



ABSTRACTS

PhD Scientific Seminar

Faculty of Electronics and Automation
Technical University of Sofia, Plovdiv Branch

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Preface

The PhD Scientific Seminar of Faculty of Electronics and Automation is held annually since 2021. It has become an expected place for meetings between PhD students, young scientists and leading researchers at Technical University of Sofia, Plovdiv Branch. Over the years, the seminar gives the chance to the PhD students of the faculty to show and share their most interesting and significant results.

This book of abstracts presents the essence of progress which the PhD students of Faculty of Electronics and Automation gained in the period of March 2025 - March 2026. As a result it contains 20 resumes, which have been extended by presentations and demonstrations during the seminar.

We would like to thank all PhD students who have contributed to the seminar. To thank all those attendees who showed to the PhD students that they are important part of the scientific community of Technical University of Sofia, Plovdiv Branch.

Editors

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METHODS AND MEANS FOR MEASURING AND MONITORING AMBIENT AIR QUALITY

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Air quality has become a critical concern in modern society due to its direct impact on human health and environmental sustainability. Pollutants such as particulate matter (PM_{2.5} and PM₁₀), carbon monoxide (CO), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), ozone (O₃) and volatile organic compounds (VOCs) originate from both natural and anthropogenic sources. Rapid urbanization and industrialization have intensified their presence, making continuous monitoring essential. Traditional monitoring systems rely on centralized stations that provide high accuracy, but they suffer from limited spatial coverage and high operational costs.

To address these limitations, modern approaches increasingly rely on distributed and scalable technologies. The emergence of the Internet of Things (IoT) has enabled interconnected sensor devices capable of collecting and transmitting environmental data in real time. These systems consist of numerous low-cost sensing units that communicate within a network, providing detailed insights into air quality across different locations. Wireless Sensor Networks (WSNs) further enhance this approach by enabling decentralized communication between nodes, improving resilience and allowing fine-grained spatial and temporal monitoring.

The integration of IoT and WSN technologies is a key enabler for smart homes and smart cities. In smart home environments, air quality monitoring systems can automate responses such as ventilation, air purification and energy optimization, improving indoor conditions.

At a broader level, smart cities use distributed sensor networks to monitor environmental factors, optimize infrastructure and support data-driven decision-making. This information can be applied to traffic management, industrial regulation and public health alerts, contributing to more sustainable urban development.

Despite these advantages, significant challenges remain. Legal concerns include data privacy, ownership and regulatory compliance, especially in residential environments, where sensitive data may be collected. Cybersecurity is another critical issue, as IoT devices are often vulnerable to unauthorized access, data manipulation and network disruptions. Therefore, robust security mechanisms, such as encryption, authentication and intrusion detection, must be implemented alongside efficient system design. Ultimately, the success of modern air quality monitoring systems depends on balancing technological innovation with reliability, security and legal considerations.

Ralitsa Petrova is a 1st year PhD student at the Technical University Sofia, branch of Plovdiv, Department of Control Systems. She has a MSc degree in Automation, Information and Control Engineering and a BSc degree in Mechatronics, from the Plovdiv branch of Technical University of Sofia. Her PhD research interests and activities are in the field of Artificial Intelligence Systems in the field of medicine.

APPLICATIONS OF INTELLIGENT CONTROL SYSTEMS AND MODELING BIOMEDICAL
PROCESSES.

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In recent years, artificial intelligence algorithms have proven to be an exceptionally promising approach for information processing, quantitative result generation, and decision-making. These technologies combine the core concepts of computational intelligence: acquiring knowledge through examples, extracting utility from big data, and developing "smart" agents. A critical area for such applications is the modeling and control of biomedical processes, specifically in tasks requiring real-time automatic management of dynamic systems. One crucial application is the monitoring of Mechanical Power (MP) in pressure-controlled ventilation, which is essential for preventing lung injury but difficult to calculate at the bedside.

The identification of key respiratory parameters and their correlations is a fundamental step in developing efficient AI models. Analysis using Principal Component Analysis (PCA) and Shapley Additive Explanations (SHAP) on high-fidelity clinical data from the VitalDB dataset indicates that specific variables, such as peak inspiratory pressure and respiratory rate, are primary drivers of Mechanical Power. These findings facilitate the creation of optimized databases to support advanced simulations and adaptive control technologies.

The implementation of advanced deep learning architectures facilitates the modeling of

complex relationships between standard ventilator settings and clinical outcomes. A hybrid 1D Convolutional Neural Network (CNN) integrated with Bidirectional Long Short-Term Memory (BiLSTM) layers is designed to process sequential respiratory signals. Such systems enable the integration of AI tools into management information systems to automate workflows and enhance the functional capabilities of medical equipment.

Participation in 8th Critical Care Datathon for Intensive Care Innovations with the topic “Protective ventilation to prevent secondary brain injury – PReVENT2BI study”.

One paper “Pre-processing and Data Analysis of Mechanical Ventilation Parameters used in Mechanical Power” has been published addressing the study objectives, and another one “Deep Learning Estimation of Mechanical Power in Pressure-Controlled Ventilation Using a 1D CNN–Bidirectional LSTM Model” is submitted for conference.

Mihail Dobrolitsky is a 1st year PhD student at the Technical University of Sofia, Plovdiv branch, Department of Electronics, Faculty of Electronics and Automation (FEA). He holds an MSc in Electronics from the Technical University of Sofia, Plovdiv branch. The subject of his PhD thesis is:

MODEL BASED DESIGN OF DC-DC CONVERTERS FOR USE IN ELECTRIC
VEHICLES

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Reducing emissions from transport is key to limiting climate change and improving air quality. Electric vehicles (EVs) contribute to this by reducing emissions of CO₂, NO_x, and fine particulate matter. In their power systems, DC/DC converters are a key functional element, and their design requires analysis of several factors, including converted power, component complexity, switching frequency, electromagnetic interference (EMI), losses, efficiency, reliability, and cost.

The subject of this work is the auxiliary power conversion systems (Auxiliary Power Modules – APM) in the EV on-board network. The conversion of high-voltage from the traction battery to low-voltage for the on-board network poses serious challenges for power electronics, including the need for galvanic isolation, high power density, and safe operation. Traditional design approaches often lead to long development cycles and difficult optimization. The application of model-based design (MBD) reduces the time needed for development and implementation and increases the reliability of power converters.

The following main tasks are envisaged in the dissertation work:

1. Comparative analysis of DC/DC converter circuits in terms of their efficiency in different output power ranges.
2. Evaluation of different types of power switches (Si, SiC, and GaN) in DC/DC converters for electric vehicles by indicators: permissible power dissipation and switching frequency limit.
3. Creation of mathematical and simulation models and development of procedures for MBD of the studied converter devices.
4. Experimental verification of individual converters and/or a system of converters in order to verify the theoretical studies and models.

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METHODS AND TOOLS FOR PROCESSING VIDEO STREAMS IN SMART CITY TRAFFIC
MANAGEMENT.

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In the modern world, especially in large cities, problems are observed in traffic management. A significant part of traffic jams in urban areas is caused by drivers circling around the streets in search of a free parking space. If drivers have the opportunity to check the available parking spaces in real time, this would reduce the number of cars looking for parking, and hence the traffic in the area.

Smart parking management systems have already been created in several smart cities. Existing parking systems can generally be classified into two groups: non-visual-based and visual-based systems (with cameras). This work focuses on camera-based approaches. Therefore, it is necessary to study the methods and tools used for video stream processing that are applied in traffic management and parking in smart cities, to analyze their limitations and advantages, and to propose possible optimizations in terms of architectures and algorithms for reducing road traffic.

The aim is to develop an optimal configuration of methods and tools for video stream processing and to apply them in an order to achieve significantly better results in terms of performance, reliability and scalability of the system, while ensuring the correctness and consistency of the resulting data.

In this way, improvements can be proposed in parking organization, reducing the time spent searching for free parking spaces, optimizing traffic during peak hours, and suggesting alternative routes during roadworks or special events.

For this purpose, it is necessary to examine and analyze architectures and platforms for video-based surveillance, study image formats and exchange protocols, and analyze the algorithms, computational methods and tools used for video stream processing. The theoretical knowledge obtained as a result of the study will then be applied by selecting an appropriate architectural model and implementing the relevant algorithms.

Ivelin Karageorgiev is a 1st year PhD student at the Technical University Sofia branch Plovdiv, Department of Control Systems. He has a MSc degree in Automation and a BSc degree in Industrial Engineering from the Plovdiv branch of Technical University of Sofia. His PhD research interests and activities are in Software Engineering, Data Science, Artificial Intelligence, Digital Twins, and Open Source.

APPLIANCE OF MACHINE LEARNING ALGORITHMS FOR OPTIMIZING MECHANICAL
VENTILATION

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Commonly referred to as the most utilized life support intervention for critically ill patients, invasive mechanical ventilation is bestowed with new opportunities for multi-factor analysis to become a coherent mediator for modeling of patient physiology as the emergence of digital twin and phenotype technologies grant richer insights retrospective and prospective clinical research. Such so, modeling rich interconnected bio-signals allows for discrete personalization and forecasting of patient care. Classification, prediction and insight discoveries are the objective of the thesis, where focus is concentrated on discovery of suboptimal respiratory control that propagates adverse phenomena alike VILI (ventilator induced lung injury) and PAV (Patient Ventilator Asynchrony). Secondary objectives are to introduce PCCP (Predetermined Change Control Plan) to accommodate clinical trials of approximator-based solutions as a device study trail for machine learning models in order to be utilized into bedside usage.

Research sources vary from extracting bio-signals from ICUs (intensive care units) via various anesthesiologic devices and open-sourced medical research platforms. So far, within the first year of program two machine and deep learning pipelines have been developed to assess the detection of sub-optimal control settings to the everchanging patient-metabolic requirements. Participation into Europe's leading data-driven research competition ESCIM Datathon resulted in achieving the highest performing models in the competition, with research topic "discovery of secondary brain injury" from analysis of respiratory control and anesthesiologic volume control. Furthermore, two papers have been published addressing solutions for the aforementioned objectives.

Diana Sinapova is 1st year PhD student at the Technical University Sofia branch Plovdiv, Department of Control Systems. She has an MSc degree in Automation, Information and Control Engineering and a BSc degree in Mechatronics Engineering. Her PhD research interests and activities are in collaborative and autonomous robotics, computer vision, mathematical analysis and digital twins.

MULTI SENSOR DATA FUSION IN RESCUE ROBOTICS

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The project considers the implementation of algorithms for learning and adaptation applied to intelligent behaviors of autonomous rescue robots. The main goal is by using technologies related to artificial intelligence, cyber-physical systems, sensors, digital models and simulations, big data - to achieve higher functionalities of robots and their effective operation in a shared and/or dangerous environment.

Disaster management encompasses immediate response to disastrous events as well as preparation for future incidents and real-time risk assessment and decision-making. A variety of robotic systems have proven useful in such dynamic real-life disaster situations due to their ability to work in challenging conditions but not without their problems. A field-deployable technology for rescue work requires key characteristics: robustness, versatility, mobility, speed, adaptability, navigation and ability for victim identification. The rise of technology sets new horizons and challenges to robotics and leads to its development with a focus on the need for a multi-sensor approach for mobile robotic systems. High-volume sensory input together with today's highly efficient artificial intelligence enhances perception and speeds up decision-making, crucial in real-time disaster management. This work aims to design state-of-the-art algorithms for multi sensor data fusion and processing for real-time dynamic mapping, navigation and traversal paths of emergency terrain, intelligent victim identification, and prompt emergency human-operator remote control for highly sensitive rescue operations.

The implementation of this goal will address several important issues concerning the wider enrollment of robots in a human-shared environment: (i) 3D scene understanding through interactive and continual learning with the use of computer vision, sensor fusion and deep learning models. (ii) Study of learning and adaptation algorithms and their capabilities for controlling robots.

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ADVANCED ALGORITHMS FOR AUTOMATIC TRAINING AND PROGRAMMING OF
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The programming, calibration, and deployment of industrial robots continue to be highly complex, time-consuming, and heavily dependent on skilled human operators. This represents a significant limitation in modern manufacturing, restricting the flexibility, efficiency, and broader adoption of robotic systems, particularly in small and medium-sized enterprises.

This PhD research aims to address these challenges by developing novel algorithms and methodologies that enable fast, intuitive, and fully automatic programming of industrial robots across different types and manufacturers. The core objective is to create intelligent systems that significantly reduce or eliminate the need for conventional manual teaching and offline programming, while maintaining high precision and reliability.

The research focuses on the integration of multi-sensor data, 3D perception, and advanced computational methods to achieve autonomous recognition of workpieces, automatic trajectory generation, and adaptive motion planning. Particular attention is given to complex industrial processes such as welding, where trajectory planning must satisfy strict technological constraints.

Through this work, the research seeks to contribute to the advancement of more flexible and user-centric robotic systems within the context of Industry 4.0 and Industry 5.0. The expected

scientific contributions include new algorithmic approaches for sensor-based robot programming and improved methodologies for bridging the gap between digital product models and real-world robotic execution. The ultimate goal is to make industrial robots more accessible, reconfigurable, and efficient, thereby supporting the transition towards smarter and more adaptive manufacturing environments.

Yordan Hristov is 1st year PhD student at the Technical University Sofia branch Plovdiv, Faculty of Electronics and Automation (FEA). He has two MSc degrees in Telecommunications and in Electrical Energy from Renewable Energy Resources from of Technical University of Sofia and Technical University of Sofia – branch Sliven. His PhD research interests and activities are in

DIGITAL TWIN OF A MANUAL ASSEMBLY WORKSTATION WITH AN INTEGRATED HUMAN
OPERATOR MODEL FOR PREDICTIVE CONTROL OF PERFORMANCE AND QUALITY

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In high-precision manufacturing still the manual workstations operated by human are predominantly used. The operator's performance and quality output variability is not monitored online during the process. These variations are detected post-process.

The goal of this dissertation is to develop a Human Digital Twin that replicates the manual workstation with continuously updated time-varying parameters. In this dynamic system the operator is modeled as dynamic system, where parameters could detect drift of the fatigue and focus by collecting physiological and kinematic signals. Acquisition will be made using non-intrusive biosensors: eye-tracker, accelerometer, electrodermal activity sensor, heart rate variability monitor.

A predictive quality module forecast assembly quality output for the next operations. An adaptive controller responds to the predicted operator state by adjusting workstation parameters — illumination, augmented reality guidance, process pace, and rest scheduling.

Such system architecture complies with all three pillars of Industry 5.0: human-centricity, sustainability, and resilience. Human-centricity is implemented by embedding operator well-being metrics directly as constraints in the adaptive controller's optimization problem —

ensuring that the system serves the operator's physical and cognitive needs as a primary control objective, not as a secondary consideration. Sustainability is addressed through continuous monitoring of biomechanical load and cognitive fatigue accumulation, while resilience is achieved through the remaining useful performance index monitoring.

Ana Dimitrova is a second-year PhD student at the Technical University of Sofia, Department of Electrical Engineering. She holds a Bachelor's and Master's degree in Mechanical Engineering and Technologies, as well as a Master's degree in Electrical Engineering from the Plovdiv branch of the Technical University of Sofia. Her research interests and activities within the framework of her PhD studies are focused on Electrical Engineering materials and the impact of technological processes on their electrical properties.

RESEARCH ON MODIFIED ALUMINUM FOR ELECTRICAL ENGINEERING APPLICATIONS

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Electrical engineering materials constitute the foundation of modern electrical systems and are essential for the manufacturing of components used in the energy sector. They play a key role in the transmission and distribution of electrical energy, thereby ensuring the operation of modern society.

Among the most widely used metallic conductors are aluminum (Al) and copper (Cu), along with their alloys containing zinc (Zn), manganese (Mn), silicon (Si), and other elements. These materials exhibit excellent electrical and mechanical properties, making them indispensable for a wide range of applications, particularly where weight reduction and mechanical performance are critical.

Aluminum (Al) is one of the most extensively used materials in electrical engineering due to its high electrical conductivity, low density, and relatively low cost compared to copper (Cu). However, pure aluminum exhibits certain limitations that restrict its application in high-reliability systems. To address these limitations, various modification approaches are applied, including alloying, the addition of modifiers, and thermal treatment processes such as quenching and aging. These treatments improve the mechanical properties of aluminum alloys with minimal reduction in electrical conductivity, which is of critical importance.

The application of methods for enhancing the mechanical properties of aluminum and its alloys, combined with the incorporation of neutral refractory particles at the nano- and

microscale following plastic deformation, significantly affects the material's structure and properties. Phase analysis confirms that the particles are incorporated into the melt. The results indicate increased hardness and a slight improvement in strength. The ongoing effort to improve the mechanical properties of electrical engineering materials without compromising electrical conductivity remains a major focus of global research.

The structural evolution of electrical-grade aluminum (Al 99.9%) modified with carbon-based nanomaterials—nanodiamonds (ND) and carbon nanoparticles (CNP)—is investigated through microstructural analysis. X-ray diffraction (XRD) is employed to determine phase composition, crystallite size, and internal stresses. The results reveal grain refinement, increased dislocation density compared to unmodified aluminum, and the presence of carbon-containing nanophases.

An increase in crystallite size (D) observed in Al+ND and Al+CNP samples, compared to unmodified Al, together with lower estimated dislocation density (ρ), indicates a restructuring toward a more ordered crystallite substructure. Possible mechanisms include: (i) recovery and/or recrystallization processes facilitated by carbon particles acting as nucleation sites, and (ii) stabilizing interfacial effects at matrix–particle boundaries that hinder dislocation motion and promote the growth of larger subgrains.

The mechanical properties of electrical-grade aluminum (Al 99.9%) modified with carbon nanomaterials are further evaluated to assess the effect of the modification process on strength and ductility. Trends in mechanical behavior are identified. Tensile strength, yield strength, elongation, and Brinell hardness are determined for both unmodified and modified samples. The influence of the modified microstructure on the material performance is also discussed.

The novelty of this study lies in the comparative analysis of two carbon-based modifiers at low concentrations, relevant for maintaining high electrical conductivity, as well as in the implementation of a reproducible, metric-oriented methodology for image analysis.

The presented results open new perspectives for the further optimization of aluminum-based materials through nanomodification while preserving their functional electrical properties.

I am attaching my latest work related to my dissertation:

1. A. Dimitrova, I. Draganova-Zlateva, S. Stefanov. Influence of Technological Processes on the Electrical Properties of Electrical Engineering Materials, 16th Electrical Engineering Faculty Conference BuIEF 2024, Varna, Bulgaria, IEEE, 2024. ISBN 979-8-3503-9167-1, ISSN: 2831-5782, DOI: 10.1109/BuIEF63204.2024.10794901

2. Ana Dimitrova, Investigation of the Mechanical Properties of Electrical-Grade Aluminum (Al 99.9%) Modified with Carbon Nanomaterials, September 2025, DOI: 10.1109/BulEF66320.2025.11298952, Conference: 2025 17th Electrical Engineering Faculty Conference - Energetics and Efficiency (BulEF)

3. Ana Dimitrova, Karel Trojan, Iva Draganova-Zlateva - Structural Modifications in Electrical-Grade Aluminum (Al 99.9%) Modified with Carbon Nanomaterials - Nanodiamonds and Carbon Nanoparticles, September 2025, DOI: 10.1109/BulEF66320.2025.11298939, Conference: 2025 17th Electrical Engineering Faculty Conference - Energetics and Efficiency (BulEF)

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ENHANCING ACCURACY AND RELIABILITY IN INDUSTRIAL FIRE AND GAS DETECTION SYSTEMS:
HARDWARE AND SOFTWARE SOLUTIONS TO MINIMIZE THE ADVERSE EFFECTS OF ENVIRONMENTAL
FACTORS AND SENSOR DEGRADATION

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Over the past 30 years, rapid industrial advancements have led to increased process efficiency and reliability, but this has come at the price of greater complexity and a heightened need for cohesive safety programs. Fire and gas detection systems have undergone significant evolution as a result. From more accurate measurements and wider integration options, to self-testing and cloud-based analytics, advancements have emerged in practically every aspect of these technologies.

Across these categories, the sensor layer is among the most significant in terms of in-field performance. Within this category research focusing on novel materials and miniaturization dominates the literature and less so on optimization possibilities for established low-cost sensor technologies. More specifically, the development of hardware and software solutions which minimize the adverse impacts of environmental factors (temperature, humidity, the presence of contaminants) and allow for dynamic drift compensation, predictive maintenance and anomaly detection, could bridge the gap between existing sensor options and the emerging needs for intelligent, adaptive control systems. Such solutions would allow practitioners to circumvent some of the limitations related to the use of low-cost sensors and perhaps offer some transferable principles to be applied in dealing with robustness challenges related to the use of micro-electro-mechanical (MEMS) sensors.

Based on the research conducted so far, the following paper has been published;

- [1] K. Hristov, B. Ganev, and T. Grigorova, “Industrial fire detection and classification via ML-enhanced semiconductor sensor matrices,” in *2025 IEEE Int. Conf. Emerging Technologies — Industrial, Communication, and Sensing Applications (ET66806)*, Sep. 2025, pp. 1–5, doi: 10.1109/ET66806.2025.11204167.

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IMPACT OF SMOTE OVERSAMPLING ON MACHINE LEARNING CLASSIFIERS FOR
PREECLAMPSIA PREDICTION UNDER SEVERE CLASS IMBALANCE: EVIDENCE FROM A
BULGARIAN SCREENING COHORT

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The presented work summarizes the evaluation of machine learning (ML) classifiers for predicting preeclampsia (PE) and pregnancy-induced hypertension (PIH) using first-trimester screening data from 1,383 pregnant women in Plovdiv, Bulgaria (2018-2020). Three classifiers - Logistic Regression (LR), Extra Trees Classifier (ETC), and Voting Classifier (VC) - are compared across multiple prediction targets and feature configurations. The impact of Synthetic Minority Oversampling Technique (SMOTE) oversampling strategies on model performance in the context of a severe class imbalance (2.46% PE prevalence) is assessed. Logistic Regression achieves the highest AUC of 0.853 for preterm PE prediction without oversampling, while the introduction of SMOTE significantly improves tree-based models (ETC: +0.058 AUC). A non-screened control cohort of 533 patients was evaluated separately using maternal characteristics alone (AUC 0.751). The ML model showed promising discrimination for preterm PE in this local cohort and warrants direct comparison with Fetal Medicine Foundation (FMF) risk stratification in future studies. These results support further validation of ML-based tools as potential components of future clinical decision support systems to extend systematic PE screening in resource-constrained settings.

Planned next steps include external validation in additional Bulgarian obstetric centers, integration of data from continuously wearable sensors (blood pressure, ECG, fasting blood sugar) into a prototype for real-time clinical decision support, and determination of personalized threshold values, including cost-effectiveness analysis against the FMF algorithm – in line with the main goal of the dissertation to develop methods and tools for implementing intelligent mobile systems in personal healthcare.

Hristo Radev is a 2nd-year PhD student at the Technical University of Sofia, branch Plovdiv, Department of Electronics. He has a MSc degree in Medical Radiation Physics and Technology from University of Plovdiv and BSc degree in Electronics from Plovdiv Branch of Technical University of Sofia. His PhD research interests and activities are in the development of methods and techniques for early detection of life-threatening sudden illnesses in motor vehicle drivers.

RESEARCH ON METHODS AND TECHNIQUES FOR EARLY DETECTION OF LIFE-
THREATENING SUDDEN ILLNESSES IN MOTOR VEHICLES DRIVERS

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Road accidents are a global issue. The increasing number of vehicles in our everyday life is raising the probability for a fatal car crash. Meanwhile the population of the developed countries is getting older. As a result, the drivers are vulnerable to sudden medical emergency events. When the two factors are combined, we can expect a growing number of road accidents in the future due to drivers' heart attacks, strokes, or loss of consciousness. These events can strike without warning putting in danger other drivers, passengers, pedestrians, and other road users. Finding a solution to this problem could significantly reduce potential tragedies and prevent serious consequences. Since our modern cars are equipped with advanced electronic systems, they can offer technological solution to the problem by real-time monitoring of the driver's health status by early detection methods.

The interest of research community and automotive industry in development of methods and techniques for physiological monitoring was described in a PhD literature review. This work includes a study of existing methods like Electrocardiogram, Photoplethysmogram, Electroencephalogram, Electrodermal Activity etc. applied in motor vehicles to improve safety and driver monitoring.

The first steps taken towards mitigation of accidents impact and vehicle collisions are real-time data collection of driver vital physiological signs in real driving scenarios on different road types. The results from that research show the optimal locations of sensing electrodes and sensors on driver's body for obtaining high quality signals. This work was presented at the XXXIII International Scientific Conference "Electronics ET2024" and was published in a paper:

"Driver physiological parameters monitoring–initial study in real-road driving", Radev Hr., Petrova G., Spasov Gr., DOI: 10.1109/ET63133.2024.10721508

A subsequent study provided a detailed review of various sensor modalities and their placement within the vehicle interior, specifically focusing on how they track physiological parameters. That work also explored how these sensors could be integrated into future Driver Monitoring Systems (DMS) to enable real-time health and state monitoring:

"Sensors and Sensing Methods for Early Detection of Life-Threatening Sudden Illnesses in Motor Vehicle Drivers", Radev Hr., Petrova G., DOI: 10.3390/engproc2025100030

Building on previous work a systematically structured and detailed classification to understand the relationships between physiological parameters and the different methods and sensors for their measurement was proposed:

"A Taxonomy of Methods, Techniques and Sensors for Acquisition of Physiological Signals in Driver Monitoring Systems", Petrova G., Radev Hr., Shopov M., Kakanakov N., DOI: 10.3390/app15137609

Future research will concentrate on applying digital signal processing techniques to the collected data to identify early signs of medical emergency events in drivers. Our final goal is monitoring the health state of the driver to recognize the first predictors of adverse and severe health conditions which can cause road accidents and fatal crashes.

PhD Scientific Seminar April 2026

Mincho Stanislavov Velkov is a part-time PhD student at the Technical University of Sofia, Faculty of Electrical Engineering, Department of Electrical Supply, Electrical Equipment and Electric Transport. In parallel with his doctoral training, he teaches at the Technical University of Sofia, Plovdiv Branch, where he conducts laboratory classes and practical instruction in disciplines closely related to his scientific field.

Optimal Operation of Distributed Generation Capacities Using Renewable Energy Sources

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The doctoral work of Mincho Velkov is focused on the study, analysis, and optimization of distributed generation capacities based on renewable energy sources, with a primary emphasis on photovoltaic systems, hybrid energy systems, and their interaction with the electricity grid. The dissertation topic addresses the optimal operation of distributed generating units using renewable energy sources in the context of technical, economic, and operational efficiency.

His research interests include modeling and simulation of photovoltaic power plants using specialized software, comparison between simulated and real operating data, investigation of hybrid systems with battery energy storage, analysis of environmental and climatic factors affecting electricity generation, and assessment of reliability, safety, and efficiency in renewable energy installations.

The research activity is carried out under the academic supervision of Prof. DSc. Eng. Valchan Gueorgiev and Assoc. Prof. PhD Eng. Stanimir Stefanov. Within the individual study plan, the PhD student has worked on theoretical topics related to the conversion and storage of electrical energy from renewable sources, optimization of electricity production from renewable energy systems, and the joint operation of different renewable sources within hybrid power plants.

The teaching activity of Mincho Velkov at the Technical University of Sofia, Plovdiv Branch, is directly related to his scientific specialization. He conducts laboratory classes and practical exercises in Renewable Energy Sources and Ecology, Safety Engineering, Power Supply and Electrical Equipment, and Electrical Engineering and Electronics. This teaching work contributes to the transfer of contemporary engineering knowledge and to the practical training of students in the field of electrical engineering and renewable energy.

The results of his research work are presented in five publications related to the PhD topic, published in peer-reviewed conference proceedings. These publications cover comparative analyses between simulation and real data from photovoltaic plants, photovoltaic street lighting

systems with hybrid inverter and battery storage, the influence of elevated temperature and potential-induced degradation in photovoltaic installations, the assessment of electricity production under different PV array configurations, and the impact of snow cover on photovoltaic systems.

In addition to his research and teaching activities, Mincho Velkov participates in educational and public initiatives aimed at promoting engineering education and renewable energy technologies. His participation in academic seminars, laboratory demonstrations, and public outreach activities reflects a strong commitment to the dissemination of scientific knowledge and the practical application of sustainable energy solutions.

Publications related to the PhD research

1. Velkov, M.; Stefanov, S. Comparative Analysis Between Simulation Using Specialized Software for Photovoltaic Power Plant Design and Real-World Data from a Solar Power Plant. *Engineering Proceedings* 2025, 100, 64. DOI: 10.3390/engproc2025100064.
2. Velkov, M. Grid-Connected Photovoltaic Street Lighting System with Hybrid Inverter and Battery Storage. In: 2025 Tenth Conference on Lighting (Lighting), Sozopol, Bulgaria, 2025, pp. 1–5. DOI: 10.1109/Lighting64836.2025.11081754.
3. Velkov, M.; Stefanov, S.; Gueorgiev, V. Influence of Elevated Temperature on Equipment Installed in Combiner Boxes and Potential-Induced Degradation on the Modules of a Photovoltaic Power Plant. In: 2025 17th Electrical Engineering Faculty Conference – Energetics and Efficiency (BulEF), Varna, Bulgaria, 2025, pp. 1–8. DOI: 10.1109/BulEF66320.2025.11298994.
4. Velkov, M.; Stefanov, S.; Gueorgiev, V. Assessment of Electricity Production in Photovoltaic Power Plants with Optimal Tilt and Orientation, Sun-Tracking, and East-West Orientation. In: 2024 16th Electrical Engineering Faculty Conference (BulEF), 2024. DOI: 10.1109/BulEF63204.2024.10794939.
5. Velkov, M.; Dimitrova, A.; Stefanov, S. Assessment of the Impact of Snow Cover on Photovoltaic System. In: 2024 Ninth Junior Conference on Lighting (Lighting), 2024. DOI: 10.1109/Lighting62260.2024.10590678.

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METHODS AND MEANS FOR REMOTE MEASURING AIR PARAMETERS

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Environmental monitoring is currently built on a foundation that largely assumes the existence of high-precision, static infrastructure. Traditional air quality monitoring stations are engineered as "perfect" instruments — fabricated with laboratory-grade components, calibrated under controlled conditions, and maintained at high costs. However, this centralized foundation will not support the granular, real-time, and spatially dense data sets required for the future of urban health and smart city maintenance. Completely new approaches that prioritize distributed sensing and remote scalability are required. These approaches must involve new communication paradigms, that suits for the need for long range and low power operation of air monitoring systems.

Among these new, large complex systems are Networked Environmental Sensor Nodes, composed of hundreds or thousands of low-cost end devices. Each device communicates using the LoRaWAN protocol to transmit data from its physical environment over long distances with minimal energy consumption. In these networks, tasks for the ensemble are dynamically managed, requiring reliable and predictable system performance even though the individual low-cost sensors may be individually unreliable or prone to environmental drift.

There are enormous possibilities for the application of such systems in both public health and industrial safety, including hyper-local pollution heatmapping, early warning systems for

hazardous leaks, and the longitudinal study of urban micro-climates. These systems are now feasible because of new low-cost technology for sensors and new connectivity means

The coordination, control, and data integrity of such distributed systems is currently a significant barrier to their effective use. Specifically, the challenge lies in ensuring **system-wide reliability** when utilizing "imperfect" low-cost hardware. Clearly, these systems must be engineered to deliver predictable performance and programmed to mitigate individual node failures or communication bottlenecks.

This thesis proposes that such system-wide efficiency and resilience can be accomplished using a Hybrid IoT Architecture. The proposed model integrates local intelligence at the end device level with centralized analytics, utilizing ns-3 simulations to validate the relationship between individual sensor nodes and the overall network structure. By moving away from the "perfect station" paradigm and toward a robust, hybrid-managed network, it can be achieved the high-resolution air quality monitoring the modern world demands.

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ARTIFICIAL INTELLIGENCE SYSTEMS

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In modern collaborative robotics, the primary challenge is achieving “cognitive intelligence,” defined as the ability of robots to perceive and process information in a manner analogous to human reasoning. Effective human–robot collaboration requires a “common language” capable of describing system states and responses within uncertain and dynamic environments.

Unlike traditional crisp (binary) logic, fuzzy logic, introduced by Lotfi Zadeh, enables the handling of uncertainty and ambiguity. In the context of robotic control, this is of critical importance, as it allows robotic systems to “reason” and make decisions under imprecise conditions, ensures smooth transitions between different operating modes (e.g., from maximum speed to safe speed reduction), and models human cognitive processes in multi-criteria decision-making.

An algorithm for controlling the robot’s motion speed and applied contact force has been developed. The system processes two main types of input data: workspace information (the robot’s position in 3D space) and sensory data from safety barriers (laser barriers and magnetic interlocks). The output variables are the robot’s motion speed and contact force. Fuzzy logic is employed to define the rule base, while a zero-order Takagi–Sugeno model is applied to ensure real-time control due to its high computational efficiency. Through the mathematical definition of membership functions, the algorithm computes the weighting coefficients of each rule to determine the robot’s safe behavior. Simulation studies have been conducted using a

collaborative robot (Mitsubishi RV-5AS-D), demonstrating the effectiveness of the proposed algorithm. The model ensures the required level of predictability and reliability, enabling a dynamic robot response to human presence.

Safety is an essential aspect of collaborative robotics. The application of fuzzy logic for multi-criteria evaluation ensures a higher level of safe operation in shared workspaces through adaptive control, which responds more flexibly to human presence compared to conventional safety systems. The transition from crisp rule-based logic to fuzzy models enables collaborative robots to operate effectively in dynamic and uncertain environments, achieving a balance between productivity and operator safety.

Future work will focus on the experimental validation and real-world implementation of the proposed approach in an industrial environment, aiming to demonstrate its practical applicability, robustness, and effectiveness under realistic operating conditions.

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AN ANALYTICAL AND EXPERIMENTAL INVESTIGATION OF LOSSES IN A
THREE-PHASE SWITCHED RELUCTANCE MOTOR

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The switched reluctance motor (SRM) has garnered significant interest for various industrial applications, including wind power systems and electric vehicles. This is largely due to its simple and robust design, high torque capacity, wide speed range, and outstanding energy efficiency.

To study energy exchange processes within the system, which includes a power source—the asymmetrical bridge converter and the switched reluctance motor—accurate data on the machine's energy characteristics are required. An important part of these characteristics is determined based on the machine's losses.

Using simulation products, the various types of losses at the SRM can be precisely determined. To achieve this, the exact dimensions must be entered, along with the materials used for each machine component. Understandably, manufacturers do not provide such information, necessitating the experimental determination of losses during machine operation.

Another preferred method is the analytical derivation of the main types of losses generated during operation across a wide range of speeds. The advantage of this method is that it does not require any specialized, precision equipment.

To assess the accuracy of the described methods, the results are verified experimentally.

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APPLICATION OF AI IN MANAGEMENT INFORMATION SYSTEMS AND BUSINESS ANALYTICS

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Management information systems (MIS) are information systems used for decision-making, and coordination, control, analysis, and visualization of information regarding the processes, people and technology employed within an organizational setting. The field of MIS increasingly often relies on the implementation and integration of AI tools (Machine Learning algorithms for data analytics, Large Language Models for agentic AI digital assistants) to transform aggregated organizational and business data into insights for improving business decisions as well as for development of process automation solutions. Initially, research efforts were focused on preparing a comprehensive literature review on the topic of application of AI in MIS with the aim of identifying types of AI models, tools and instruments utilized in and developed for MIS, types of platforms for AI deployment, as well as types of business tasks, processes and workflows that most benefit from the introduction of AI in terms of value generated. The study recognized gaps in previous research efforts in the field as opportunities, identified challenges in the research field and offered future research directions that can bridge these gaps:

- Artificial Intelligence for Management Information Systems: Opportunities, Challenges, and Future Directions, Stoykova, S., Shakev, N., Algorithms 2023, 16, 357, **DOI:** 10.3390/a16080357

Three main categories of tasks, inherent to MIS, which can benefit from the introduction of AI-based methods and solutions were identified in the literature review:

- Intelligent Robotic Process Automation (iRPA)
- Operational Analytics

- Cognitive Interaction

The aim of the dissertation is to research and evaluate existing AI-based solutions in the identified categories of tasks, recognize challenges and opportunities for improvements and develop AI-based solutions in these categories, which address the challenges and opportunities. The following research and development have been conducted as part of the dissertation work:

- Intelligent Robotic Process Automation (iRPA) for document processing in ERP systems: two transformer-encoder models were developed and trained for document information extraction and document classification, the resulting document processing solution was compared to industry alternatives, showing significant improvements.
- Operational analytics for CRM and ERP systems: ML algorithms were trained on industry provided datasets for the purpose of evaluating AI-driven operational analytics approaches for scoring on KPIs with industrial significance.
- Cognitive interaction for digital AI assistants in onboarding and training of personnel in HRM/HXM and ERP systems:

Within the field of cognitive interaction, a chatbot digital assistant solution was developed. A version of the solution was integrated as a cloud service within the SAP cloud ERP system. The aim of the chatbot is to contribute to the workforce on-boarding and training process as a human experience management (HXM) tool in the field of industrial robotics:

- Generative AI-Driven Personnel Training in Industrial Robotics through Intelligent HXM, Stoykova, S., Shakev, N., **DOI:** 10.1109/ICAI63388.2024.10851547

The digital assistant has been trained locally on manuals and technical documentation for a Mitsubishi industrial robot as well as a command database for the programming language MELFA Basic V. Some of the identified disadvantages to existing solutions in the field of AI-driven digital assistants were regarding data privacy, operational costs and downtime due to reliance on cloud infrastructure. Thus, a second version of the digital assistant platform was developed, which can be trained on user-provided content with the ability to store all data and LLMs locally on user machines. Parameter efficient fine-tuning techniques (LoRA, QLoRA, etc.) are implemented to allow for local (in some instances on single GPU) fine-tuning of LLMs through the developed platform. The developed platform provides privacy as no data is shared with LLM providers or cloud GPU/TPU providers unless specified by the user that they wish to use hybrid mode of training with API to a specified cloud-hosted model (GPT 4, Gemini) or GPU/TPU cloud provider. The ability to ensure local storing of data and computation is ideal for implementation in research organizations, as well as significantly reducing operational costs, which also makes the developed platform ideal for small and medium-sized enterprises.

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ALGORITHMS AND PROGRAMS DEVELOPMENT TO ENSURE PRODUCTION SYSTEM
OPERATION WITH NETWORK COMMUNICATION

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The field of information and communication technologies is defined as one of the current areas of development of science and innovation in the world. Modern industrial automation is based on the integration of achievements in the fields of information, control, and communication technologies. In this meaning, the work is focused on developing solutions, algorithms, and programs to ensure the operation of intelligent production systems with network communication. The tasks are aimed at designing specialized modules for data collection and processing for diagnostics and notification in the maintenance and management of production processes. The research and analysis provided in the dissertation are focused on developing a comprehensive system for predictive support to help operators to make adequate decisions based on the accumulated, summarized and stored in a special database experience. It is planned to analyze in detail the existing methods for maintenance of technological facilities and sites, and their positive and negative sides will be analyzed. Existing software systems and standards for predictive diagnostics and maintenance will be thoroughly researched and analyzed. Based on the requirements for the predictive support system, the aim of this dissertation will be formulated. A widely used approach is based on data from previous developments and the current state of the forecasting process to determine how much time is left before failures occur. The time remaining until the failure occurs is called "Remaining Useful Life (RUL)", which means "remaining useful time". Predictive maintenance is based on the condition, performed as a result, of a prognosis obtained from the analysis and evaluation

of significant parameters of degradation of an element of the facility. It is planned to develop a software module to support decision-making on the condition, using intelligent methods for predictive diagnostics. The idea is to develop a module for analyzing production and reducing losses by using various algorithms and methods. The prognosis development for of the RUL, the ways of decision-making in the presence of alternatives and proposals for a model will be goal finding solutions and applying to the industrial system. The requirements for automated systems are becoming higher, and their performance is improved through the methods of self-optimization, self-configuration, self-organizing logistics, adaptive diagnostics.

So far the recent work is presented and published in two papers:.....

- 1) Petrov, A. Taneva, Network Design for Gathering Data in Manufacturing Process, International Conference AUTOMATICS AND INFORMATICS`2022, October 06 - 08, 2022, Varna, Bulgaria (ICAI'22) , DOI: 10.1109/ICAI55857.2022.9960027, 978-1-6654-7625-6/22/\$31.00 ©2022 IEEE, Electronic ISBN:978-1-6654-7625-6, Print on Demand (PoD) ISBN:978-1-6654-7626-3
- 2) Petrov, A. Taneva, Process Inspection and Data Collection for Manufacturing, International Conference AUTOMATICS AND INFORMATICS`2022, October 06 - 08, 2022, Varna, Bulgaria (ICAI'22) DOI: 10.1109/ICAI55857.2022.9960000 , 978-1-6654-7625-6/22/\$31.00 ©2022 IEEE,
- 3) Petrov, A. Taneva, Algorithm for Pneumatic actuator control and diagnostics, 2023 International Scientific Conference on Computer Science (COMSCI), Sep 18 - 20, 2023, Sozopol, Bulgaria DOI: 10.1109/COMSCI59259.2023.10315855 , 979-8-3503-2525-6/23/\$31.00 ©2023 IEEE,
- 4) A.Taneva, A. Petrov, M. Petrov Fault Detection Algorithm for Pneumatic Measuring and Sorting Station, 18th IFAC CONFERENCE on PROGRAMMABLE DEVICES and EMBEDDED SYSTEMS - PDES 2024, <https://www.ifac-control.org/conferences/programmable-devices-and-embedded-systems-18th-pdes>, 2024

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IMAGE-BASED VISUAL SERVOING

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Visual servoing, also known as vision-based robot control and abbreviated VS, is a technique which uses feedback information extracted from a vision sensor (visual feedback) to control the motion of a robot.

The control law in Image-based visual servoing (IBVS) is based on the error between current and desired features on the image plane, and does not involve any estimate of the pose of the target. The features may be the coordinates of visual features, lines or moments of regions. IBVS has difficulties with very large rotations, which has come to be called camera retreat.

Conceptualization of a IBVS control system for fire detection system is developed. Method based on three different color models (RGB, HSV and YCbCr) is used for the detection of fire/flame. Afterwards a IBVS control law is developed for 6 degrees of freedom robot to move (and camera respectively) so that the current image “moves” to a desired state, so that the system error is minimized. Since IBVS control systems has difficulties with rotations a support fuzzy-like control is developed so that the robot moves in a single 2D plane, so that rotations to be minimized.

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SECURE HETEROGENEOUS ARCHITECTURE

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Embedded processors are the core of smart and IoT devices. For the last decades, they were primarily ARM instruction set based but since the RISC-V instruction set was introduced 17 years ago, things came to a state where RISC-V challenges ARM supremacy. Due to the open nature of this instruction set, it became popular for both industry and academic studies, as it enables freedom of design, implementation and scalability.

Along with the benefits, RISC-V becoming mainstream technology leads to an increased risk of cyber attacks, necessity for data protection and execution security. Many solutions to these challenges are ported from other platforms, new approaches were introduced and advanced researches are being conducted to handle the ever-existing security threads.

The latest technology and future development direction of RISC-V security research is still to be defined.

A common tendency in computer security especially implementing Root-of-Trust is isolation in terms of hardware resources and access to these resources. Best results can be achieved if there is a complete isolation, even between the execution flows of user programs, kernel and security targeted code, which naturally leads to the use of multi-processor systems. Based on

the security level of each processor it might or might not have access to the other processor resources thus defining one of the processors as a security core. These processors perform different computations and algorithms. To optimize the device means that these processor cores should not be identical but have the minimum functionality to perform their tasks. As RISC-V base instruction set includes just 47 instruction it means that we can have very small cores perform different tasks which minimizes chip size and power consumption.

Cyber-security faces constant attempts to exploit previously undiscovered security holes. While software can easily be patched and misbehavior detected by the user, hardware security issues can only be partially fixed by software resulting in performance degradation and can also go unnoticed by the user. Hardware implemented mechanisms can spot unauthorized code on very low level. Having a separate RISC-V RoT core which is able to identify security threads can significantly improve the reliability of a RISC-V base heterogeneous computer system.