarity, correctness, completeness), with Camunda BPMN Copilot—the bestperforming tool in our previous benchmark—serving as the baseline. MITOS Modeler outperformed the baseline in syntactic and semantic correctness (3.76 vs. 3.33) while remaining competitive overall, and—unlike general-purpose assistants—requires no textual prompt authoring, operating end-to-end from a single process identifier. The results indicate that registry-grounded, agent-based generation offers a scalable and reproducible foundation for accelerating public sector digital transformation.

Interactive Web-Based Exploration of High-Resolution ICON-LAM Precipitation Forecasts Using Client-Side Spatial Filtering

Catalin-Stefan Rucareanu

*National University of Sciences and
Technology Politehnica of Bucharest, RO*

Abstract: High-resolution numerical weather prediction (NWP) models provide increasingly detailed information about the spatial and temporal evolution of atmospheric variables, but the resulting datasets can be difficult to explore interactively. This paper presents a browser-based framework for interactive exploration of high-resolution ICON-LAM precipitation forecasts. The proposed approach combines local preprocessing of GRIB-formatted model output with a client-side visualization layer and experimentally evaluates lightweight spatial filtering for reducing the computational cost of interactive exploration. Selected precipitation products and forecast periods are converted into hourly JSON datasets and accessed by a web application that supports geographical selection, temporal navigation, point-level value inspection, and precipitation maximum identification. Spatial filtering is implemented using an axis-aligned bounding box (AABB), allowing the number of grid points processed and rendered to be reduced without modifying the original NWP data. The framework is evaluated using ICON-LAM precipitation fields at approximately 2.8 km and 1.6 km horizontal resolution for a precipitation event over Romania. For the tested 2.8 km dataset, reducing the selected geographical extent decreased spatial-filtering time from 0.050 s to 0.003 s and rendering time from 3.852 s to 0.100 s, corresponding to reductions of approximately 94% and 97%, respectively. Comparison with the original NWP fields showed no numerical differences in the processed precipitation values. The results demonstrate that lightweight client-side spatial restriction can substantially

reduce processing and rendering costs during localized exploration of high-resolution NWP precipitation data, while the complete dataset remains subject to the initial data-transfer cost.

An empirical and comparative study of Agile and Waterfall approaches to IT project management and their application in corporate organizational structures

Ivaylo Petrov

Technical University of Varna, BG

Abstract: The present scientific research aims to conduct a comparative analysis of the Agile and Waterfall methodologies in the context of IT project management in corporate management, examining their main characteristics, advantages, limitations and areas of application. Particular emphasis is placed on their effectiveness in different organizational environments and project types. The structure of the work includes a theoretical presentation of IT project management, a presentation of the two main methodologies, a comparative analysis between them, as well as a practical part with conclusions regarding their applicability in a real business environment in Bulgaria.

SESSION A31 - DECISION SUPPORT SYSTEMS UNDER
UNCERTAINTY

Stream 1

Chair: Valeriy Kolesnikov

American University Kyiv, UA

Saturday, October 10th 09:00 – 10:30

Hall 109TV

Favourable Dynamic Change as a Proxy of Difference in Values of Utility

Mohamed Daboos

Varna Free University, BG

Natalia Nikolova

Varna Free University, BG

Gabriela Petrova

Varna Free University, BG

Kiril Tenekedjiev

Australian Maritime College, University of Tasmania, AU

Abstract: Let the parameter X be influenced by the presence or absence of an intervention R . In quasi-experimental design, we form paired samples. We calculate the values of X before (a) and after R (b) for every entity from the samples. The best estimate for the effect of transitioning from a to b is the difference in utilities, $u(b)-u(a)$. The difference $w(b)-w(a)$ between value-difference functions can play the same role, although it is rarely used. For a number of reasons, specifically in medical practice, utility and value difference functions are neither readily available nor widely used. Instead, we have partially known ordinal value functions $v(\cdot)$. We introduce the favorable dynamic change FDC(a, b) as a proxy of $u(b)-u(a)$ and of $w(b)-w(a)$. FDC(a, b) only uses information from the partially known ordinal value function. In the special cases of hill or decreasing preferences, which covers the majority of cases in medical practice, we develop a user-friendly table method to calculate FDC. FDC has possible applications that will allow more intuitive and practical

experimental or quasi-experimental designs.

A Novel Classification Approach for Disasters in Intelligent Decision Support Systems

Martin Bakardzhiev

University of Mining and Geology, BG

Abstract: Intelligent Decision Support Systems (IDSS) are becoming increasingly integrated into building automation. Their application to emergency and crisis management can support the timely and informed decision-making required to respond to disruptive events. This paper discusses the concepts of hazard, incident, disaster, emergency, and crisis, and proposes a novel approach for a faceted classification scheme based on selected dimensions that serve as important characteristics of the different adverse events that can occur and be managed by an IDSS, including but not limited to those occurring in buildings. The proposed classification can be implemented computationally to enable IDSS to differentiate between problems and scenarios. Finally, a select number of known adverse events have been mapped against the proposed classification, demonstrating its features. These contributions address a gap in the academic literature and enable the development of IDSS for emergency and crisis management, including, but not limited to buildings.

Hazard-Aware Routing to Civil Protection Shelters Using Dijkstra's Algorithm and Multi-Layer Geospatial Graphs

Valeriy Kolesnikov

American University Kyiv, UA

Kateryna Abramova

American University Kyiv, UA

Maksym Ovcharenko

American University Kyiv, UA

Abstract: Timely access to civil protection shelters during emergencies requires routing models that represent both pedestrian connectivity and differences in exposure along route segments. This paper presents a software-based hazard-aware routing approach that combines OpenStreetMap road data with municipal GIS shelter and metro data in a multi-layer graph. The graph uses explicit semantics for road intersections, metro entrances, underground stations, and terminal shelters, while Dijkstra's algorithm minimizes a modeled exposure cost rather than physical distance alone. The paper's scientific contribution is the integration of shelter-specific graph semantics with an explicit, interpretable hazard-weighting model in a reproducible software architecture. The evaluation includes a controlled scenario analysis and a one-at-a-time sensitivity analysis of the hazard multipliers. The results show that the illustrative route pair used in the original implementation changes from 51.2% to 22.9% modeled exposure reduction as the underground multiplier varies from 0.05 to 1.0, demonstrating that the magnitude of the claimed improvement is parameter-dependent. The study therefore treats the hazard model as a tunable decision-support model rather than a validated physical safety model

and identifies the data and expert validation required for future empirical evaluation.

User adoption of AI decision support systems

Krasimira Georgieva

Technical University of Varna, BG

Iskra Karaivanova

Technical University of Varna, BG

Abstract: Artificial Intelligence (AI) is increasingly used to support human decision-making across various domains. This paper examines the adoption of Artificial Intelligence Decision Support Systems (AI-DSS) through a theoretical overview and an empirical study involving 138 respondents. The analysis focuses on AI usage, user trust, reliance on AI recommendations, and the factors influencing adoption. The results provide insights into current user adoption patterns and may support the development of more reliable, transparent, and user-centered AI-DSS.

**SESSION B31 - DEEP LEARNING FOR MEDICAL IMAGING
AND CLINICAL TESTS**

Stream 2

Chair: Idilia Batchkova

University of Chemical Technology and
Metallurgy-Sofia, BG

Saturday, October 10th 09:00 – 10:30

Online

**Persistent Homology Meets Deep Learning for Crohn's Disease Lesion
Classification**

Abbass Rammal

Phoenicia University, LB

Nadine Chreim

Phoenicia University, LB

Abbass Harb

Phoenicia University, LB

Mageda Sharafeddin

Phoenicia University, LB

Abstract: Crohn's disease is a chronic inflammatory bowel disease whose diagnosis using wireless capsule endoscopy (WCE) is time-consuming due to the large number of acquired images and the visual similarity among lesion categories. This paper proposes a topology-aware deep learning framework for fine-grained seven-class Crohn's disease lesion classification using the public CrohnIPI dataset. The proposed approach integrates persistent-homology descriptors with deep visual representations to capture complementary structural and semantic information. Multiple convolutional and Transformer-based architectures were evaluated, together with topology-aware feature fusion, machine learning classifiers, ensemble learning, and test-time augmentation. The proposed ResNet18--TDA ensemble achieved an accuracy of $\text{\textbf{89.06\%}}$, a weighted F1-score of $\text{\textbf{89.07\%}}$, a macro F1-score of $\text{\textbf{80.96\%}}$, and an AUC of $\text{\textbf{0.978}}$. The results demonstrate that incorporating topological information consistently improves lesion discrimination and provides an effective framework for fine-grained Crohn's disease lesion classification.

Real-Time Brain Tumor Detection and Patient Understanding Using Computer Vision

Derrick Mirindi

Morgan State University, US

Frederic Mirindi

University of Manitoba, CA

David Sinkhonde

*Pan Africa University Institute of Basic Sciences, Technology
and Innovation, KE*

Abstract: Brain tumor detection on magnetic resonance imaging (MRI) matters clinically because late recognition delays diagnosis, treatment planning, and follow-up. You Only Look Once (YOLO) models analyze images rapidly, but speed alone says little about whether a model can be relied upon: threshold choices must be transparent, failures should be attributed to a cause, attention must be inspected, and claims should be bounded by what a single dataset can support. Neuro-YOLO addresses this reporting gap as a proof-of-concept evaluation protocol rather than a new model backbone. We apply it to one public dataset and split the data into training (70%), validation (15%), and testing (15%). We report precision, recall, mAP@50, mAP@50–95, F1 score, and intersection over union (IoU), decompose errors with the Toolbox for Identifying Object Detection Errors (TIDE), and inspect model attention with Eigen-CAM (Class Activation Map using Principal Components). Three tools—Brain Tumor Guide, XBrain, and TumorVision—accompany the protocol as educational demonstrations rather than clinical software. Performance declined from internal validation to held- out evaluation, with precision of 0.598 and 0.549, recall of 0.577 and 0.525, mAP@50 of 0.602 and 0.473, and F1 score of 0.588 and 0.536, respectively. TIDE showed that classification errors and missed detections dominated, with missed detections increasing from 12 to 18 across the two evaluations. Eigen-CAM placed the strongest activation on lesion-relevant tissue in the illustrated case. Neuro-YOLO should therefore be regarded as an evaluation and educational framework, not as a substitute for assessment by qualified medical specialists.

Optimizing Clinical Decision Support: Deep Learning Architectures for Brain Tumor Classification

Klaus Caka

University of Europe for Applied Sciences, Potsdam DE

Usman Akhtar

Arden University Berlin, DE

Meerah Karunanithi

University of Europe for Applied Sciences, Potsdam DE

M. Kamran Asif

King Saud University, SA

Ahmed Hassan

Arden University Berlin, DE

Zeeshan Ali

Saudi Telecom Company, SA

Abstract: Brain tumor detection from magnetic resonance imaging (MRI) scans is critical for early diagnosis and treatment planning, yet manual

interpretation remains time-consuming and error-prone. Deep learning, particularly transfer learning, offers a scalable solution for automated classification. This paper presents a comparative evaluation of three widely used pretrained convolutional neural network (CNN) architectures—VGG16, ResNet50, and DenseNet121—on a standardized brain MRI dataset containing 7,023 images across four classes: glioma, meningioma, pituitary tumor, and no tumor. All models were fine-tuned under identical preprocessing, augmentation, and hyperparameter conditions to ensure fair benchmarking. Performance was assessed using accuracy, precision, recall, F1-score, confusion matrices, and training/validation convergence. Results show that ResNet50 achieved the best overall performance with 88.33\% test accuracy, outperforming VGG16 (87.64\%) and DenseNet121 (87.41\%). Moreover, ResNet50 demonstrated superior validation accuracy, faster convergence, and lower overfitting risk. Data augmentation improved generalization across all models, confirming its importance in medical imaging tasks with limited data. The findings suggest that ResNet50 provides the best trade-off between diagnostic accuracy and computational efficiency, making it a strong candidate for clinical decision support pipelines. This comparative framework offers valuable guidance for selecting architectures in future brain tumor detection research.

Multilingual AI-Powered Medical Report Summarization with Symptom Localization

Aarushi Singh

University of Europe for Applied Sciences, Potsdam DE

Nilofer Shaikh

University of Europe for Applied Sciences, Potsdam DE

Ritesh Jadhav

University of Europe for Applied Sciences, Potsdam DE

Prathamesh Surve

University of Europe for Applied Sciences, Potsdam DE

Shan Faiz

University of Europe for Applied Sciences, Potsdam DE

Abstract: Reports and documentation in healthcare systems are generally written in the language that is commonly used by healthcare providers and patients. Most of the tools used for the summarization of reports have been extensively tested in English. This creates a problem as the reports are generated in native languages other than English and using a simple word to word English translation introduces errors and can be misleading. In our study, we are implementing and evaluating DistilBART and mT5-small models synthetic discharge summ corpus (442 PMC-Patients pairs). Fine-tuned DistilBART reaches ROUGE- 1 of 0.431 versus 0.356 for the baseline (+21.2% relative). mT5-small performs poorly on this corpus ROUGE-1 0.025 EN near-zero DE/AR. Body-region localization using a keyword lexicon reaches 100% accuracy on English test notes but labels and predictions use the same rule set. The pipeline combines summarization and body-region mapping in one

reproducible workflow.
Index Terms—Multilingual NLP, clinical report summarization, body-region mapping, body part localization, DistilBART, mT5, low-resource languages.

SESSION C31 - GOVERNANCE, STANDARDS AND RESPONSIBLE AI ADOPTION		Stream 3
Chair: Sevinch Gulsechen		Istanbul University, TR
Saturday, October 10 th 09:00 – 10:30		Online
AI Adoption in Sensitive Data Environments: Expert Insights from Healthcare and Public Administration		
<i>Stefanie Filipczyk</i>		<i>University of Library Studies and Information Technologies, BG</i>
<i>Katia Rasheva-Yordanova</i>		<i>University of Library Studies and Information Technologies, BG</i>
Abstract: Despite its considerable potential, the adoption of artificial intelligence (AI) in sensitive data environments—particularly in healthcare and public administration—remains limited. This study therefore examines the influence of data protection risks, governance structures, and responsibilities regarding the potential implementation of AI in highly regulated organizations. Methodologically, semi-structured expert interviews were conducted with professionals from the healthcare, public administration, and consulting sectors and evaluated using qualitative, thematic analysis. The results of this study suggest that AI adoption is constrained less by technological availability than by regulatory uncertainty, governance maturity, organizational readiness, and limited trust. Data protection requirements therefore prove to be a key prerequisite for ensuring the necessary transparency, accountability, and trustworthy use of AI. Based on these findings, a conceptual model is developed that describes the relationships between data protection risks, organizational capabilities, governance mechanisms, and the necessary trust. The study highlights that risk-based governance approaches and clear responsibilities are crucial for the sustainable adoption of AI in sensitive data environments.		
A Governance-Oriented Framework for Privacy-Preserving AI Adoption in Regulated Information Systems		
<i>Stefanie Filipczyk</i>		<i>University of Library Studies and Information Technologies, BG</i>
<i>Katia Rasheva-Yordanova</i>		<i>University of Library Studies and Information Technologies, BG</i>
Abstract: Artificial intelligence (AI) creates new opportunities for automation, analysis and decision-making, which is why it is increasingly used in organizations that process sensitive data. Despite its widespread use, the application of AI in an institutional environment continues to face various challenges, including the protection of personal data and the management of		

sensitive information. Although significant progress has been made in addressing these challenges, most existing research addresses individual aspects of the problem separately and rarely provides integrated models for their application in regulated information systems. This article proposes a framework for implementing AI that protects personal data in regulated information systems. The framework is developed through a synthesis of existing research and integrates privacy-preserving technologies, governance and control mechanisms, regulatory requirements, and principles of trustworthy AI into a unified conceptual structure. As part of the framework, an AI Governance Readiness Index (AGRI) is proposed to assess organizational readiness for AI adoption in environments processing sensitive data. An initial empirical appraisal, informed by expert interviews conducted in healthcare, public administration, and consulting environments, provides preliminary support for the relevance of the AGRI dimensions and their application in regulated information systems. The proposed approach can support organizations in planning, evaluating, and governing AI-based solutions in compliance-sensitive environments.

The Adaptive Layered Standardization Model: A Formal and Simulation-Based Approach to Overcoming Standardization Debt in an Era of Exponential Technological Change

Miroslav Mitev

University of Library Studies and Information Technologies, BG

Abstract: Technical standards mediate between science, industry and regulation, yet the algorithm by which international, regional, national and sector standards are written and approved remains a sequential, consensus-bound process whose cycle time is measured in years. As the underlying digital technologies advance at an exponential rate, this cadence produces a widening gap that this paper formalizes as standardization debt: the time-integrated, cost-weighted divergence between the state of the art and the state of the standard. This problem is acute in the European Union, where Regulation (EU) 2024/2847 (the Cyber Resilience Act, CRA) obliges the European Standardization Organizations to deliver 41 harmonized standards on a timetable the traditional waterfall model cannot meet. We make four contributions. First, we give a formal definition of standardization debt as a functional over per-clause obsolescence, remediation cost and importance. Second, we propose the Adaptive Layered Standardization Model (ALSM), a process-level redesign that decomposes a standard into three layers of differing volatility (Core, Methods, Profiles), governs their evolution by a semantic-versioning discipline, and specifies a continuous-standardization pipeline as an explicit algorithm. Third, we conceptually evaluate the model through a discrete-time simulation calibrated to the CRA request, which estimates a 59% reduction in cumulative debt and an 82% reduction in the update latency of fast-

ageing content, with no increase in full-consensus committee workload. The simulation is intentionally explanatory rather than predictive: its purpose is to isolate the effect of layered update cadences under transparent assumptions, not to estimate real-world performance for a particular standards body. Fourth, we specify a reproducible empirical validation protocol (formalizability assessment, compatibility-regression measurement, and expert Delphi study) as immediate future work. We argue that ALSM localizes legal effect in the slow, consensual Core while confining velocity to layers without direct normative status, thereby reconciling speed, expertise and legitimacy.

The European Cybersecurity Skills Framework as a Basis for Establishing the Cybersecurity Profession and Developing Competence-based Educational Models

Miroslav Mitev

University of Library Studies and Information Technologies, BG

Yasen Tanev

University of Library Studies and Information Technologies, BG

Abstract: In the context of the growing role of cybersecurity, this article analyses how the European Cybersecurity Skills Framework (ECSF) can serve as a foundation for building the cybersecurity profession and developing competence-based educational models. A systematic review of the related European frameworks and standards is presented — ECSF (ENISA, 2022), the European Qualifications Framework (EQF), the DigComp 2.2 Digital Competence Framework, and the new Bulgarian state educational standard for the cybersecurity profession (Regulation No. 78/2025). A comparison is made between the role profiles defined in the ECSF and the units of learning outcomes (ERU) in the Bulgarian standard, with the correspondences and gaps between them identified in tabular form. The paper discusses how the state educational standard based on the ECSF can support the structuring of bachelor, master and doctoral programmes in cybersecurity, ensuring continuity between vocational education and higher education. The methodology combines a systematic literature review, qualitative content analysis of documents and critical discourse analysis to distinguish between descriptive and normative statements. Applying a transparent three-dimensional Coverage Index, the analysis finds that the national standard fully covers five of the twelve ECSF role profiles, partially covers three, and offers only low coverage of four (mean coverage 65 percent), the widest gaps being the Researcher, Penetration Tester and Digital Forensics profiles. These results underscore the importance of a common European skills framework for overcoming the shortage of cybersecurity personnel and for developing modern competency programmes. In conclusion, recommendations and guidelines for future research are formulated, including the need to periodically update and synchronise the frameworks with the dynamically changing cybersecurity landscape.

SESSION D31 - EDGE-CLOUD, NETWORKING AND IOT DATA ARCHITECTURES	Stream 4
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Chair: Veneta Aleksieva

Technical University of Varna, BG

Saturday, October 10th 09:00 – 10:30

Online

Applying A-MAPSS to an Elixir-Based IoT Sensor Data Processing Platform*Hristo Hristov**Technical University of Varna, BG**Dimitrichka Nikolaeva**Technical University of Varna, BG*

Abstract: This paper investigates the application of the A-MAPSS (An Advanced Methodology for Architectural Prototyping of Software Systems) methodology to the architectural design, implementation and evaluation of an Elixir-based Internet of Things (IoT) sensor data processing platform. An 18-in-1 Air Quality Detector is used as an experimental source of real-world heterogeneous measurements, while the research focuses on the architecture responsible for data acquisition, transformation, processing and visualization. The architecture is systematically derived through all seven A-MAPSS steps and implemented using Elixir, Phoenix Framework and Phoenix LiveView. The resulting prototype demonstrates successful processing of heterogeneous sensor records, dynamic browser visualization through WebSocket-based communication and separation of architectural responsibilities. The experimental evaluation confirms the feasibility of the derived architecture and demonstrates a traceable transition from requirements to an operational prototype. The results extend the experimental evidence supporting A-MAPSS and demonstrate its applicability to the systematic development of IoT data processing architectures.

Towards Low-Latency Networking: A Hybrid Cloud–Edge Architectural Perspective*Mohammad Al Rawajbeh**Al Zaytoonah University of Jordan, JO*

Abstract: The substantial increase witnessed over the last two decades in the use of applications characterized by high sensitivity to latency and intensive data requirements, such as Internet of Things (IoT) applications, has led to the development of a hybrid architecture that supports, on one hand, the requirements of latency-sensitive and real-time applications, and on the other hand, enables the use of cloud computing technology to provide large storage capacities and significant computational power. This development has resulted in the emergence of the Hybrid Edge-Cloud Architecture. This paper presents a review of the definition and concept of the Hybrid Edge-Cloud Architecture, benefits, components, and operational mechanisms. The paper focuses on the achievements of this architecture in reducing latency, optimizing resource utilization, enhancing scalability, and improving resource management. It also discusses the challenges associated with the adoption of this architecture,

including task offloading, security and privacy, interoperability, and energy efficiency. Furthermore, the paper addresses the technologies and mechanisms that have been employed to overcome these challenges. At the same time, it reviews and analyzes future research directions, which are expected to focus primarily on the use of artificial intelligence-based techniques, reinforcement learning, and renewable energy solutions in an effort to mitigate these challenges.

Connection and Abstraction Modules for Software Defined Network with Different Controllers

Delyan Genkov

Technical University of Gabrovo, BG

Miroslav Slavov

Technical University of Gabrovo, BG

Hristo Kilifarev

Technical University of Gabrovo, BG

Abstract: Software defined networks are widely deployed in modern networking world. They allow centralized monitoring and control of all the network devices through a software application – the controller. Many controllers exist, some of them are open-source, other are commercial. Currently most of the networking vendors propose their own solutions, using different controllers, but they are often incompatible between each other. The overall goal of our project is to create an application that can interact with most available solutions for software defined networking. This article presents the connection establishment and maintenance module and abstraction module, designed to interact with the most popular controllers – OpenDaylight, ONOS and Faucet open-source SDN controllers.

Measuring What Gets Lost: An Empirical Comparison of CRDT-Based and Conventional State Synchronization for Digital Twins

Petar Chakalov

University of Plovdiv "Paisii Hilendarski", BG

Svetoslav Enkov

University of Plovdiv "Paisii Hilendarski", BG

Abstract: Digital Twin (DT) architectures synchronize twin state to a cloud master replica over MQTT brokers or vendor edge runtimes; prior work argued qualitatively that this fails under network partitions and Conflict-Free Replicated Data Types (CRDTs) offer a resilient alternative; the empirical comparison has been missing. We contribute it: a reproducible benchmark in which an edge and a cloud site synchronize identical twin state through an MQTT bridge (Mosquitto, four configurations), a shadow-document synchronizer with documented AWS/Azure semantics, a production CRDT engine (Yjs), and a CRDT-over-MQTT control pair, under injected partitions, concurrent writes, and crashes. At 20 msg/s, a 300 s partition cost the default-configured conventional systems 77–97% of acknowledged telemetry while every system reported 100% write success; the CRDT replica lost nothing. Concurrent writes left the MQTT twin permanently divergent and halved an

aggregate counter under both MQTT and shadow reconciliation; CRDT replicas converged with all increments preserved. On the identical bounded bridge, a naive CRDT update stream diverged permanently past the queue cap while state-vector anti-entropy restored zero loss: the guarantee follows from merge-and-repair semantics, not transport. Under process crashes, broker acknowledgments decoupled from outcomes in both directions, while the CRDT recovered every acknowledged write. All results reproduce on a physical testbed (Raspberry Pi 5 over live WiFi): loss ratios agree within three points, at long outages within 0.03. The CRDT's cost is catch-up bandwidth linear in outage length; the conventional stacks instead lose data silently.

SESSION A32 - MACHINE LEARNING FOR FINANCE AND
BUSINESS ANALYTICS

Stream 1

Chair: Yanka Alexandrova

University of Economics Varna, BG

Saturday, October 10th 10:30 – 12:00

Hall 109TV

Modeling Borrower Repayment Performance in Consumer Credit Lending

Dimitre Tomov

University of Chemical Technology and Metallurgy-Sofia, BG

Alexander Efremov

Technical University of Sofia, BG

Atanas Atanasov

University of Chemical Technology and Metallurgy-Sofia, BG

Abstract: This study investigates borrower repayment performance in consumer credit lending using borrower-level, lender-level, and macroeconomic information. Repayment performance is measured as the ratio of cumulative payments over a 12-month period to the corresponding contractual payment obligation and transformed to reduce target skewness. Linear Regression (LR), Decision Tree Regressor (DTR), Random Forest Regressor (RFR), and Extreme Gradient Boosting (XGBoost) are evaluated separately for existing and new applicants. Nonlinear ensemble methods achieve the highest predictive performance, with validation R2 values reaching approximately 0.76, while maintaining low systematic bias after retransformation to the original repayment-performance scale. XGBoost consistently provides the highest explanatory power, whereas DTR exhibits the lowest aggregate bias, demonstrating that predictive accuracy and systematic bias provide complementary measures of model quality. The results indicate that repayment performance can be predicted with substantial accuracy and limited systematic error, supporting applications in credit risk assessment, portfolio management, and cash-flow forecasting.

**Machine Learning for Corporate Distress Prediction across Information
Environments: Evidence from Bulgaria**

Yanka Alexandrova

University of Economics Varna, BG

Abstract: The current research paper proposes and validates a framework for company distress status prediction with normalized financial data representation across industries. The framework adopts the idea that a certain value of a financial coefficient carries different information across different industries. Instead relying on the models to determine this relationship from a categorical variable, the frameworks embed it into the feature space by calculating the deviation from industry median values, calculated as median absolute deviation under strong leakage control between training and testing data. The framework validation is implemented through full factorial design including two main feature regimes and five different configurations, resulting in ten experiments. Each experiment is evaluated using tenfold cross validation on data about 24839 Bulgarian companies downloaded from the Orbis database and with 2.34% ratio of distress companies. The industry normalization increases the average precision from 0.4505 to 0.5441 for full regime design and from 0.4495 to 0.5232 for financial only design regime. The improvement is confirmed by Wilcoxon test ($p=0.002$ for both regimes) and by a paired bootstrap in which all two thousand replications give positive difference. The predictive performance of models under different regimes and configurations is demonstrated by the coverage achieved at target precision level. At a target precision of 0.60 the baseline model exhausts its list after eight enterprises, capturing 1.4% of future distress cases, whereas the sector-relative model covers 623 enterprises and 64.5% of future cases. This difference has a direct effect on the applicability of the framework. Experimental results reveal that features describing proximity to similar enterprises do not bring substantial improvement within a globally defined neighborhood. Proximity features and the administrative signal of reporting behavior proved to be mutually reinforcing, rather than substituting for one another. Permutation importance analysis shows that a feature may account for more than half of the trained model's importance without adding information when introduced to the training data. This is a distinction of direct methodological significance.

Combining Statistical and Machine Learning Forecasts for Erratic Retail Demand

Yanka Alexandrova

University of Economics Varna, BG

Yordan Atanasov

Doverie Brico Jsc., BG

Violeta Dimitrova

University of Economics Varna, BG

Abstract: Forecasting erratic demand for retail procurement is difficult because demand varies sharply in quantity and the available historical monthly date is limited. Under these conditions, the standard practice of selecting a forecasting model based on errors over the test set is unreliable. The winning model depends strongly on which months fall within the test window rather

than on the actual merits of the model. This paper presents a forecasting framework that combines classical statistical models with machine learning models and evaluates them under conditions that are transparent about small sample uncertainties. Using 96 monthly observations for a single power tool product sold by one of the stores from a Bulgarian DIY retail chain, we conducted a rotating origin in sixteen models, tested for differences in point errors, and estimated full predictive distributions using continuous range probability estimation, Winkler interval estimation, and inventory costs. Validation of the framework allowed us to highlight three important findings. First, the point accuracy is statistically saturated as 14 out of 16 models are indistinguishable from the best performer after correction for multiple comparisons. It confirms that model complexity does not reliably lead to lower error in a short run. The second finding is that significant separation only occurs when the forecasts are evaluated as predictive distributions and as inventory decisions - the most accurate distribution is not the cheapest to stock at the high service levels imposed by unit product economics. And third, a parsimonious combination of a statistical model (Theta) and a machine learning model (Extra Trees) achieves the best point accuracy and the best calibrated distribution, with the gain of the combination attributable to low error correlation between the components rather than individual model complexity. The framework has practical application in demand planning by providing a rigorous, decision-oriented framework for selecting an appropriate model in conditions of limited data, with possibilities for integration into retail ERP system.

A Business Intelligence-Centered Framework for Explainable and Actionable Machine Learning

Yanka Alexandrova

University of Economics Varna, BG

Mihaela Muntean

West University of Timisoara, RO

Abstract: Business Intelligence and Machine Learning have evolved as separate disciplines, and in many deployments Business Intelligence is limited to displaying results that are computed elsewhere, while the predictive logic, the choice of decision thresholds, and the reasoning behind individual predictions remain outside the analytical interface used by business users. This paper proposes a Business Intelligence centered framework that integrates Machine Learning and Explainable Artificial Intelligence within a single closed loop architecture organized into four layers: business intelligence, machine learning, explainability, and decisions and actions. Instead of acting as a passive visualization-only layer, Business Intelligence becomes the operational hub of the machine learning lifecycle, embedding predictions, profit oriented threshold analysis, global and local explanations, and business narratives generated by large language models into interactive dashboards. The framework is validated through a peer-to-peer lending case study in which exploratory analysis, model

development, threshold optimization, SHAP explanations, and counterfactual recommendations are combined and returned to the dashboard. The results show that the framework makes every stage of the pipeline visible and controllable by business users and supports transparent, trustworthy, and action-oriented decisions. The layered design is domain independent and can be regarded as a conceptual reference model transferable to other application areas.

SESSION B32 - SPEECH, VOICE AND INTERACTION TECHNOLOGIES	Stream 2
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Chair: Tzvetomir Vassilev

University of Ruse “Angel Kanchev”, BG

Saturday, October 10th 10:30 – 12:00

Online

A Modular Software Framework for Reproducible Multi-Factor Evaluation of Automatic Speech Recognition Systems

Hasan Gyulyustan

University of Plovdiv Paisii Hilendarski, BG

Svetoslav Enkov

University of Plovdiv Paisii Hilendarski, BG

Abstract: Automatic speech recognition evaluation increasingly combines conventional edit-based measures with semantic and context-sensitive signals. Applying these heterogeneous methods through separate tools or ad hoc scripts makes it difficult to hold preprocessing constant, inspect individual records, compare component substitutions, and retain experimental provenance. This paper presents a modular, configuration-driven software framework that integrates conventional metrics and complementary evaluation components within one controlled process. It applies shared normalization, computes word- and character-level errors together with lexical, semantic, and rule-based context-sensitive components, optionally composes them into a Multi-Factor ASR Accuracy Score, and persists record-level and aggregate outputs. The framework is demonstrated through an end-to-end evaluation of three English Whisper configurations on a fixed LibriSpeech sample, isolated substitution of token-overlap semantics with sentence embeddings, and reuse with multilingual Whisper models and Bulgarian FLEURS material. The demonstrations show software-level modularity and traceability without implying universal metric superiority, language independence, or guaranteed reproducibility.

Unified Multilingual Web-Based Framework for Bidirectional Speech–Text Conversion Using Intelligent Processing Technologies

Maksat Churiyev

International University of Oil and Gas named after Yagshygeldi Kakayev, TM

Maral Geldiyeva

International University of Oil and Gas named after Yagshygeldi Kakayev, TM

Tzvetomir Vassilev

University of Ruse “Angel Kanchev”, BG

Gadam Akmyradov

State energy institute of Turkmenistan, TM

Oguljan Akmyradova

State energy institute of Turkmenistan, TM

Ayna Nurmyradova

State energy institute of Turkmenistan, TM

Abstract: The rapid development of intelligent speech technologies has significantly transformed human–computer interaction, digital accessibility, and automated information processing. However, low-resource languages remain underrepresented in modern speech recognition and speech synthesis systems. This paper presents the development, implementation, and evaluation of the first integrated Speech-to-Text (STT) and Text-to-Speech (TTS) platform for the Turkmen language. The proposed web-based framework combines automatic speech recognition and speech synthesis within a unified architecture capable of operating both online and in fully local environments. The system supports bidirectional speech–text conversion and was developed using modern artificial intelligence technologies, including Whisper-based speech recognition and XTTS-based speech synthesis. Particular attention was devoted to linguistic adaptation of the Turkmen language through collaboration with professional philologists and linguists responsible for phonetic rules and pronunciation validation. The development process involved the creation and processing of a speech corpus consisting of approximately 457 hours of recorded speech, 96 speakers aged between 12 and 76 years, more than 5,600 pages of textual materials, and a vocabulary of approximately 20,000 words. Experimental validation involved around 100 participants and approximately 500 speech recordings. The results demonstrated stable recognition and synthesis performance across different genders and age groups. The scientific novelty of the research lies in the creation of the first national bidirectional Turkmen speech platform integrating both STT and TTS technologies, supporting local deployment, multilingual operation, and practical applicability in education, government administration, libraries, and scientific institutions. The developed software products have been officially registered and protected by national copyright certificates.

Toward Voice-Oriented Architectural Styles: A Conceptual Framework for AI-Driven Conversational Systems

Hristo Hristov

Technical University of Varna, BG

Abstract: Recent advances in Artificial Intelligence (AI), Automatic Speech Recognition (ASR), Natural Language Processing (NLP) and Large Language Models (LLMs) are transforming human–computer interaction from command-oriented communication toward intent-oriented and context-dependent interaction. While Voice User Interfaces, Conversational User Interfaces and multimodal interaction have been extensively studied, considerably less attention has been given to whether voice-mediated intent acquisition may

introduce recurring architectural characteristics that justify investigation at the level of software architectural styles. This paper presents the initial concept of Voice-Oriented Architectural Styles (VOAS) as a conceptual framework for exploring this possibility. Two candidate architectural styles are examined: Voice-Oriented Architecture (VOA), in which speech serves as the primary mechanism for expressing user intent and Voice-Multimodal Architecture (VMA), in which voice interaction is coordinated with complementary interaction channels to form unified logical application operations. The analysis identifies potential architectural responsibilities, connector semantics, interaction rules, constraints and quality concerns associated with voice-oriented processing. A common architectural characteristic of both approaches is the emergence of an intermediate interaction state between user expression and application execution. The study does not claim VOA and VMA as established architectural styles; rather, it provides an initial architectural hypothesis and a conceptual foundation for their future formalization and experimental evaluation.

The Influence of User-Friendly Interface Design on Technology Acceptance and Continuance Intention in Digital Editing Applications

Yohanes Philip Subekti

Bina Nusantara University, ID

Ahmad Sultan Pahlevi

Bina Nusantara University, ID

Yanti Tjong

Bina Nusantara University, ID

Abstract: Abstract—Digital editing applications have become increasingly popular among both professional and non professional users for creating and modifying digital content. As competition among editing platforms intensifies, interface quality and usability have emerged as critical factors influencing user adoption and retention. This study investigates the influence of user friendly interface design on technology acceptance and continuance intention in digital editing applications. Drawing upon the Technology Acceptance Model (TAM), the study examines the relationships between usability, perceived usefulness, perceived ease of use, and continuance intention. A quantitative explanatory approach is proposed through an online survey targeting active users of digital editing applications such as CapCut, Canva, VN, PicsArt, and Adobe Lightroom. The expected findings aim to demonstrate that user friendly interface design positively influences users' perceptions of usefulness and ease of use, which subsequently encourage long term usage intention. The study contributes to Information Systems and Human Computer Interaction research by providing insights into how usability oriented interface design can support sustainable user engagement.

SESSION C32 - SECURE DEPLOYMENT, DATA PROTECTION AND DIGITAL FORENSICS	Stream 3
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Chair: Plamen Vasilev University of Chemical Technology and Metallurgy, BG

Saturday, October 10th 10:30 – 12:00

Online

Origin side penetration testing and remediation framework for Cloudflare fronted self-hosted LLM deployment

Tsvetomir Bogdanov

Bulgarian Academy of Sciences, BG

Nayden Chivarov

Bulgarian Academy of Sciences, BG

Stefan Chivarov

Bulgarian Academy of Sciences, BG

Abstract: A CDN (content delivery network) is increasingly used to optimize traffic flow, and only on specific platforms also to protect the traffic that passes through it. Any service on the origin host that is exposed, and sometimes visible even through the CDN, is still considered vulnerable. We ran an origin side penetration testing on a production planned Open WebUI frontend and Ollama deployment with 12 LLM (large language models). They were deployed behind NPM (Nginx Proxy Manager) and a CDN and as main contribution we present a prioritized remediation framework for the exposure, that the edge cannot handle. We verified that the origin is reachable directly, bypassing the CDN, also the exposure is already present in public internet scanned data. We assessed the full surface: reachability over IPv4 and IPv6, alternate hostnames, and SNI and host-header manipulation; authenticated origin pulls and tunnel posture; access control for admin and application routes; reverse-proxy trust; allowed HTTP methods and CORS (cross-origin resource sharing); inference-API network segmentation; and container hardening and detection. We grouped those into five areas as a reusable defense-in-depth checklist for self-hosted LLM deployments.

Detection engine constraints and pattern portability across five cloud Data Loss Prevention platforms

Tsvetomir Bogdanov

Bulgarian Academy of Sciences, BG

Abstract: Cloud delivered DLP (Data Loss Prevention) services contain three generations of detection technology: regular expressions, machine-learning classifiers and more recently adopted large-language-model based analysis. This paper is an overview of the system capabilities of five widely used platforms, based on the current vendor documentation and validated on the first stage against 94 PII (personally-identifiable-information) detectors and covering 31 countries. They were assembled from the vendors' own detection dictionaries (most available publicly, some obtained over developer and partner channels) and expanded with the help of self-hosted language models. We find that the set of regex features shared by all of the five engines is smaller than what any one engine supports on its own and we define this shared subset. Only

one pattern in the pack relies on a feature outside of it – the US Social Security Numbers, this is why we use a rewritten version, that matches the same text and is cross-platform usable for testing. Testing across the pack also shows that national ID patterns for the separate countries can have very strong similarities (f.ex. for countries in EU) and often match each other's data. For them we measure how much checksum validation improves precision and how much recall it costs in return. Finally, we set out a framework to compare accuracy, cost, privacy and scalability.

Comparison of Machine Learning Models at Analysis of Image Files in Digital Forensics

Veselina Vukova

Technical University of Sofia, BG

Malinka Ivanova

Technical University of Sofia, BG

Abstract: Technologies provide great opportunities for users who can perform various activities in the web space through their devices. At the same time, technologies preserve traces, keep a register and archive of the activities performed. Forensics experts use these traces and archives to find evidence when violent actions have been committed by an attacker. The processing and analysis of digital artifacts is carried out on the basis of specially created copies, called images, in order to preserve the original files and to not disrupt the information on them. In addition to the well-known software tools for image processing, machine learning (ML), artificial intelligence and natural language processing techniques (NLP) have recently been applied. The aim of the paper is to present results regarding exploration and comparison of three ML models for classification of artifacts in forensic images. These models are applied on fully balanced, partial balanced and imbalanced datasets. The most significant result of the experiments is related to the contribution of NLP as the main factor for the high classification ability of the developed analytical system, while the structural forensic features have a complementary role. Data balancing has a secondary but measurable effect as the best accuracy is obtained at full balance between classes in NLP-based models.

Security Aspects in Multi-tired Architectural Frameworks for Intelligent Internet of Things Systems

Andon Nenov

Technical University of Sofia, BG

Ivaylo Atanasov

Technical University of Sofia, BG

Maria Nenova

Technical University of Sofia, BG

Georgi Iliev

Technical University of Sofia, BG

Abstract: Advanced intelligent Internet of Things (AIoT) architectural frameworks are usually hierarchically structured in four layers – physical layer, network layer, analytics layer, and application layer. In this paper, we study security aspects related to the application and analytic layers, both of which are

divided into time-critical and non-critical ones. Some of the threats are identified and a possible solution that mitigates the risk is proposed. The solution is verified by modeling the application state during an extended registration process.

SESSION D32 - LPWAN AND IOT SENSING NETWORKS

Stream 4

Chair: Grisha Spasov

Technical University Sofia Plovdiv Branch, BG

Saturday, October 10th 10:30 – 12:00

Online

Simulation study of the applicability of LoRaWAN IoT in an air parameter measurement system

Grisha Spasov

Technical University Sofia Plovdiv Branch, BG

Abstract: Traffic monitoring systems are an essential part of intelligent transportation systems (ITS). The rapid development of modern transport systems has led to a global problem of air pollution. This has raised the topical issue of measuring and monitoring environmental parameters in traffic monitoring stations in ITS. Such systems often have to operate in remote locations or in urban environments, which necessitates the use of appropriate means for wireless data transmission. This predetermines the requirement for low energy consumption and operation over long distances. One of the optimal solutions is the use of wireless communication networks LoRa and LoRaWAN. In this article, we present a simulation study of a wireless system based on LoRa and LoRaWAN for monitoring environmental parameters, used as a subsystem of a traffic monitoring station. A simulation analysis has been made regarding the values of the parameters the spreading factor (SF), bandwidth (BW) and coding rate (CR) of the wireless interface, which influence the quality of connection and the covered distance, and are decisive for choosing a compromise between connection stability, transmission speed, packet transfer time and energy consumption.

W-Mesh: a Duty-Cycled LoRa Mesh Extension for Windowed Buffered Telemetry

Nikolay Milovanov

New Bulgarian University, BG

Abstract: A duty-cycled LoRaWAN network operates at the Bulgarian Antarctic base on Livingston Island: sensor nodes buffer their measurements locally, and gateway, backhaul and nodes wake together for a short daily communication window. The approach has proven itself around the base, but it cannot reach instruments beyond the radio horizon of a single gateway, and building further gateway sites across terrain that is inaccessible for most of the year is not realistic. This paper proposes W-Mesh, a store-and-forward extension of the same windowed protocol, in which a suitably placed node also listens for and forwards the payloads of deeper neighbours. The window is

partitioned into cascade phases ordered by hop depth; loop freedom follows by construction from a gradient forwarding rule; listening is gated by channel activity detection, far cheaper in charge than continuous reception. A published single-hop capacity model is extended to multiple hops, giving closed-form energy, capacity and fan-in bounds for the European unlicensed band. The analysis shows that relaying is practically free in energy, that capacity degrades gracefully with depth, and that the binding constraint is the regulatory duty cycle. A working prototype exists; field validation is planned for the coming Bulgarian Antarctic expedition.

IoT LPWAN as the Monitoring and Diagnosis Layer of Smart Water Networks (SWN)

Nikolay Milovanov

New Bulgarian University, BG

Abstract: A drinking-water distribution network is a complex distributed system: thousands of hydraulically coupled elements, buried assets, slow developing faults, and measurement points that are dispersed, unpowered and installed in difficult radio conditions. This paper examines Low Power Wide Area Networks (LPWAN) as the observability layer that makes such a system monitorable and diagnosable at acceptable cost. The paper relates the LPWAN landscape of 2026 to the principal monitoring, control and diagnosis tasks of a water utility: district metered area (DMA) flow and pressure monitoring, minimum-night-flow trending and leak localization by superposition of zone meters (diagnosis), acoustic surveillance, reservoir and well telemetry, pressure management and pumping-station supervision (control). A duty-cycle calculation shows that LoRaWAN can support the 15-minute sampling used in Bulgarian DMA monitoring, and representative one-hour measurements show substantially lower integrated consumption for the tested LoRaWAN and NB-IoT devices than for a legacy GSM logger; because the devices were tested at different temperatures, these measurements are reported as engineering observations rather than a controlled benchmark. Operational examples from Bulgaria, Austria and Italy illustrate the diagnostic workflows in production, including a customer- side leak localized from superposed zone, control and customer meters before a crew was dispatched. The regional deployment wave in Southeast Europe is reviewed, and the regulatory context (Drinking Water Directive leakage assessment, NIS2, RED cybersecurity) is related to the monitoring architecture.

An AI-driven predictive humidity control architecture for smart greenhouses using distributed LoRaWAN sensor networks in arid climates

Palvan Kalandarov

"Tashkent institute of irrigation and agricultural mechanization engineers" National Research University Tashkent, UZ

Shakhnoza Ubaydullayeva

"Tashkent institute of irrigation and agricultural mechanization engineers" National Research University Tashkent, UZ

Mariela Alexandrova

Technical University of Varna, BG

Abstract: Modern precision agriculture requires high-precision microclimate management to optimize crop yields and minimize resource consumption, especially in regions with arid and sharply continental climates like Uzbekistan. Traditional threshold-based and conventional PID control systems often fail to manage greenhouse humidity efficiently due to high thermal inertia, non-linear environmental dynamics, internal crop transpiration, and external ambient fluctuations. This paper introduces a novel AI-driven predictive control architecture integrated with a distributed wireless sensor network based on LoRaWAN technology, developed within the research framework of TIAME National Research University. The hardware layer utilizes low-power end-nodes deployed across distinct greenhouse zones to capture spatial microclimate variations, transmitting data via the EU868 standard. At the application layer, a Long Short-Term Memory (LSTM) neural network model is deployed to forecast internal humidity trends 60 minutes in advance, utilizing sequential historical logs and ambient meteorological profiles. The system architecture incorporates a fault-tolerant parsing mechanism to withstand a simulated 3% network packet loss rate typical of industrial agricultural infrastructures. Based on the neural network predictions, an automated actuator subsystem dynamically modulates ventilation and misting systems before critical threshold breaches occur. Experimental validation based on mathematical modeling demonstrates that the proposed predictive architecture suppresses relative humidity fluctuations by 73.2% and cuts cumulative ventilation energy demand by 21.4% compared to conventional reactive feedback control methods. The proposed decentralized framework offers high scalability for large-scale agrotech infrastructures in Central Asia by offloading heavy computational demands to centralized university cloud servers.

SESSION A33 - EDUCATIONAL DATA ANALYTICS AND E-LEARNING		Stream 1
Chair: Valeria Simeonova Sofia University “St. Kliment Ohridski”, BG		
Saturday, October 10 th 12:00 – 13:30		Hall 109 TV
A Case Study Comparison of Logistic Regression, Random Forest, and Gradient Boosting for Predicting Computer Science Student Placement: Evidence from a Single Institution Dataset		
<i>Ivo Rakitin</i>		<i>Technical University of Varna, BG</i>
<i>Evgeniya Rakitina-Qureshi</i>		<i>Technical University of Varna, BG</i>
<i>Hristo Nenov</i>		<i>Technical University of Varna, BG</i>
<i>Neli Arabadzhieva-Kalcheva</i>		<i>Technical University of Varna, BG</i>

Donika Stoyanova

Technical University of Varna, BG

Daniela Ivanova Petrova

Technical University of Varna, BG

Abstract: This study compares Logistic Regression (LR), Random Forest (RF), and Gradient Boosting (GB) for predicting student placement outcomes using a dataset of 2,000 computer science student records from a single Bulgarian technical university containing only five basic features: age, GPA, failed courses, attendance, and a derived academic risk score. After identical preprocessing (min-max scaling, age binning, feature engineering) and stratified 80/20 split, Random Forest achieved the highest performance, followed by Gradient Boosting and Logistic Regression. Attendance and GPA were the dominant predictors in both ensemble models; Logistic Regression coefficients confirmed the same directionality. While ensemble methods clearly outperformed the linear baseline on this particular dataset, the very limited feature set and single-institution origin prevent broad generalisation. The study serves primarily as an illustrative case study of algorithm behaviour rather than a definitive statement on placement drivers.

Impact of Dataset Scale on Predictive Performance in Educational Analytics: A Learning Curve Analysis of Random Forest for Student Placement Prediction

Ivo Rakitin

Technical University of Varna, BG

Evgeniya Rakitina-Qureshi

Technical University of Varna, BG

Milen Georgiev Angelov

Technical University of Varna, BG

Donika Stoyanova

Technical University of Varna, BG

Dimitrichka Nikolaeva

Technical University of Varna, BG

Stefka Popova

Technical University of Varna, BG

Abstract: This study quantifies how training-set size affects the predictive performance of a tree-based ensemble in educational analytics. Extending prior comparative work on student placement prediction [1], [3], we performed a learning-curve analysis by stratified subsampling of a publicly available 2,000-record engineering student placement dataset [10]. Random Forest was used as a representative bagging ensemble, with fixed hyperparameters, so that sample size remained the only experimental factor. Performance was evaluated at 100, 250, 500, 1,000 and 2,000 records. Results followed a logarithmic pattern: accuracy rose from 0.59 (± 0.10) at 100 samples to 0.69 (± 0.04) at 500 samples ($+0.10$), then to 0.75 (± 0.03) at 1,000 and 0.79 (± 0.02) at 2,000 samples. The F1-score increased from 0.45 to 0.68 and AUC-ROC from 0.58 to 0.80, while standard deviations decreased monotonically. The study does not claim a new learning-curve law; logarithmic scaling is well established [4], [8]. The contribution is applied: domain-specific thresholds for a four-feature binary placement task, and a practical recommendation of at least 1,000 samples for accuracy of about 0.75 under this feature set. Lower scores relative to the fixed-

split results in [1], [3] (0.87–0.92) are attributed to the repeated-subsample protocol and to the shallower forest used here, not to a different feature set. The results can inform data-collection planning in educational predictive analytics when only a small number of academic features is available.

ROTLA: A Temporal Learning Analytics Core Combining Behavioral, Psychological and Affective Indicators in Moodle-Based Courses

Maria Garbova

Sofia University “St. Kliment Ohridski”, BG

Krassen Stefanov

Sofia University “St. Kliment Ohridski”, BG

Valeria Simeonova

Sofia University “St. Kliment Ohridski”, BG

Dafinca Miteva

Sofia University “St. Kliment Ohridski”, BG

Abstract: This paper presents ROTLA (Rule-based Observational Temporal Learning Analytics), a methodology that specifies the indicator core of a broader early-warning architecture through three complementary signals: a composite Behavioral Index (BI) computed monthly from raw Moodle logs; a Psychological Index (PI) aggregating self-reported readiness for self-regulated learning; and an affective signal (Q7, task-related anxiety) modeled separately from PI and interpreted as a temporal trajectory. BI integrates three formative indicators — the Session Index (SeI), the Submission Index (SI), and the Weighted Normalized Activity Volume Score (AVR) — each discretized on a three-level scale. Two studies on consecutive cohorts of the same Moodle-based course at Sofia University are reported. Study 1 computed BI for all 118 enrolled students (March–June 2025): semester rankings remained highly stable under alternative schemes (Spearman correlation of at least 0.91), and semester BI categories were associated with timely certification (chi-square test with two degrees of freedom, p below 0.001; rank-biserial correlation 0.57). Study 2 instrumented PI and Q7 with a weekly questionnaire in the next cohort (2025/2026; 38 students) as a feasibility check: no significant association between anxiety and readiness was detected, and anxiety varied widely among high-readiness students — 8 of 38 (21 percent) combined high readiness with elevated anxiety, a configuration a readiness-only screen would miss. We position ROTLA as a transparent indicator core for teacher-facing monitoring. Limitations include a self-selected, low-variance Study 2 sample and the provisional nature of PI and Q7 thresholds; full validation of the self-report layer and robustness testing with synthetic cohorts remain future work.

ACRA-ROTLA: An Integrated Affective-Cognitive Risk Analysis Framework for Early Detection of At-Risk Students in E-Learning

Maria Garbova

Sofia University “St. Kliment Ohridski”, BG

Krassen Stefanov

Sofia University “St. Kliment Ohridski”, BG

Valeria Simeonova

Sofia University “St. Kliment Ohridski”, BG

Dafinca Miteva

Sofia University “St. Kliment Ohridski”, BG

Abstract: Early detection of at-risk students remains a central challenge in e-learning, as single-signal approaches often fail to capture the interplay between behavioral, cognitive, and affective dimensions of learning. This paper introduces ACRAROTLA, an integrated framework in which an AffectiveCognitive Risk Analysis (ACRA) layer extends the ROTLA indicator core — a Behavioral Index (BI), a Psychological Index (PI), and an independent temporal anxiety signal (Q7) — whose computation and two-cohort empirical validation are presented in a companion paper. Building on this empirically grounded core, the present paper contributes the theoretical superstructure of the framework: a six-layer architecture linking learning design to run-time analytics; formally defined per-student state vectors for cognitive processing and multimodal affect, together with a resonance function quantifying cognitive-affective synchrony; and a rule-based convergence layer that maps index configurations to dynamic learner profiles with explicit teacher-in-the-loop intervention logic. The extended module is a formal specification defining the measurement targets of the next research phase; no empirical values for the extended constructs are reported. ACRA-ROTLA provides an interpretable, theory-grounded architecture for teacher-facing early-warning systems and a basis for targeted pedagogical interventions.

SESSION B33 - KNOWLEDGE REPRESENTATION,
MANAGEMENT AND ONTOLOGIES

Stream 2

Chair: Stanislav Penchev

University of Ruse “Angel Kanchev”, BG

Saturday, October 10th 12:00 – 13:30

Online

Integrating Artificial Intelligence into Knowledge Management Systems: Trends, Challenges and Future Prospects

Kiril Luchkov

Technical University - Sofia, BG

Nadya Velinova-Sokolova

Sofia University “St. Kliment Ohridski”, BG

Abstract: The paper analyzes the main directions of using artificial intelligence in knowledge management systems and their impact on working with organizational information. A structured literature review of scientific publications and primary institutional sources is applied. The results are systematized in three groups: trends, challenges and future prospects. The transition from document search to search by meaning, conversational intelligent assistants, use of internal sources when creating a response and systems with autonomous agents is traced. A gradual transfer to the system of some of the activities of discovering, comparing and summarizing information is established. The main limitations are the quality and relevance of the sources, security, confidentiality, trust and human control. Future development is related to processing text, tables and images and with closer participation of intelligent assistants in work processes. Their practical value is deter

A conceptual framework for using artificial intelligence in digitalization and effective knowledge management

Kiril Luchkov

Technical University - Sofia, BG

Nadya Velinova-Sokolova

Sofia University "St. Kliment Ohridski", BG

Abstract: The paper proposes a conceptual framework for the use of artificial intelligence in digitalization and effective knowledge management. The interaction between human expertise, organizational processes and technologies in the discovery, organization, verification, sharing and application of knowledge is traced. The study is based on a structured literature review of 20 scientific publications with DOI and a conceptual comparison of the main statements. The organizational conditions for the use of artificial intelligence, the possibilities for automated knowledge discovery and the stages for introducing such solutions are systematized. It is established that the practical benefit depends on the quality of information sources, the clear distribution of responsibilities and the alignment of human control with the nature of the task. Guidelines are proposed for the preparation of knowledge, trial use, evaluation of results and subsequent expansion of the application.

Protected Plants in Bulgaria: Ontology, Passport Descriptor Pattern and Integration with the GeneBank Ontology

Sebiha Madanska

University of Plovdiv "Paisii Hilendarski", BG

Asya Stoyanova-Doycheva

University of Plovdiv "Paisii Hilendarski", BG

Zornica Radeva

*Institute of Information and Communication
Technologies-BAS, BG*

Abstract: Ontology engineering is well established in the technological world and the areas of interest expand even more. Here it is used in the context of plant genetic resources conservation and digitization of the Red Data Book of the Republic of Bulgaria. Two ontologies are created using the Protégé environment, and in this article we present modifications to the ontology, focused on protected plant species. Moreover, we present a new ontology design pattern derived from the process of working with the ontology for genetic resources and the ontology for protected plant species of Bulgaria, with a focus on protected plant species and their description for the IS-PGR-SADOVO project "Intelligent system for management of the Bulgarian plant gene pool stored in the gene bank of IPGR - Sadovo". The ontology for the gene bank, partially overlapping with the ontology for rare species, is integrated, using a new bridge ontology — through the reuse of Internationalized Resource Identifiers (IRIs) and equivalence axioms. The reasoning process over the imported ontologies is presented.

Formal, Mathematical, and Computational Interpretation of the "Tree of Life" Motif in Bulgarian Embroidery via Prolog and SVG

Tanya Srebrev

University of Plovdiv "Paisii Hilendarski", BG

<i>Veneta Tabakova-Komsalova</i>	<i>Centre of Excellence in Informatics and Information and Communication Technologies Sofia, BG</i>
<i>Stanimir Stoyanov</i>	<i>Centre of Excellence in Informatics and Information and Communication Technologies Sofia, BG</i>
<i>Srebrin Srebreva</i>	<i>University of Plovdiv "Paisii Hilendarski", BG</i>
<i>Ivan Stoyanov</i>	<i>Institute of Information and Communication Technologies-BAS, BG</i>
<i>Sebiha Madanska</i>	<i>University of Plovdiv "Paisii Hilendarski", BG</i>

Abstract: The paper proposes a formal and computational model of the traditional “Tree of Life” motif in Bulgarian embroidery. The main claim is that the motif can be understood not merely as an ornamental image but as a structured system of elements, relations and invariants: root, trunk, branches, leaves, axial symmetry, hierarchy, recursion and geometric scaling. The model combines first-order logic, graph theory, inductive algebraic types, categorical semantics and logic programming. A SWI-Prolog implementation is proposed in which domain knowledge is represented declaratively and visualisation is derived through SVG generation or an XPCE scene. The mathematical part shows that the idealised motif can be treated as a symmetric rooted tree, a fixed point of an endofunctor and a self-similar ϕ -scaled object. The results indicate that Prolog is suitable for verifying structural invariants, generating variants and producing traceable digital representations of intangible cultural heritage.

SESSION C33 - INTELLIGENT ASSESSMENT AND ACCREDITATION PLATFORMS	Stream 3
Chair: Todorka Glushkova University of Plovdiv “Paisii Hilendarski”, BG	
Saturday, October 10 th 12:00 – 13:30	Online

A local human-in-the-loop system for AI-assisted assessment

<i>Milen Sotirov</i>	<i>Nikola Vaptsarov Naval Academy, BG</i>
<i>Dilyana Dimitrova</i>	<i>Nikola Vaptsarov Naval Academy, BG</i>

Abstract: Assessment of mixed Moodle quizzes combines two different tasks: exact scoring of closed-ended questions and semantic evaluation of open-ended responses. Local artificial intelligence (AI) can assist with open-answer evaluation, but institutional use also requires exact grade calculations, recovery after interrupted processing, clear rules for handling disagreements, and a final teacher decision. This paper presents LIRA (Local Integrated Response AI Assistant), a local human-in-the-loop system that combines them within one workflow. Closed answers are scored by program rules. Local language models generate score and feedback proposals for open answers. Every AI proposal passes through a separate verifier model. Server-side rules combine the verification result with calculation checks and invoke an arbiter model only when a critical issue remains unresolved. The same logic enforces point limits, totals,

grade conversion, workflow transitions, and grade confirmation. Regression tests, grade-confirmation checks, assessment imports, and simulated arbitration scenarios were used to test the implemented workflow. LIRA provides semantic AI assistance while preserving the final decision for the teacher.

Intelligent Programme Accreditation Platform

Milen Sotirov

Nikola Vaptsarov Naval Academy, BG

Valentina Petrova

Nikola Vaptsarov Naval Academy, BG

Donika Nikolova-Sotirova

Technical University of Varna, BG

Miroslav Tsvetkov

Nikola Vaptsarov Naval Academy, BG

Abstract: Programme accreditation depends on evidence, staff input and documents prepared by different contributors and validated under formal responsibility. The authors propose a new integrated local AI-assisted process model and an accreditation workflow approach, implemented in an accreditation management platform at Nikola Vaptsarov Naval Academy. The process model is paired with a data model that links each record to a requirement of the accreditation commission, a responsible person and a review state, so that only approved content reaches the final submission. A new system architecture combines a role-based interface with application, local AI and data layers. Within it, the authors build a Local AI Monitoring and Workflow Assistance Agent around locally installed language models, which applies twelve fixed rules to detect missing or unresolved information and prepares drafts, classifications and translations as proposals for users. The evaluation showed that the rules detected every introduced defect and that the local model proposed the correct evidence type in 87.5% of cases, which confirms that human confirmation remains necessary. The paper also outlines the expected process improvements and an evaluation plan for a full accreditation cycle, a combination not described in the reviewed studies.

Formal Modeling of an Automated Student Assignment Assessment System Using the Calculus of Context-Aware Ambients

Konstantin Rusev

University of Plovdiv "Paisii Hilendarski", BG

Todorka Glushkova

University of Plovdiv "Paisii Hilendarski", BG

Angel Georgiev

University of Plovdiv "Paisii Hilendarski", BG

Abstract: Automated assessment of student assignments is a growing need in modern education, yet existing platforms such as Google Classroom, Moodle, and Blackboard lack robust mechanisms for evaluating open-ended and code-based submissions. Prior work has proposed conceptual architectures for extending these platforms with automated grading capabilities, but such designs remain informal and do not address concurrency, context-awareness, or inter-component coordination. This paper presents a formal model of an automated student assignment assessment system using the Calculus of Context-aware Ambients

(CCA). The proposed model formalizes the assessment pipeline (from submission intake through syntax validation, sandboxed execution, result comparison, plagiarism detection, and feedback generation) as a hierarchy of context-aware ambients. A multi-agent scenario demonstrates how assessment components coordinate grading decisions when conflicting evaluation criteria arise. The model is implemented using the CCA Editor visual modeling tool and validated through the ccaPL interpreter. The approach bridges the gap between conceptual system design and formal specification, enabling rigorous analysis and simulation-based validation of concurrent assessment workflows.

Layered-Modular Conceptual Model of a Digital University Information Ecosystem

<i>Vassil Milev</i>	<i>St. Cyril and St. Methodius University of Veliko Tarnovo, BG</i>
<i>Miroslav Dechev</i>	<i>Institute of Robotics-BAS, BG</i>
<i>Marian Ileana</i>	<i>POLITEHNICA Bucharest, Pitesti University Center, RO</i>
<i>Pavel Petrov</i>	<i>St. Cyril and St. Methodius University of Veliko Tarnovo, BG</i>
<i>Filipp Safronov</i>	<i>St. Cyril and St. Methodius University of Veliko Tarnovo, BG</i>

Abstract: The paper presents a layered-modular conceptual model of the Digital University Information Ecosystem (DUIE) for structuring and analyzing the digital university information environment. The study is conceptual-analytical and combines a targeted review of university information systems, sectoral reference models, enterprise architecture, interoperability standards, and ecosystem approaches with a sequential conceptual synthesis. The resulting structure comprises six analytical layers and twenty-six functional modules, defined according to their persistent domain scope and dominant institutional role. Criteria for module boundaries and five types of intermodule dependencies are formulated. The layered-modular structure supports comparison of different institutional implementations without requiring uniform product configurations. This makes it possible to distinguish functional responsibilities and dependencies from the specific technological organization of a university environment. The model provides a common coordinate framework for analyzing functional coverage, overlap, authoritativeness, traceability, and institutional comparability without prescribing a specific technological implementation.

SESSION D33 - MATERIALS, SENSORS AND MANUFACTURING TECHNOLOGIES		Stream 4
Chair: Stefan Ivanov		Technical University of Gabrovo, BG
Saturday, October 10 th 12:00 – 13:30		Online
Experimental Validation of a Simulation-Based Methodology for Quality Improvement in Transparent Polymer Components		
Todor Todorov		Technical University of Sofia, BG

Georgi Todorov

Technical University of Sofia, BG

Mario Semkov

R&D&I Consortium, Sofia Tech Park, BG

Abstract: The work presented explores a combined numerical and experimental methodology to improve the accuracy of simulation-based predictions and reduce manufacturing defects in transparent injection-molded polycarbonate safety glasses. A comprehensive thermo-mechanical model, based on conservation of mass, momentum, and energy, and incorporating a Cross–WLF viscosity law, is implemented using CAE virtual simulation analysis. A soft aluminum mold prototype is manufactured to validate the simulations and to replicate industrial processing conditions. Experimental characterization included measurements of fill time, cavity pressure, part warpage, total light transmittance, and haze, all obtained with calibrated metrology equipment. Numerical predictions closely matched experimental data, with fill time predicted at 1.2 s compared to an observed value of 1.3 ± 0.05 s and injection pressure predicted at 120 MPa versus a measured value of 130 ± 2 MPa. Warpage deviation remained within 11%, while optical metrics such as haze and transmittance are predicted with an accuracy of up to 95% within the validated process window. Optimization of the gating system resulted in a 40% reduction in burn mark severity and improved overall optical quality. The optimal solution depended on component geometry, with hot-runner configurations proving advantageous for the viewfinder component, while a cold-runner design provided superior optical quality for the arm component. The work demonstrates a validated, simulation-driven workflow capable of bridging modelling and manufacturing, providing a robust methodology for optical-grade polymer components.

Static Structural Analysis of a 3D-Printed PLA Lattice Structure under Multiple Loading Conditions

Vasil Lozanov

Institute of Information and Communication Technologies-BAS, BG

Nayden Chivarov

Institute of Information and Communication Technologies-BAS, BG

Albena Daskalova

Institute of Electronics -BAS, BG

Abstract: This study shows the results of modelling the mechanical behaviour of a 3D printed lattice structure. The analysis is performed using Autodesk Inventor software. The objective is to determine how the lattice structure would behave under different loads prior to its printing. The studied object consists of a series of parallel struts that are to be printed from PLA plastic. Three simulations were run with loads of approximately 10 N (about 1.02 kg) applied to the structure. The von Mises stress, displacement and principal stresses of the lattice structure were calculated for each simulation. These calculations are useful for determining the points within the structure that are subjected to the greatest stresses and displacements due to the loads applied to it.

Integrated Automated System for Extraction and Assembly of Injection-Molded Protective Eyewear

Todor Todorov

Technical University of Sofia, BG

Yavor Sofronov

Technical University of Sofia, BG

Todor Gavrilov

Technical University of Sofia, BG

Mario Semkov

Technical University of Sofia, BG

Abstract: This paper presents the development, prototyping, and experimental validation of an automated device designed to perform both extraction and assembly of injection-molded protective eyewear within a single integrated manufacturing cycle. Conventional production systems typically require separate extraction and assembly stations, resulting in additional handling operations, increased cycle times, and higher system complexity. The proposed solution combines vacuum gripping, synchronized rotational motion, and linear positioning mechanisms into a compact robotic end-effector capable of extracting molded components and assembling them without intermediate transfer operations. The mechanical structure incorporates aluminum alloys, stainless steel, brass, and polyoxymethylene (POM), selected according to their functional requirements regarding stiffness, wear resistance, dimensional stability, and surface protection. A prototype was designed, manufactured, assembled, and experimentally tested under realistic operating conditions. The results demonstrate reliable operation, accurate positioning of the eyewear components, reduction of production cycle time, and elimination of additional assembly workstations. The developed system represents a practical and scalable approach for automated assembly of plastic products with snap-fit connections and sensitive optical surfaces.

Multilayer TiO₂–SiO₂–ZnO Humidity Sensing Element Prepared via a Sol–Gel Method

Stefan Ivanov

Technical University of Gabrovo, BG

Nedyu Nedev

Technical University of Gabrovo, BG

Stephan Kozhukharov

University of Chemical Technology and Metallurgy-Sofia, BG

Zvezditzia Nenova

Technical University of Gabrovo, BG

Georgi Avdeev

Institute of Physical Chemistry - BAS, BG

Toshko Nenov

Technical University of Gabrovo, BG

Abstract: Humidity sensors are widely used in numerous scientific, industrial, and environmental applications. This paper presents a multilayer humidity sensing element prepared via a sol–gel method. The sensing structure consists of three thin layers. The first two layers are based on TiO₂–SiO₂ doped with Ce and were calcined at temperatures of up to 800 °C and up to 400 °C, respectively. The third layer is ZnO-based and was calcined at up to 400 °C. The impedance characteristics of the fabricated sensing element were experimentally investigated over a relative humidity (RH) range of 15% to 95%.

at 25 °C and an excitation frequency of 20 Hz. Reference values of relative humidity and temperature were generated using a calibrated humidity and temperature calibrator. The sensing element parameters—namely, resistance (R), capacitance (C), impedance (Z), and phase angle (θ)—were measured as functions of RH using a precision impedance analyzer. The experimental results demonstrate that the resistance R exhibits the highest sensitivity to humidity, changing by 2.7 orders of magnitude over the investigated RH range. The characteristics of the humidity sensing element were modeled using an artificial neural network (ANN). To improve the training process, the experimental dataset was augmented through interpolation using the Piecewise Cubic Hermite Interpolating Polynomial (PCHIP) method. The developed ANN serves as a digital model of the sensing element characteristics, where the input is the relative humidity RH and the outputs are the corresponding values of the resistance R and capacitance C. The proposed model reproduces the experimental characteristics with an accuracy of $\pm 1\%$ for resistance and $\pm 0.14\%$ for capacitance.

SESSION A34 - IMAGE ANALYSIS FOR ENVIRONMENTAL MONITORING

Stream 1

Chair: Monika Bedzheva

NMU "Vasil Levski", Shumen, BG

Saturday, October 10th 14:30 – 16:00

Hall 109 TV

A methodology for studying temperature changes in the marine areas of the Republic of Bulgaria using thermal satellite imagery

Monika Bedzheva

NMU "Vasil Levski", Shumen, BG

Daniel Draganov

NMU "Vasil Levski", Shumen, BG

Yordanka Yordanova

BioNTech SE, BG

Abstract: Climate change is a fact and it affects everyone. The planet's waters play an important role in shaping the climate. That is why it is necessary to constantly monitor the state of the planet's waters and take measures to normalize the processes. Bulgaria also has its share, because it is a maritime country. The Black Sea is an important climatic, economic and strategic factor of national and international importance. In view of this the paper proposes and tests a methodology for studying temperature changes in the marine areas of the Republic of Bulgaria using a remote sensing method. The results are analyzed and conclusions are drawn.

A methodology for monitoring of sea beaches using multispectral satellite imagery

Monika Bedzheva

NMU "Vasil Levski", Shumen, BG

Tatyana Moneva

NMU "Vasil Levski", Shumen, BG

Naylyan Salieva

University of Shumen "Konstantin Preslavsky", BG

Stanimira Stoyanova

University of forestry, BG

Andriana Ivanova

Varna Free University "Chernorizets Hrabar", BG

Abstract: Bulgaria is a country that has access to the Black Sea. This provides many opportunities for the economy, livelihoods, and tourism. One of its key advantages is its sandy beaches. For this reason, every year, state authorities monitor the condition of the beaches. Photogrammetric, GNSS and classical geodetic methods are used, in accordance with the current regulatory framework. In view of the importance of sandy beaches as a resource and the increasingly topical issues of environmental protection, this paper proposes and tests a methodology for monitoring sea beaches using a remote sensing method. The results are analyzed and conclusions are drawn.

Comparative Assessment of Classical Machine Learning and Temporal Neural Networks for SAR-Based Forest Disturbance Detection in the Burgas Region

Philipa Aleksandrova

Nikola Vaptsarov Naval Academy - Varna, BG

Chavdar Alexandrov

Nikola Vaptsarov Naval Academy - Varna, BG

Miroslav Tsvetkov

Nikola Vaptsarov Naval Academy - Varna, BG

Abstract: Monitoring Forest disturbance is critical for the evaluation of environmental risk, especially in areas where vegetation dynamics are affected by both natural and man-made forces. This paper describes a comparative study between classical machine learning and temporal neural network methods for Sentinel-1 SAR-based forest disturbance detection in Burgas, Bulgaria. Sentinel-1 VV and VH backscatter composites of monthly form were used to generate SAR anomaly features (VV–VH ratio, backscatter differences, z-score deviations, and SAR anomaly score). CORINE Land Cover data was used to extract forest-related land cover classes, while elevation and slope layers were integrated for terrain information. Classical anomaly-based machine learning based on Isolation Forest with negative-disturbance filtering was compared with temporal neural network models, namely an autoencoder and the CNN-LSTM architecture. The models were evaluated using an independent optical confirmation layer for 2025. The CNN-LSTM model had high internal validation performance with an F1 score of 0.978, and the autoencoder achieved an F1 score of 0.948. In contrast to independent optical confirmation, the temporal neural network showed 614 points with high risk but just 28 points were confirmed, with a 4.56% confirmation rate. The classical machine learning process, on the other hand, detected 539 negative-disturbance points, 488 of which were confirmed, and the precision was 90.54%. Results showed that the classical anomaly-based ML approach performed better on spatial agreement in conjunction with optical validation than the temporal neural network for this SAR-based disturbance detection experiment. The results indicate that simpler machine learning models can be more efficient than complex neural architectures on weak training labels and spatial reliability as the aim.

A system for analysis of digital images of underwater objects

Ventsislav Nikolov

Technical University of Varna, BG

Daniel Hernández-Sosa

University of Las Palmas de Gran Canaria, ES

Abstract: The article presents an approach for images analysis and identification of algae, stones and other underwater objects. The presented solution is based on the analysis of objects presented in a scene of color images by determining edges and by using of convolution matrices, through which a description is formed and a neural network for recognition is trained. The system allows systematization of data which makes possible to build a classification and recognition system based on information technologies.

SESSION B34 - ENTERPRISE AND INDUSTRIAL SYSTEMS:
SECURITY, RELIABILITY AND OPERATIONS

Stream 2

Chair: Plamen Vasilev

University of Chemical Technology and
Metallurgy, BG

Saturday, October 10th 14:30 – 16:30

Online

Extension of Conventional Cybersecurity Risk Assessment for ERP–SCADA Integration

Hristo Hristov

Technical University of Varna, BG

Stela Kostadinova

Technical University of Varna, BG

Abstract: This paper proposes an extension of conventional cybersecurity risk assessment for ERP–SCADA integration. Conventional approaches evaluate assets, threats, vulnerabilities, likelihood, and impact but do not consolidate integration-specific architectural characteristics. The proposed extension introduces five assessment elements, a unified ordinal scale, element-specific scoring criteria, and an Integration Exposure Score. Its application to a representative scenario identified protocol heterogeneity, middleware dependency, and data synchronization criticality as the dominant architectural characteristics. The extension complements the conventional assessment process by incorporating integration-specific architectural information without replacing likelihood, impact, or overall risk estimation.

Design of an ERP–SCADA NIS2 Readiness Framework for Industrial IoT Environments

Hristo Hristov

Technical University of Varna, BG

Abstract: This paper proposes an ERP–SCADA NIS2 Readiness Framework for Industrial Internet of Things environments, considering both the European NIS2 Directive and its Bulgarian transposition through the Cybersecurity Act in 2026. The framework maps regulatory requirements to technical and organizational controls covering governance, access control, segmentation, monitoring, incident response, supply-chain security, resilience, and evidence management. Its

applicability is demonstrated through requirement-to-control mapping, maturity-based readiness assessment, and scenario-based evaluation.

Fault Injection-Based Timing Robustness Analysis of a Siemens S7-1500V Virtual PLC Runtime

Yavuz Şişkolü

Siemens Türkiye, Kartal R&D Center, TR

Görkem İnci

Siemens Türkiye, Kartal R&D Center, TR

Gökşen Örnekci

Siemens Türkiye, Kartal R&D Center, TR

Abstract: Virtual programmable logic controllers (vPLCs) support flexible deployment in software-defined industrial automation, but their timing behavior can be affected by virtualization overhead, host scheduling, communication disturbances, and runtime fault-handling mechanisms. This paper evaluates the impact of software-implemented fault injection (SWIFI) and hardware-implemented fault injection (HWIFI) on cycle-time behavior of a Siemens SIMATIC S7-1500V runtime. Four scenarios were analyzed: Non-existing Data Block Move Error (S1), T_DIAG diagnostic instruction error (S2), pull-plug disturbance (S3), and rack-failure disturbance (S4). S1 remained stable (min 1.414 ms, mean 1.606 ms, max 1.814 ms). S2 produced severe transient delays (min 1.420 ms, mean 23.136 ms, max 1079.607 ms). S3 exhibited a high maximum cycle time, but its mean and maximum remained close to the baseline values. (min 1.256 ms, mean 16.006 ms, max 731.795 ms). S4 had the largest degradation (min 1.257 ms, mean 76.974 ms, max 3405.947 ms). A baseline condition also showed long-tail timing events (min 1.440 ms, mean 16.243 ms, max 721.072 ms). The results indicate that timing degradation is mainly scenario-dependent and linked to runtime handling paths rather than fault origin label alone. This implies that practical vPLC validation should include scenario-based timing robustness testing in addition to nominal functional testing.

A Framework for Integration of Cybersecurity into Project Management Office

Angel Angelov

*Institute of Information and Communication Technologies,
BAS, BG*

Daniela Borissova

*Institute of Information and Communication Technologies,
BAS, BG*

Ivan Blagoev

*Institute of Information and Communication Technologies,
BAS, BG*

Magdalena Garvanova

*University of Library Studies and Information
Technologies, BG*

Ivan Garvanov

*University of Library Studies and Information
Technologies, BG*

Abstract: The rapid digitalization of project management, the growing adoption of cloud-based tools, and the shift towards cross-functional, hybrid teams have substantially increased organizations' exposure to cyberattacks. Nevertheless, cybersecurity continues to be treated as a peripheral technical function rather than an integral component of project governance. This paper proposes a conceptual framework for integrating cybersecurity into the Project Management Office, transforming it into a Cyber Project Management Office. The framework is based on some internationally recognized standards and guidelines and introduces a horizontal security control layer across all phases of the project lifecycle. The framework was validated through application to a real IT project, where it demonstrated improved coordination between business, technical, and regulatory stakeholders and confirmed the need for a dedicated cybersecurity coordination role within the Project Management Office. The analysis shows that the Cyber Project Management Office model offers substantial strategic, financial, and operational benefits, including reduced cyber risk exposure, optimized allocation of expert resources, improved regulatory compliance, and the development of a proactive security culture at the organizational level.

Predictive Failure Detection in Oracle SOA and Oracle EBS Ecosystems Using Artificial Intelligence and AIOps

Nagireddy Vasipally

Creoal + SMX, US

Abstract: Oracle Service-Oriented Architecture (SOA) Suite and Oracle E-Business Suite (EBS) remain the operational backbone of financial institutions and enterprise organisations worldwide, processing millions of daily transactions across payment, procurement, and financial reporting workflows. Traditional operational monitoring for these platforms is reactive — alerts are generated only after service degradation or transaction failure has already impacted business operations. This paper proposes a five-layer Artificial Intelligence for IT Operations (AIOps) framework specifically designed for Oracle SOA and Oracle EBS ecosystems, addressing the absence of Oracle-native predictive failure detection in the existing AIOps literature [5]. The framework integrates Oracle-specific telemetry collection, feature engineering over BPEL execution logs and EBS Concurrent Manager records, Long Short-Term Memory Variational Autoencoder (LSTM-VAE) anomaly detection [4], XGBoost supervised failure prediction, automated root cause analysis across Oracle service dependency graphs, and autonomous remediation workflows. A Design Science Research evaluation [1] validates the framework on a prototype combining Oracle SOA Suite 12c, Oracle EBS Accounts Payable, Accounts Receivable, and General Ledger modules, Oracle Enterprise Manager, ELK stack telemetry aggregation [18], and Kubernetes-based auto-scaling [15]. Results demonstrate advance warning signals 8–12 minutes before observable service degradation, an F1 score

Chair: Georgi Mihalev	Technical University of Gabrovo, BG
Saturday, October 10 th 14:30 – 16:30	Online

Dharmik Champaneri *University of Europe for Applied Sciences, Potsdam DE*
Shan Faiz *University of Europe for Applied Sciences, Potsdam DE*

Abstract: Sensor-instrumented buildings generate continuous electricity, temperature, humidity, and occupancy streams whose deviations can signal equipment faults, operational waste, or metering error. This paper executes an identical Z-score, interquartile-range (IQR), and Isolation Forest consensus pipeline against two structurally different, publicly available datasets: the ASHRAE Great Energy Predictor III (GEP3) electricity data (565 buildings, 4.91 million hourly rows) and the Sharjah 2024 IoT smart-building dataset (power, temperature, humidity, and motion across eight appliances and three rooms), and extends it on ASHRAE with a reconstruction-based LSTM Autoencoder, a SHAP TreeExplainer layer, and an LLM-generated natural-language explanation layer surfaced through a Streamlit dashboard. The central finding is a granularity effect: Isolation Forest’s flagged rate falls from 9.00% dataset-wide to 0.18% at single-building resolution under identical tuning, showing that a detector calibrated at one level of aggregation does not transfer to another without re-tuning. IQR fencing is separately shown to be the most permissive detector on Sharjah’s bursty, high-frequency streams, most visibly on motion (16.91%). In the absence of a manually verified ground truth, this work reports executed anomaly incidence and cross-method agreement rather than classifier accuracy, and proposes a synthetic-injection labelling protocol as the necessary next step before formal precision/recall/AUC-ROC evaluation.

<i>Polina Kesova</i>	<i>University of Chemical Technology and Metallurgy, BG</i>
<i>Tsvetelina Ivanova</i>	<i>University of Chemical Technology and Metallurgy, BG</i>
<i>Yordan Belev</i>	<i>University of Chemical Technology and Metallurgy, BG</i>
<i>Idilia Batchkova</i>	<i>University of Chemical Technology and Metallurgy, BG</i>

Abstract: Industrial energy management systems require continuous monitoring of heterogeneous measurements together with their equipment, process, and production context. This paper proposes a six-layer semantic architecture for energy management. It collects data from smart meters and Industrial Internet of Things (IIoT) devices via Open Platform Communications Unified Architecture (OPC UA). Web Ontology Language (OWL) and Resource Description Framework (RDF) provide the formal representation of the data. The Sensor, Observation, Sample, and Actuator (SOSA) and Semantic Sensor Network (SSN) ontologies describe sensors and observations. IEC 62264 links measurements to production equipment, while ISO 50001 provides the energy management context. A knowledge graph brings this information together to support Semantic Web Rule Language (SWRL) rules and statistical analysis. The semantic model specializes EnergyMeasurement as a `sosa:Observation` and EnergyMeter as a `sosa:Sensor`, relates MeteringPoint to its sensor, and aligns energy and production objects with IEC 62264 equipment structures. A one-week industrial data set comprising 1008 10-minute intervals at a 110 kV delivery point is used to validate the measurement-processing and standards-evaluation stages. The mean negative-sequence voltage-unbalance factor is 0.488%; its maximum is 0.71%; the maximum positive voltage deviation is 9.82%; frequency remains between 49.879 and 50.104 Hz; and voltage Total Harmonic Distortion (THD) is 0.80%. Context-dependent SWRL and SPARQL (SPARQL Protocol and RDF Query Language) patterns are specified for low power factor and physically grounded overcompensation assessment. The industrial results validate the monitoring and statistical components; comparative evaluation of the machine-learning extension on labelled anomaly data remains future work.

Adaptive IoT Controller for Pellet Boilers

Stanimir Yordanov

Technical University of Gabrovo, BG

Georgi Mihalev

Technical University of Gabrovo, BG

Stefan Ivanov

Technical University of Gabrovo, BG

Hristina Stoycheva

Technical University of Gabrovo, BG

Abstract: Biomass heating systems based on wood pellets exhibit complex, nonlinear combustion dynamics that are strongly influenced by variations in fuel properties, such as moisture content and degradation. Traditional control laws operate reactively, generating a control signal only after the flue gases have passed through the sensors. This paper presents a novel intelligent cyber-physical system (CPS) architecture incorporating artificial intelligence for the industrial Plum ecoMAX860P3 KL boiler controller. The proposed architecture introduces Predictive Edge Control and Autonomous Safety. The developed system is based on an ESP32 microcontroller operating at the network edge and monitoring the

properties of the solid fuel in the hopper in real time by means of a gas sensor array (MQ2/MQ7). An artificial intelligence (AI) model estimates thermodynamic deviations and proactively adjusts the combustion process. At the same time, a local deterministic safety filter based on predefined rules is implemented to execute an emergency shutdown algorithm. In this way, the system completely eliminates dependence on cloud latency in critical situations. Experimental results demonstrate an 8.4% increase in thermal efficiency and a 14.2% reduction in fuel consumption. These results confirm that the combination of AI-based analysis and deterministic edge computing constitutes an effective approach even for potentially hazardous residential installations.

Detecting Anomalies in Household Behaviour as an Early Health Signal: A Review and Decision-Support Framework for Unobtrusive Monitoring of Older Adults

Ivo Gergov

Technical University of Sofia, BG

Adelina Aleksieva-Petrova

Technical University of Sofia, BG

Abstract: Unobtrusive monitoring of everyday behaviour at home can detect deviations that act as early signals of deteriorating health, particularly for older adults living alone and those with chronic conditions such as heart failure, diabetes, or prior stroke. This review summarises technical and organisational solutions for detecting household behavioural anomalies as an early warning for older adults and organises them into a decision-support framework. Literature was identified through reproducible queries and organised across six axes: behavioural profiles, sensor modalities, detection methods, condition-specific signals, escalation architecture, and ethics. Sensing (from motion to contactless radar and wearables), detection methods (probabilistic, change-point, deep learning), and condition-specific signals are now mature for realistic systems. The clinical evidence is strong but mixed: in heart-failure telemonitoring, some trials show benefit and others none, and the sign of the result follows the intensity and integration of the clinical response the monitoring triggers, not the sensing modality. The detected signals are assembled into a sensor-to-escalation pipeline with local processing, in which clinical value is carried by the escalation and care layer. The evidence is organised into a rule-based framework for decision support and early warning, explicitly not a medical device or diagnostic. Because benefit depends on the integrated clinical response, the design burden falls on linking detection to care, alongside privacy, false-alarm management, equitable access, and validation against clinical outcomes.

Letter codes of the countries

where ICAI 2026 participants are from:

AL	- Albania	US	- United States
AU	- Australia	UZ	- Uzbekistan
AZ	- Azerbaijan		
BD	- Bangladesh		
BG	- Bulgaria		
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DE	- Germany		
ES	- Spain		
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JO	- Jordan		
ID	- Indonesia		
IN	- India		
KE	- Kenya		
KZ	- Kazakhstan		
LB	- Lebanon		
MK	- North Macedonia		
MY	Malaysia		
RO	- Romania		
RS	- Serbia		
RU	- Russia		
SA	- Saudi Arabia		
SK	- Slovakia		
TM	- Turkmenistan		
TR	- Turkey		
UA	- Ukraine		

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