INNOVATION TRENDS IT 2025

Conference Proceedings of the INTERNATIONAL SCIENTIFIC CONFERENCE INNOVATION TRENDS 2025

Lomza, 31st May 2025
POLAND

FACULTY OF COMPUTER SCIENCE AND TECHNOLOGY

UNIVERSITY OF LOMZA

FACULTY OF SOCIAL SCIENCES AND HUMANITIES

PATRONAGE

National Centre for Research and Development

Prof. Dariusz Surowik - Rector of University of Lomza

UNIMA Research Commission

International Association of Theatre Critics Polish Section

Dr Mariusz Chrzanowski - Mayor of the Town of Lomza

Polish Foundation Pillars of Development

Podlaska Regional Development Foundation

klauCODE - High-Performance platforms for modern business

STRATEGIC PARTNERS

EDPOL Food &Innovation

Phoenix Systems

PianpolTex Sp. z o.o.

Pianpol Styła Sp. J.

UNICO POLSKA Sp. z o.o. Sp. k.

Zakład Usług Informatycznych NOVUM Sp. z o.o.

Zakłady Spożywcze BONA sp. z o.o.

ZBJW Łukasz Wądołowski

ZURAD Sp. z o.o.

Przedsiębiorstwo Handlowo-Usługowe Zacharzewski

Innovation Trends is an international scientific conference, which provides for fruitful discussions and exchange of experience in the field of broadly understood research activities from various scientific disciplines as well as economic and teaching environments.
A session with in-person participation of speakers and a session with remote, online participation and a poster session are foreseen.
An accompanying session for representatives of companies, teachers, students and pupils is planned.

Scientific Committee

Dr Ryszard Szczebiot, PL (Chairman)
Prof. Andrzej Chudzikiewicz, PL
Prof. Cariad Astles, MX
Dr Magdalena Forfa, PL
Prof. Andrzej Jordan, PL
Prof. Romuald Kotowski, PL
Prof. Tomasz Krzyżyński, PL
Dr Natalia Malenko, PL
Prof. Valeriu Potecea, RO
Prof. Veronika Stoffová, SK
Prof. Liudmyla Shulhina, UA
Prof. Dariusz Surowik, PL
Prof. Ladislav Várkoly, SK
Prof. Michal Zábovský, SK
Prof. Pedro Vera Serna, UK
Dr Aneta Wiktorzak, PL
Dr Piotr Krzysztof Tronczyk, PL

Organizing Committee

Dr Ryszard Szczebiot - Chairman
Dr Natalia Malenko - Member
Dr Aneta Wiktorzak - Member
Dr Magdalena Forfa - Member
Mgr Marlena Włodkowska - Secretary
Mgr Justyna Konopka – Secretary

CONTENT **page**

VISUALISED SIMULATION MODELS IN DEEP LEARNING ALGORITHMS AND PROGRAMMING

Veronika STOFFOVá

Trnava Universty in Trnava, Faculty of Education, Department of Mathematics and Informatics, Trnava, Slovakia

veronika.stoffova@truni.sk

ABSTRACT

Simulation modelling is a suitable tool for acquiring new knowledge not only in research but also in education. Appropriate visualization can increase the clarity of teaching, and shorten the time needed to understand complex dynamic phenomena. Didactic simulations can involve students in “deep learning” (DL), which support for better understanding. DL means that students learn to apply scientific methods and procedures for getting new knowledge, recognize the individual steps of the model building process and the importance of following them. They understand the relationships and connections between parameters and variables in a model. Students solve data-related tasks apply probability and sampling theory. They investigate how the model can be used to predict outcomes, or how to achieve the desired results. Observe the properties of the system and its reactions to changes in parameters, etc. They learn to reflect and expand their knowledge by actively participating in student-student or teacher-student conversations and discussions that are necessary to conduct simulation experiments. Students are able to transfer the acquired knowledge to solve new problems, situations. They learn to systematize their knowledge by understanding and developing their own thought processes. Build your knowledge system correctly and thus acquire usable knowledge - they learn actively. They see the observed processes and their parts in interaction, i.e. in real operation. Simulations help students understand that scientific knowledge is based on the results of testing hypotheses. Teaching with visualized simulation models significantly increases the quality and efficiency of learning.

Key words: modelling, simulation, deep learning, algorithms, programming

CONCLUSION (SUMMARY)

Visualized simulation models (VSM) play a significant role in teaching thematic units that require understanding the basic principles of the functioning of the dynamic phenomena and processes under study and the relationships between them.They help to understand how the “world” around us works.Simulation experiments can be very effective tools for active learning using constructivism.The effectiveness of teaching by depends on the active participation of students in problem solving, discussion, and evaluation of the results of simulation experiments. Using selected interactive visualized simulation applications, we will demonstrate how to create didactic simulation models, how to use them in teaching and learning and how to design simulation experiments.The presented examples of visualized simulation models primarily focuses on the deep learning of algorithms and programming.

REFERENCES

[1] I. Paholok(2008). *Simuláciaakovedeckámetóda.* [online] (Simulation as a scientific method). 2008,fromhttps://e-logos.vse.cz/pdfs/elg/2008/01/10.pdf

[2] K. Czakóová, R. HorváthandV.Stoffová,(2023),*Modelovanie, simuláciaaanimácia v edukácii.* Trnavskáuniverzita v Trnave. Pedagogickáfakulta. [online]. 2023. fromhttps://pdfweb.truni.sk/doi?978-80-568-0624-1-2023

[3] S. M. Sanchez and H Wan(2018),*Work smarter, not harder: a tutorial on designing and conducting simulation experiments* [online]. Simulation.su [cit.2024-11-19]. Available at http://simulation.su/uploads/files/default/2018-sanchez-sanchez-wan.pdf

[4] D. Goldsman, (1998),*Comparisons with a Standard in Simulation Experiments* [online]. ResearcgGate [cit.2024-11-19]. fromhttps://www.researchgate.net/profile/David-Goldsman/publication/2449438_Comparisons_with_a_Standard_in_Simulation_Experiments/links/567982c308ae40c0e27dc89b/Comparisons-with-a-Standard-in-Simulation-Experiments.pdf

TESTING OF A PROTOTYPE OF A STAKE BASKET FOR TRANSPORTING TIMBER AND CONTAINERS

Andrzej CHUDZIKIEWICZ[1], Jan GĄSIOREK[2]

Helena Chodkowska University of Technology and Economics, Faculty of Transport, Warsaw, Poland[1]
University of Warsaw, Faculty of Journalism, Information and Book Studies, Warsaw, Poland [2]
chudzikiewicz.andrzej@gmail.com[1],

ABSTRACT

Analyses of cargo transport in 2021 show that despite the increased volume of cargo transported by all types of transport compared to 2020, road transport is still dominant compared to rail transport [1]. Therefore, all actions aimed at improving these unfavourable relations, rail transport vs. road transport, in transport, and in particular in the transport of cargo, should be considered purposeful and justified. One such activity is the ongoing work on the design and construction of freight wagons for specialized transport. Specialized wagons, unlike universal wagons, are characterized by a limited ability to transport a wide range of material groups. An example is the transport of timber. However, the development of new transport technologies, and above all technical and organisational progress, force the organisers of these transports to look for new solutions, both logistic and rolling stock. The aforementioned transport of timber is an example of this. The transport of wood does not constitute a large volume of transport but taking into account its transport nuisance (transport with large truck tractors, high axle loads, high risks for other road users), it is a classic example of the fact that it should not be carried out by road over long distances. Therefore, all actions aimed at reducing its nuisance and improving efficiency by using rail transport are desirable and even necessary [2]. The project presents an innovative design solution in the form of a stanchion basket, installed on flat wagons, allowing the use of standard wagons of this type to transport both containers and timber as well as loads such as beams, pipes, etc. Such a solution will allow the use of empty runs of these wagons, after unloading wood at the destination station, for further transport of containers and vice versa. The considerations described in the article show the process of research and testing the prototype of the built basket and the wagon with the stanchion basket structure placed on it.

Key words: rail transport, timber, containers

CONCLUSION (SUMMARY)

The tests made it possible to improve the design with a view to its operational utility and safety. The results obtained, in the form of a prototype and technical and operational documentation of the basket, were used to prepare an application for a certificate of release for operation.

REFERENCES

[1] *Projekt NCBiR* – WP Radwan Sp. z o.o., 01.01.01-00-0986/19 pn. „Opracowanie innowacyjnej usługi przewozu drewna w oparciu o wielozadaniowy kosz kłonicowy”. [In Polish: *NCBiR project* 'Development of an innovative timber transport service based on a multipurpose stanchion basket']

[2] F. Marciniec, T. & Szkoda, M. Analiza łańcucha dostaw surowca drzewnego. *Autobusy*. 2013. Vol. 14. No. 3. P. 1497 – 1506. [In Polish: Analysis of the wood raw material supply chain. *Buses*]

THE DSAT SYSTEM AS AN ELEMENT OF RAILWAY TRAFFIC SAFETY ASSESSMENT

Andrzej CHUDZIKIEWICZ[1], Seweryn KOZIAK[2], Andrzej KRZYSZKOWSKI[1], Anna STELMACH[2]

University in Radom,Radom, Poland[1], WarsawUniversity of Technology, Warsaw, Poland[2]
chudzikiewicz.andrzej@gmail.com, seweryn.koziak@pw.edu.pl, a.krzyszkowski@utrad.edu.pl, anna.stelmach@pw.edu.pl

ABSTRACT

Rail transport as one of the essential components of the functioning of the economy, including transport activity, is subject to special assessment taking into account the safety of passenger and goods transport that are entities in the transport process. This results from both the transport tasks performed, characterized by passenger-kilometers and ton-kilometers, and the range of transports performed.Safety has become, with the advent of the new 21st century, an interdisciplinary concept and its level has begun to be significantly determined by the technical solution used, as in the case of rail traffic, in the field of infrastructure and rolling stock.Increasing the speed of transport while meeting the requirements related to improving the comfort of travel and the safety of transport requires the use of specialist systems for monitoring the technical condition of railway vehicles, both from the track and vehicle position. One of the systems that allows for the diagnosis of rolling stock failures is the DSAT system [1]. It includes devices for detecting damage to the running elements of the rolling stock during travel, protecting the rolling stock and rail infrastructure from damage, increasing the level of safety and improving the quality of transport.DSAT devices simultaneously support the rolling stock maintenance process by verifying the rolling stock's technical parameters, which allows for ongoing management of inspections and tracking the growth of adverse phenomena occurring in the rolling stock's running components, and through qualitative and quantitative analysis of the recorded data allows for the assessment of the safety of the transport operations. The paper will present the DSAT system and sample results of recorded events in the context of assessing the safety of transport [2].

Key words: rail transport safety, rolling stock diagnostics, DSAT system

CONCLUSION (SUMMARY)

- DSAT devices are an important element supporting the safety of rail transport, including passenger transport
- The current number of DSAT devices per 1 km of line installed on railway lines in Poland differs significantly from the average of other European operators
- The problem of placing DSAT devices, taking into account the location on the line and the geographical location of these places (so-called white spots) requires analysis and adoption of new solutions
- The current philosophy presented by PKP PLK in the scope of using these devices (the basic purpose is to protect the infrastructure) requires verification and changes

REFERENCES

[1] StandardyTechniczne – szczegółowewarunkitechnicznedlamodernizacji lub budowyliniikolejowych do prędkości V_{max}< 250 km/h. PLP PLK, Tom VIII, 2022 r.
[2] Sprawozdanieze stanu bezpieczeństwa ruchu kolejowegow 2023 r. Urząd Transportu Kolejowego,Warszawa, 2024

SYNTHETIC DATA FOR SMART TRAFFIC ANALYTICS

Michal ZABOVSKY[1], Martin MAZUCH[2]

Lead Researcher, Syntelia, s.r.o., Data Analytics and AI, Zilina, Slovak Republic[1]

Researcher, University of Zilina, Faculty of Management Science and Informatics, Dept. of Informatics, Zilina, Slovak Republic[2]

michal.zabovsky@syntelia.tech[1], martin.mazuch@uniza.sk[2]

ABSTRACT

Article investigates the use of computer-generated or synthetic data to enhance AI models used in transportation systems. Difficulties in obtaining sufficient real-world transportation data, particularly for unusual or challenging scenarios, and propose that synthetic data can expand training datasets for AI models to improve their accuracy, reliability, and safety, especially in addressing less common occurrences are discussed. Authors present an application concept using the Unreal Engine 5 physical engine to create realistic 3D virtual environments and are testing the effectiveness of YOLOv8 object detection models on these synthetic scenes, demonstrating promising results for identifying objects even under difficult conditions. The paper proposes use of synthetic data for training to fundamentally improve the resilience and adaptability of transport systems to anomalous situations.

Key words: synthetic data,smart transportation, data analytics, artificial intelligence models, objects recognition

CONCLUSION (SUMMARY)

To receive as realistic data as possible, we created series of 3D virtual environment using physical engine Unreal Engine 5. An essential motivating factor is the ability to create inputs for AI models that prevent the models created from generating erroneous decisions that, for example, a human would not commit or recognize that they are wrong. Foundation of data came from camera systems located in the city of Zilina and cameras located in vehicles. We use the database of image data to detect objects in the direction of travel of the vehicle, vehicles in parking lots, pedestrians, and dynamic traffic. We also have part of the data for object identification and segmentation in the form of cloud points from 3D scanning (static, aerial). However, for specific types of objects that do not have a well-defined character (potholes, water on the road, light-affected parts, but also traffic density), we do not have sufficiently large data sets that we can use to better create prediction models.

We prepared synthetic scenes from 3D physical based simulations prepared in Unreal Engine 5. Image data from scenes can be used as raw scene data or parametrized for challenging conditions (weather, lights, rain, etc.). For the experimental evaluation we used 4 images rendered directly from Unreal Engine 5. Two of them were additionally post processed with AI model Sora. Sora is a text-to-video model developed by OpenAI. The model generates short video clips based on user prompts and can also extend existing short videos.

Based on the use of generated scenes, it can be said that such data can be used for models that were created using real data to verify their properties in rare situations and difficult conditions. This fact demonstrates the usefulness of our proposed approach of using synthetic data as a substitute for hard-to-obtain real data. The originality of proposed solution is determined by its application domain in the field of transport, namely increasing the safety and resilience of the transport system by detecting phenomena that cannot be sufficiently captured by the collected real data. The application of the created models and their results contributes in a fundamental way to the better usability of solutions based on them in application practice. While real-world data alone may be sufficient to address typical, easily predictable scenarios, there is still a gap in the protection and resilience of systems in dealing with anomalous situations. Gathering big data through synthetically generated data for a range of scenarios allows target wide range of challenges for the emergence of truly intelligent systems.

REFERENCES

[1] E. Devaux, “List of synthetic data startups and companies — 2021”, 2021. [Online]. Available: https://elise-deux.medium.com/the-list-of-synthetic-data-companies-2021-5aa246265b42.

[2] E. Devaux, “[New] List of synthetic data vendors— 2022”, 6 10 2022. [Online]. Available: https://elise-deux.medium.com/new-list-of-synthetic-data-vendors-2022-f06dbe91784.

[3] Unity Technologies, “Unity”, 2025. [Online]. Available: https://unity.com/.

[4] Epic Games, “Unreal Engine”, 2025. [Online]. Available: https://www.unrealengine.com/en-US.

CERAMIC MATERIAL WITH NANOPARTICLES INCREASED MAGNETIZATION WITH DIFFERENT CHROMIUM CRYSTALLINE STRUCTURESUSING GREEN CHEMISTRY

Pedro VERA-SERNA[1], Luis A. GARCIA-CAMACHO[2]

Universidad Politécnica de Tecámac, División de Ingenierías, Centro de Ingeniería Avanzada, Tecámac, Estado de México, México[1,2]

Author's e-mail[1]: pedrovera.upt@gmail.com, author's e-mail[2]: armando.camacho101@outlook.com

ABSTRACT

This research is oriented towards the synthesis of materials with possible applications in electronics due to their magnetic response and the observed ceramic phases, as well as the generation of knowledge regarding the modification of properties based on the characterization of advanced materials by using solid state reaction and being considered as green chemistry processes. The process started with a stoichiometric chemical balance of iron and chromium oxides, then they enter a mechanochemical process at different times, in which the material is characterized, identifying the modification in its crystalline structure, the variation of particle size to nanometers, morphology and magnetization increase and the relationship between them, determining a variety of reactions that result in a superior magnetic response compared to previously published information. The techniques used were X Ray Diffraction, Scanning Electronic Microscopy, Analysis of Particle Size Distribution and Vibrating Sample Magnetometry.

Key words: advanced nanomaterials, magnetic materials, synthesis of ceramics, iron (II) chromite, green chemistry

CONCLUSION (SUMMARY)

From green chemistry processes such as solid state reaction by mechanochemistry at room temperature, it was possible to document and generate knowledge of the synthesis reaction of advanced materials that gave rise to different crystalline phases that emerged from the precursors Fe_2O_3 and Cr_2O_3, observing in the product an irregular morphology which was decreasing in size according to the particle size distribution analysis, appreciating a proportional relationship when determining spinel type structures by X-Ray Diffraction, nanometric sizes and the increase of magnetization after 12 hours of milling, obtaining a material with structures $FeCr_2O_4$, $(Cr0.25Fe_{0.75})O_3$, $Cr_{0.2}Fe_{0.8}$ and powders of precursors too. The magnetization reached values of 9 emu/g which are higher than those reported in the literature around 2 emu/g, giving rise to a soft magnetic material behavior.

REFERENCES

[1] A. O. Adeeyo et al., (2025). "Magnetic Nanoparticles: Advances in Synthesis, Sensing, and Theragnostic Applications", Magnetochemistry, https://doi.org/10.3390/magnetochemistry11020009, vol 11, no 2, 9.

[2] S. Abhishek et al., (2022). "Electronic and magnetic properties of FeCr2O4 nanoparticles by advanced synchrotron based soft X-ray magnetic circular dichroism", Physica B: Condensed Matter, https://doi.org/10.1016/j.physb.2022.414373, vol 647, 2022, 414373.

[3] Kurul, F., B. Doruk&Topkaya, (2025)."Principles of green chemistry: building a sustainable future. Discover Chemistry, https://doi.org/10.1007/s44371-025-00152-9F, vol 2, no 68.

[4] J. F. Montoya Carvajal, E. A. Chavarriaga Miranda, S. Villada Gil, A. M. Muñoz García, & O. J. Restrepo Baena, (2015). "Síntesis y caracterización de la Espinela FeCr2O4". Producción + Limpia, vol 10, no 1, 64-72.

MULTIMODAL AI MODELS FOR HUMAN-MACHINE INTERACTION IN FINANCIAL, INDUSTRIAL AND EDUCATION ENVIRONMENTS

Mgr. René KLAUČO, PhD. [1]

Prof. Ing. Ladislav Várkoly, PhD.[2]

Founder, KLAUCODE – High-Performance digital platforms for modern business (https://klauco.de), Poprad, Slovakia[1]
Professional guarantor, INTERNET SCHOOL – Educational social network
and digital library (https://internetovaskola.sk), Poprad, Slovakia[2]

ABSTRAC

The paper focuses on the field of artificial intelligence as a tool for transformation with a strong impact on industry, economy and society. The pace of innovation in AI is unprecedented, with new models and techniques emerging in extremely short time iterations. This dynamic creates a need to systematically track and evaluate different research directions within AI in order to subsequently identify areas with the highest current impact and, most importantly, future potential. This is essential in the education and training of future professionals for these fields. In this context, the paper focuses on the AI categories with the highest "popularity" at present, at the same time as the largest projected growth trend over the coming period. Geographically, it focuses on the regions of the US, EU and China, which are "drivers" of innovation and pre-represent global ecosystems for R&D and investment in this field, but also competitors. The available information suggests the dominance of several high momentum areas, notably Generative AI (especially LLM), AI for Science, Responsible/Safety AI or Reinforcement Learning. At the same time, from a regional perspective, the US confirms its dominance in AI investment and development of the most advanced models, while China dominates in the volume of publications and patents and is rapidly catching up in terms of quality. Europe has a strong talent base, underlining the growing importance of interdisciplinary research, the need for robust infrastructure (computing power, data) and the necessity to address ethical and security challenges associated with AI advancement, but the necessary investments to develop and scale innovation are still in process.

Key words: artificial intelligence, AI, LLM, Generative AI, AI for Science, Reinforcement Learning

THE SIMILARITY BETWEEN IMPROVING COMPUTER PERFORMANCE AND BASAL STIMULATION METHODS

Mgr. Marcela MUŠÁKOVÁ, MBA[1], Prof. Ing. Ladislav VÁRKOLY, PhD.[2], Mgr. René KLAUCO, PhD.[3]
CEO, Terézia n.o., Lokca, Slovakia[1]
Professional guarantor, INTERNET SCHOOL – Educational social network and digital library, Poprad, Slovakia[2]
Founder, KLAUCODE – High-Performance digital solutions for modern business, Poprad, Slovakia[3]
riaditel@terezia-lokca.sk[1], kolysama7@gmail.com[2], rene@klauco.de[3]

ABSTRACT: This conference paper explores the parallels between optimizing computer applications and stimulating the human body through the concept of Basal Stimulation. Just as one can equate visual impairment due to damage to the retina of the eyes to "burned out" pixels on a screen, one can equate an increase in computer performance (e.g., "making the computer faster") to an improvement in human body function through targeted stimulation. Supporting the enhancement of quality of life and sensory perception is addressed by methods such as 'Somatic Stimulation' and 'Vestibular Stimulation'. This paper presents the concept of Basal Stimulation, which focuses on maintaining and improving motor and sensory pathways, similar to software optimization to prevent performance deterioration. Techniques such as "Initial Touch" and "Contact Breathing" are presented as specific interventions, similar to software updates or debugging. This analogy suggests that understanding and applying the principles of stimulation can significantly impact a person's quality of life, especially for those with limited mobility or sensory impairments. This paper is based on the practical application of Basal Stimulation methods at Theresa, n. o., Lokca.

Key words: basal stimulation, somatic stimulation, vestibular stimulation, motor and sensory pathways

INTRODUCTION

In the environment of modern medicine and special education, interdisciplinary approaches are increasingly being sought to enable new perspectives on the care of people with limited mobility or sensory impairments. One such approach is Basal Stimulation, a therapeutic-treatment concept that finds application in work with people with severe central nervous system impairment, in geriatric care or with patients in a minimally conscious state.

In this paper, we attempt an unconventional connection between the world of information technology and human neurophysiology through an analogy between optimization of computational systems and goal-directed stimulation of the human body. Just as a modern computer requires regular maintenance, tuning, and updating, the human body needs external stimuli that activate sensory and motor pathways, prevent their decay, and promote neuroplasticity. Using selected methods of Basal Stimulation such as Initial Touch, Contact Breathing, Somatic Stimulation and Vestibular Stimulation as examples, we show how purposefully administered stimulation can lead to improved quality of life for people with severely limited mobility or communication skills. We draw on the practical experience of the organisation Terézia, n. o., Lokca, where these techniques are systematically applied in everyday care.

CONCLUSION

Basal stimulation is an important concept in rehabilitation and care that focuses on stimulating the basic sensory and motor abilities of individuals with various limitations. Its holistic approach, taking into account individual needs and biography, allows for improvements in the areas of perception, communication, movement and overall quality of life. The work of Professor Dr. Andreas Fröhlich laid a solid foundation for this concept, which continues to evolve and find application in a variety of clinical and nursing settings, as demonstrated by the work of Theresa, n. o.

REFERENCES

[1] PINČÁKOVÁ, M.: Edukácia žiaka s ťažkým zdravotným znevýhodnením prostredníctvom bazálnej stimulácie - Osvedčená pedagogická skúsenosť edukačnej praxe In: Moderné vzdelávanie pre vedomostnú spoločnosť. 2013. Online document. Retrieved from: https://mpc-edu.sk/sites/default/files/projekty/vystup/5_ops_pincakova_margita_-_edukacia_ziaka_s_tazkym_zdravotnym_znevyhodnenim.pdf

[2] FRIEDLOVA, K. M.: Bazální stimulace podle prof. Dr. Fröhlicha. Asociace poskytovatelů sociálních služeb, 2024. 978-80-88361-40-4.

AN INNOVATION OF A POWERTRAIN SYSTEM OF A MULTIPLE-UNIT TRAIN

Ján DIŽO[1], Alyona LOVSKA[1], Miroslav BLATNICKÝ[1], Martin BUČKO[1]

Department of Transport and Handling Machines, Faculty of Mechanical Engineering, University of Žilina, Univerzitná 8215/1, 010 26 Žilina, Slovak Republic[1]

jan.dizo@fstroj.uniza.sk, alyona.lovska@fstroj.uniza.sk, miroslav.blatnicky@fstroj.uniza.sk, martin.bučko@fstroj.uniza.sk[1]

ABSTRACT

Railway transport is a very important part of the transportation system. It ensures the movement of goods and passengers from shorter to very long distances. Regarding passenger railway transport, there are several kinds of passenger rail vehicles used in urban and rural areas. Despite efforts for electrification, there are still some locations in a country that electrification is not possible or there are some other difficulties. Therefore, rail vehicles with an independent traction system are operated in such regions. These rail vehicles with independent traction systems are usually powered by a diesel engine. However, stricter and stricter emission limits and requirements for saving fossil fuels force to invite and apply innovative and non-conventional sources of energy [1, 2]. Currently, hydrogen is supposed one of the future source of energy. The main goal of the presented research is a presentation of an idea of an innovation of a multiple-unit powertrain system. It is supposed that the original diesel powertrain system of a multiple-unit would be replaced by an innovative hydrogen fuel cells powertrain system. This system would be built for an existing passenger multiple-unit train. As such an innovation of a multiple-unit train requires a different distribution of the needed components of the hydrogen powertrain (Fig. 1) together with expected change of parameters, the presented study includes a comparison of conceptual design of a vehicle and a comparison of the selected parameters of the original and innovative powertrain system [2].

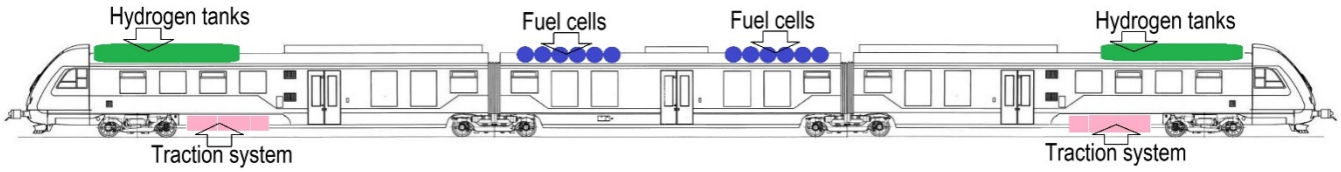

Fig. 1. A scheme of a components distribution of the modified multiple-unit train with the hydrogen powertrain system.

Key words: rail vehicle, multiple-unit train, hydrogen powertrain, hydrogen fuel cells, emissions

CONCLUSION

The current state of the knowledge's about the development of powertrain systems, which use hydrogen as a source of power in the railway transport sector allowed to design a concept of an innovative powertrain system of a commercially produced multiple-unit train including hydrogen fuel cells. A proposal for the design of the vehicle was created based on the available data about the selected multiple-unit train. A distribution of the needed components together with the required modifications of the existing design of the vehicle was processed. Another step was performing a weight evaluation of the vehicle and its comparison with the original vehicle. The distribution of the components needed for the hydrogen powertrain seems that there is still a space for modification. The current state showed that a crucial issue is the exceeded permissible axleload of the vehicle together with the total weight of the vehicle.

REFERENCES

[1] S. Rahim Marjani, S. Motaman, H. Varasteh, Z. Yang and J. Clementson, (2025), "Assessing hydrogen as an alternative fuel for rail transport – a case study," Scientific Reports, vol. 15, DOI 10.1038/s41598-025-90887-3, no. 1, 6449.

[2] J. Krško, (2023), "Concept and structural design of the main drive units when replacing a diesel drivetrain by an electric one with hydrogen fuel cells for DMU r. 861 (in Slovak)," Technológ, vol. 15, no. 4, pp. 22-29.

THE RECENT CRISES AND THEIR IMPACT AT THE REGIONAL AND GLOBAL LEVEL

Valeriu POTECEA[1], Georgiana SURDU[2]

Romanian-American University, Bucharest, Romania[1]
Romanian-American University, Bucharest, Romania[2]
valeriu.potecea@rau.ro, georgiana.surdu@rau.rol[2]

ABSTRACT

The development of international trade transactions is not a linear process. Often, the development mechanism knows the following development scheme: production, processing, packaging, transportation, logistics, storage, batching, retail and use. But sometimes there are exogenous factors that play an enormous role in disrupting the usual mechanism, as the 2 major crises of the last 5 years, the pandemic and the war in Ukraine, have had. Secondarily, more or less potentiated, other crises also appear during this period, which the general public does not look at with as much interest, perhaps also because of the way they are reflected in the media. The chain can be longer or shorter depending on the quality of the seller, manufacturer or intermediary, or whether one of the participants has its own international transport capacity.

Among the secondary crises that have occurred in recent years, the container crisis, the crisis caused by the obstruction of the Suez Canal, the semiconductor crisis or the energy crisis stand out.

But perhaps the most important is the recent crisis of the internationalization-based development model, which began with the new White House administration. In this new contemporary economic picture, of a rather dichotomous nature until recently, marked both by the illusion of new protectionism, but also by the challenges induced by the emergence of the quaternary sector, participants in the international business environment are subjected to pressures they have never faced and for which they must develop new “antibodies”.

Key words: crises, internationalization, protectionism, adaptation

CONCLUSION (SUMMARY)

The countries in the central, southern and eastern parts of the European continent have experienced continuous development in recent years and are still considered to be some of the best locations for manufacturing operations, even to the detriment of some countries in the west of the continent. Given that further development is based on stability and predictability, the future looks challenging.

Adaptation is the key to any crises: we are witnessing the ***reemergence of countertrade operations*** like barter, reexport (as India does with the Russian oil), or offset.

REFERENCES

[1] Ovidiu Folcuț (2025), “Războiultarifar. Noul context comercial global – va fi furtunăsauuragan?” (Tariff war. The new global trade context – will it be a storm or a hurricane?), www.cursdeguvernare.ro
[2] Eurochambres,(2023), Global Economic Survey.
[3] EY, (2023), Europe Attractiveness Survey

LANGUAGING AND ECOLOGICAL LANGUAGE COMPETENCY IN THE HUMAN ECOLOGY

Paul J. THIBAULT

The Education University of Hong Kong

Key Words: Ecological Languaging Competencies; Human Ecology; Languaging

Languaging is something that we *do* with others rather than a static pre-existing set of forms that we "use." Languaging is a social mode of (inter)action, or communicative co-action, which has specific characteristics. ELC refers to two dimensions of languaging: (1) the offline ability of persons to create utterances that serve their own and others' purposes in languaging activity; and (2) the online participation in and management of the flow of languaging. ELC requires the achievement of functional fits between the learned capacities and skills of languaging selvesand the affordances (artefacts, tools, technologies, objects, etc.) of the environments (taskscapes, situations, activities and practices) in which persons are required to contribute productively to the flow of languaging. Current formulations of "competence" focus on the individual and seek to assess the competence of the individual in terms of the outputs of individuals. However, languaging is always co-production in different ways that cannot be properly explained or assessed if the individual is the sole locus in teaching, learning, and assessment. ELC emphasies languaging as ecologically embedded and embodied co-participation and co-production whereby persons coordinate with other persons and with aspects of their worlds. The ecological view of languaging (Thibault, 20921a, 2021b) will frame the discussion and definition of key theoretical constructs. Nonhuman perspectives will also be discussed. Video recorded examples will illustrate key aspects of the discussion.

METHODS OF IMPLEMENTING DIGITAL MARKETING TOOLS IN THE INTERNATIONAL COMPANIESACTIVITIES

Roman BASISTYI [1], Liudmyla SHULHINA [2]

Master's Student, of the National Technical University of Ukraine, “Igor Sikorsky Kyiv Polytechnic Institute”[1]

National Technical University of Ukraine, “Igor Sikorsky Kyiv Polytechnic Institute”[2]

Abstract. Introduction. The article examines the methods of implementing digital tools in international markets, focusing on cultural, legal, and economic aspects that determine their adaptation. An analysis of key tools and models that can enhance the effectiveness of digital strategies for the U.S. and European markets is conducted.

Objective. The primary aim of the article is to study the specifics of digital marketing strategies in international markets and to identify key tools and metrics that contribute to their effective adaptation.

Materials and Methods. This research utilized analytical data on key digital marketing tools, such as SEO, SEM, content marketing, social media, and PPC advertising. The main research methods included comparative analysis.

Results. The study analyzed findings that demonstrated the success of using digital marketing tools in international markets depends on adapting to cultural and regional specifics. It also revealed that, to enhance effectiveness, specific tools should be used for each market.

Prospects. Further research is expected to analyze the effectiveness of digital tools for specific industries and adapt them to the conditions of particular regions.

Keywords: digital tools, international market, SEO, SMM, content marketing.

PROBLEM STATEMENT

In the context of globalization, adapting marketing strategies to the specifics of international markets becomes critical for business. Digital marketing tools require in-depth analysis to take into account the specifics of each market.

CONCLUSIONS AND PROSPECTS OF THE STUD

The study of the features of digital marketing strategies in international markets revealed the importance of adapting strategies to regional cultural, economicand other macro factors of the marketing environment. The use of tools such as SEO, content marketing, PPC advertising and social networks contributes to achieving business goals, improving customer interaction and increasing communication efficiency.

Prospects for further research include the development of innovative methods for assessing the effectiveness of digital strategies,analysis of consumer behavior in different cultural segments, as well as studying the latest tools for marketing process automation. This will allow enterprises to more accurately adapt their strategies to dynamic market conditions, while maintaining flexibility and efficiency in decision-making.

REFERENCES

[1] Levchenko, M. (2022). Doslidzhennia efektyvnosti intehratsii onlain ta oflain marketynhu cherez model ROPO. Ekonomika ta upravlinnia pidpryiemstvamy, (4), pp. 56-62.

[2] Yogesh, K., Nripendra, P., Emma, L., Nitish, S., Hatice, K. (2020). Editorial introduction: Advances in theory and practice of digital marketing,Journal of Retailing and Consumer Services,Volume 53,ISSN 0969-6989,https://doi.org/10.1016/j.jretconser.2019.101909.https://www.sciencedirect.com/science/article/pii/S0969698919309737.

[3] Shafique A., Samiran S. (2024). Navigating the modern marketing landscape:Strategies and Innovations in contemporarymarketing management, International Journal of Multidisciplinary Trends, 6(2), 06-10, DOI: https://dx.doi.org/10.22271/multi.2024.v6.i3a.386.

[4] Omelchak, O.(2023). Vykorystannia instrumentiv targetovanoi reklamy u mizhnarodnomu marketynhu. Marketynh ta tsyfrovi tekhnolohii, pp. 54-59.

ANALYSIS REGULATORS WITH NON-CONVENTIONAL ALGORITHMS USING DIFFERENTIAL EQUATIONS OF INTEGRAL AND NON-INTEGRAL ORDER

Leszek GOŁDYN [1], Ryszard SZCZEBIOT [2]

University of Lomza, Faculty of Computer Science and Technology, Lomza, Poland [1,2]
lgoldyn@al.edu.pl[1], ryszard@szczebiot.pl[2]

ABSTRACT: The paper compares the operation of the classic PID controller and two different controllers with unconventional algorithms using fractional-order differential equations. The equality in the use of differential equations of different orders (integer and fractional) was justified. The time characteristics of different orders of these controllers were determined by simulation and presented graphically in a summary graph.

Key words: fractional order differential equation, unconventional algorithm controller, fractional order controller, PID controller

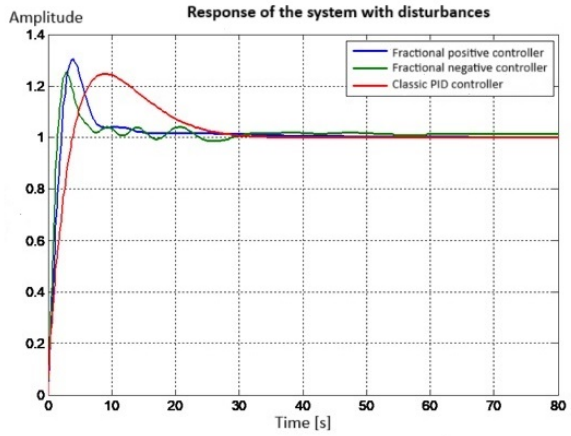

Fig. 1. Comparative dynamic characteristics of control systems with classical and unconventional controllers.

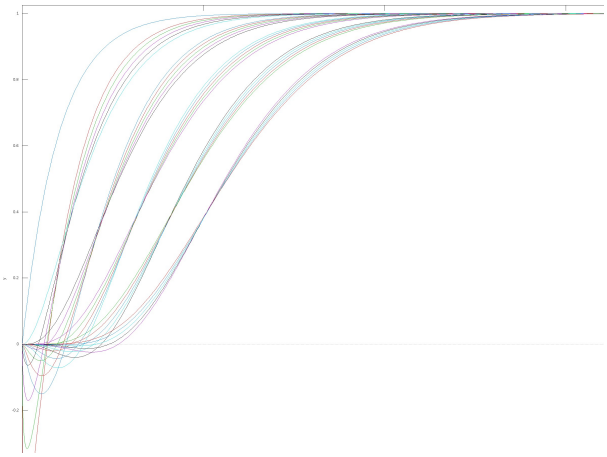

Fig. 2. Dynamic characteristics solutions of the order of 1 to 6 equations.

CONCLUSION

Lower fractional-order differential equations describe more precisely (they constitute a better mathematical model) many physical phenomena, e.g. inductive couplings in electrical engineering or classical electrical circuits, in mechanics, in control and regulation systems. Currently, fractional-order differential equations are used in the construction of fractional-order controllers and they fulfill their role very well in control systems.

REFERENCES

[1] CAMPISTROUS, Luis Augusto; LOPEZ, J. M.; RIZO, C. (2009), Reflexiones sobre la didáctica del cálculo a propósito de una lectura del primer texto publicado sobre esta materia por el Marqués Guillaume François Antoine L'Hospital: Analyse des infiniment petits pour l'intelligence des lignes courbes.

[2] GOŁDYN Leszek, SZCZEBIOT Ryszard, (2017), VARIABLE PID CONTROLLERS AND UNCONVENTIONAL CONTROLLERS, Present Day Trends of Innovations 7, Lomza State University of Applied Sciences, Łomża 2017, ed. Ladislav Várkoly, Michal Zábovský, Ryszard Szczebiot, pp. 94-108, ISBN 978-83-60571-49-1

[3] GOŁDYN Leszek, SZCZEBIOT Ryszard, (2017), PARAMETRIC IDENTIFICATION OF MATHEMATICAL MODELS OF INTEGER AND FRACTIONAL ORDERS, Present Day Trends of Innovations 7, Lomza State University of Applied Sciences, Łomża 2017, ed. Ladislav Várkoly, Michal Zábovský, Ryszard Szczebiot, pp. 108-119, ISBN 978-83-60571-49-1

[4] Caputo's definitions for the description and initialization of fractional partial differential equations. *IFAC-Papers On Line*, 2017, 50.1: 8574-8579.

[5] Kaczorek T., Dzieliński A., Dąbrowski W., Łopatka R.,(2005) Podstawy teorii sterowania, WNT, Warszawa.

HYBRID LSTM MODELS WITH ATTENTION MECHANISM FOR FORECASTING SMOG EPISODES UNDER EXTREME CONDITIONS

Dr Eng. Aneta WIKTORZAK

University of Lomza, Lomza, POLAND

awiktorzak@al.edu.pl

ABSTRACT

This article presents the application of a hybrid model based on LSTM networks with an attention mechanism for forecasting PM10 and PM2.5 pollutant concentrations under extreme weather conditions. The objective of the study was to improve the accuracy of smog prediction during high-risk periods when standard models tend to become unstable. The LSTM+Attention model was compared with classical approaches (pure LSTM and NARX). The network was trained using data from over 40 InConTech sensors located in the PodlaskieVoivodeship, as well as meteorological data from the IMGW API. The results confirm that incorporating the attention layer significantly enhances prediction performance, especially during sudden meteorological shifts and pollution spikes.

Key words: LSTM+Attention, prediction, PM10, PM2.5

CONCLUSION

This article presented an innovative smog prediction model that combines the LSTM network architecture with an attention mechanism. The results of the conducted study clearly indicate that the hybrid approach delivers significantly better outcomes compared to traditional methods, both in terms of accuracy (lower RMSE and higher R^2) and operational stability. This model performs particularly well in short-term forecasting under extreme conditions, which is essential for practical applications in early warning systems.

The attention mechanism enables a dynamic analysis of the temporal context and enhances model interpretability. This is a crucial feature in an era of growing demands for explainability in decisions made by artificial intelligence. The analysis of attention weights identified which moments within the input sequence were most influential in the forecasting process, offering a foundation for further research into the causal nature of smog-related phenomena.

In summary, the proposed model is not only an analytical tool but also a potential foundation for a modern, automated system for monitoring and forecasting air pollution. Combined with pro-environmental policies and the expanding infrastructure of environmental data, it can contribute to improved public health and quality of life for urban populations.

REFERENCES

[1] S. Hochreiter and J. Schmidhuber, (1997), “Long short-term memory,” Neural Computation, vol. 9, no. 8, pp. 1735–1780.
[2] D. Bahdanau, K. Cho, and Y. Bengio, (2014), “Neural machine translation by jointly learning to align and translate,” arXiv preprint, arXiv:1409.0473.
[3] S. Raschka and V. Mirjalili, (2021), Python. Machine Learning i Deep Learning. BibliotekiScikit-Learn iTensorFlow 2, Gliwice, Poland: Helion.
[4] D. Qin, et al., (2019), “A combined CNN-LSTM-Attention model for PM2.5 forecasting,” IEEE Access, vol. 7, pp. 108368–108376.
[5] D. R. Liu, S. J. Lee, Y. Huang, and C. J. Chiu, (2021), “Air pollution forecasting based on attention-based LSTM neural network and ensemble learning,” Expert Systems with Applications, vol. 168, pp. 114421.
[6] IMGW-PIB, (2024), Dane meteorologiczne API, [Online]. Available: https://danepubliczne.imgw.pl/api/
[7] OpenWeatherMap, (2024), API do danych pogodowych, [Online]. Available: https://openweathermap.org/api

MODELING ELECTRIC VEHICLE ENERGY CONSUMPTION: A CASE STUDY OF THE 'ELECTROMOBILITY AND SMART CITY TECHNOLOGIES' COURSE

Rafał MELNIK

University of Lomza, Faculty of Computer Science and Technology, Department of Automation and Robotics, Łomża, Poland

rmelnik@al.edu.pl

ABSTRACT

In recent years, Polish technical universities have increasingly recognized the importance of sustainable transportation by introducing new study programs related to electromobility. These programs are primarily offered by faculties of electrical engineering, often under titles such as Electromobility or Engineering of Electric and Hybrid Vehicles. Reflecting the growing societal and industrial relevance of this field, postgraduate studies have also emerged, aiming to enhance the qualifications of engineers and professionals working in transport, energy, and related sectors.

Responding to these trends and the rising demand for expertise in this domain, the Faculty of Information and Technology Sciences has introduced an elective course titled Electromobility and Smart City Technologies as part of the undergraduate Computer Science program. This course seeks to bridge the gap between computer science and modern transport technologies, fostering interdisciplinary skills among students.

The main objective of this study is to present the scope and content of the course from a practical perspective. In particular, the focus is placed on battery modeling and energy consumption estimation in electric vehicles, as well as, exploring the key factors that influence energy usage. The case study discussed herein aims to demonstrate how theoretical concepts are translated into practical skills and to emphasize the importance of data analysis and simulation in the field of electromobility.

Key words: electromobility,engineering education, vehicle longitudinal dynamics, energy consumption, WLTC

SUMMARY

In the practical part of the course, students explored factors influencing the energy consumption of road vehicles. The mathematical modeling was conducted using the Python programming language, primarily with the NumPy library.

To estimate vehicle energy consumption, formulas for calculating rolling resistance, aerodynamic drag, and inertial forces were applied. This enabled students to analyze the contribution of individual resistance components as a function of driving speed. At this stage, students were also tasked with selecting parameters affecting driving resistance for a chosen car model.

Energy consumption was first evaluated on a simple simulated road segment during steady-speed driving. In the next phase, energy usage was estimated based on the WLTC Class 3 driving cycle.

The procedure presented in the paper can be used as an initial study in determining the design assumptions of the vehicle, as well as to develop a strategy for the operation of the Battery Management System.

REFERENCES

[1] I. Miri, A. Fotouhi, and N. Ewin, 'Electric vehicle energy consumption modelling and estimation—A case study', Int J Energy Res, vol. 45, no. 1, pp. 501–520, Jan. 2021, doi: 10.1002/er.5700.

[2] W. Gołębiewski and M. Lisowski, 'Theoretical analysis of electric vehicle energy consumption according to different driving cycles', IOP Conf. Ser.: Mater. Sci. Eng., vol. 421, p. 022010, Oct. 2018, doi: 10.1088/1757-899X/421/2/022010.

[3] M. Etxandi-Santolaya, L. Canals Casals, and C. Corchero, 'Estimation of electric vehicle battery capacity requirements based on synthetic cycles', Transportation Research Part D: Transport and Environment, vol. 114, p. 103545, Jan. 2023, doi: 10.1016/j.trd.2022.103545.

[4] R. Xiong, Battery Management Algorithm for Electric Vehicles. Singapore: Springer Singapore, 2020. doi: 10.1007/978-981-15-0248-4.

SECURITY ANALYSIS OF PUBLIC ADMINISTRATION DATABASES IN POLAND WITHIN A ZERO-TRUST ENVIRONMENT

Marta CHODYKA
University of Łomza, Poland
mchodyka@al.edu.pl

ABSTRACT

This article provides a comprehensive assessment of database security within Poland's public administration using CERT Polska and CSIRT GOV statistics (2022–2024). An entropy-based model assigns Shannon weights to five threat categories, revealing that phishing (w=0.41) and configuration vulnerabilities (w=0.38) together constitute nearly 80% of the risk. Comparing perimeter and Zero-Trust (ZT) architectures via NIST SP 800-207 and CISA models, the analysis highlights weaknesses of firewalls and VPNs, while ZT effectively mitigates lateral movement and insider threats by over 60%. Identified implementation challenges include modernising federated IAM, integrating advanced SIEM/SOAR systems with database telemetry, and containerising legacy systems. A transformation roadmap proposes cultural cybersecurity changes, long-term investments, legacy migrations, shared security operations centres, and regulatory alignment with NIS 2 and NSC 800-207, emphasizing Zero-Trust adoption as essential to enhancing national data repositories' cyber-resilience.

Key words: Zero-Trust architecture; public administration; database security; social engineering; entropy-based risk assessment; micro-segmentation; multi-factor authentication

CONCLUSION (SUMMARY)

The evidence confirms that classical perimeter security architectures no longer effectively defend Polish public-sector databases, as incidents—particularly social-engineering attacks—have quadrupled in two years. Excessive implicit internal trust and human vulnerabilities remain critical weaknesses, facilitating unauthorised data access. Zero-Trust (ZT) architecture directly addresses these issues through continuous identity validation, micro-segmentation, multi-factor authentication, and strict privilege enforcement, significantly reducing attack probabilities related to access control and system vulnerabilities.

Successful transition to ZT requires coordinated action across five domains: cultural transformation with targeted training; multi-year infrastructure investments; a realistic strategy for managing legacy systems; enhanced SOC capabilities through shared services; and regulatory alignment with NIS 2 and NSC 800-207 standards. Priority operational steps include universal MFA, network micro-segmentation, least-privilege access enforcement, continuous database monitoring, vulnerability assessments, and user-awareness campaigns. Given increasing threat intensity, adopting Zero Trust is essential to national cybersecurity, positioning public administration as a catalyst for broader cyber resilience.

REFERENCES

[1] X. Kuang, Y. Zhang and H. Liu (2024), 'Research on the new generation of network data security protection technology for Zero-Trust environment', in Proceedings of the 24th IEEE International Conference on Computer and Information Technology (CIT 2024), Athens, Greece, 653–660.
[2] CERT Polska (CSIRT NASK) (2025), Raportroczny z działalności CERT Polska 2024 [Annual report of CERT Polska for 2024]. Warsaw: NASK – National Research Institute.
[3] [8] CISA – Cybersecurity & Infrastructure Security Agency (2021), Federal Zero Trust Strategy. Washington, DC: U.S. Department of Homeland Security.
[4] CSIRT GOV (AgencjaBezpieczeństwaWewnętrznego) (2024), Raport o staniebezpieczeństwacyberprzestrzeni RP w 2023 roku [Report on the state of Poland's cyberspace security 2023]. Warsaw: ABW.
[5] NIST – National Institute of Standards and Technology (2020), Zero Trust Architecture (Special Publication 800-207). Gaithersburg, MD: NIST.

"THEY DON'T SEE THE REAL ME!" STUDENT VOICES ON BEHAVIOUR AND BELONGING

Simon FARRUGIA[1], Bernice PIZZUTO[2]

Malta Leadership Institute, School for Educational Studies, Malta[1]
Learning Support Educator, St. Patrick's Salesian School, Malta[2]
farrugia.sim@gmail.com[1],pizzutobernice@hotmail.com[2]

ABSTRACT

Students with social, emotional, and behavioural difficulties (SEBD) often encounter educational environments that misinterpret their actions as defiance rather than distress (Cefai & Cooper, 2006). This study seeks to foreground student voice by exploring the lived experiences of secondary school students in Malta who have beeen identified as exhibiting SEBD. Adopting a qualitative interpretivist design, this research involved focus groups, reflective journaling, and ethnographic classroom observation.

Thematic analysis revealed five interrelated themes: emotional distress misread as defiance, anxiety and overwhelm, mistrust and withdrawal, autonomy-seeking through opposition, and internalised failure. These themes illuminated how students' behaviours often serve as protective strategies rather than signs of disobedience (Fonagy & Target, 2006; Raudales et al., 2019). Participants also identified classroom practices that helped or hindered their engagement, highlighting the importance of relational safety, autonomy, and emotional validation.

The findings affirm the need to shift from control-based approaches to relational and trauma-informed pedagogies (Kearney & Lanius, 2022). Rather than treating SEBD as pathology, this research reframes behaviour as meaningful communication shaped by prior adversity and relational context. This has practical implications for schools seeking to foster inclusive, emotionally attuned environments that uphold student dignity and participation (Council of Europe, 2023).

Key words: SEBD, inclusion, student voice, trauma-informed, behaviour

CONCLUSION (SUMMARY)

This study underscores the importance of understanding behaviour as a relational signal rather than a disciplinary issue. Students experiencing SEBD described a need for emotionally safe spaces, flexible pedagogies, and trusted adult relationships. By positioning their voices at the centre, this research advocates for school cultures that respond with connection rather than control. The work contributes to a growing body of trauma-informed and participatory research and offers guidance for educators and policymakers seeking to create inclusive environments where students with SEBD can learn, belong, and thrive.

REFERENCES

[1] C. Cefai and P. Cooper, (2006), "Social, emotional and behavioural difficulties in Malta: An educational perspective," Journal of Maltese Education Research, vol. 4, no. 1, pp. 18–36.
[2] P. Fonagy and G. Target, (2006), The mentalization-focused approach to social development, Handbook of Mentalization-Based Treatment, 1st ed. UK: John Wiley & Sons.
[3] M. Raudales, D. Davis and S. Frazier, (2019), "Understanding trauma and resilience in students, Educational Psychology Review," vol. 31, no. 3, pp. 587–602, USA: Springer.
[4] C. A. Kearney and R. A. Lanius, (2022), "The brain-body disconnect: A somatic sensory basis for trauma-related disorders," Frontiers in Neuroscience, vol. 16, article 1015749, Switzerland: Frontiers Media.
[5] Council of Europe, (2023), "Improving well-being at school. Democratic Schools for All," Strasbourg, France: Council of Europe Publishing.

CREATIVE ASSOCIATIONS IN THE HYBRID ORGANISATION OF POLISH THEATRICAL LIFE: ZASP AND THE POLISH AICT SECTION

Konrad SZCZEBIOT

Doctoral School of Cardinal Stefan Wyszyński University in Warsaw
konrad@szczebiot.eu

ABSTRACT

This paper explores the role of creative associations in the hybrid organisation of theatrical life in Poland, focusing on two key institutions: ZASP (Association of Polish Stage Artists) and the Polish Section of AICT/IATC (International Association of Theatre Critics). Drawing from the concept of hybrid cultural organisations, the paper situates these associations within a framework of cultural policy transformation and creative industry evolution. It presents historical and contemporary perspectives on both bodies, illustrating their function as intermediaries between tradition and innovation. The analysis shows how they balance preservation of artistic heritage with adaptation to new forms of cultural production, including digital transformation, international collaboration, and educational initiatives. The research highlights their influence on cultural policy, their contribution to sustaining professional standards, and their role in shaping a resilient and adaptive theatrical ecosystem in 21st-century Poland.
Key words: creative associations, hybrid organisation, theatre, ZASP, AICT/IATC

CONCLUSION (SUMMARY)

Creative associations such as ZASP and the Polish AICT section illustrate the crucial role of hybrid cultural organisations in balancing heritage and innovation. They act as custodians of theatrical traditions while dynamically responding to the demands of the contemporary creative industries. Their contributions range from legal representation and rights management to education, criticism, and cultural advocacy. However, challenges persist, including generational divides, financial sustainability, and the need for stronger policy influence. The future of such associations depends on their ability to remain inclusive, innovative, and connected to both historical legacies and emerging artistic paradigms.

REFERENCES

Miłkowski, T. (2020). POLAND: Internet-theatre and Insufficient State Support for the Artists. Critical Stages, 21.

Kostrubiec, M. (2017). ZASP – Stowarzyszenie Polskich Artystów Teatru, Filmu, Radia i Telewizji. Jagiellonian University.

Polskie Radio 24. (2024, January 23). Dr Tomasz Miłkowski on the history, mission and activities of the Theatre Critics Association.

Tsanos, C., et al. (2024). Hybrid organisations: a classification within economic sectors. Humanities & Social Sciences Communications, 11(1).

HYBRID QPU-FPGA-CPU-GPU ARCHITECTURE FOR EFFICIENT QUANTUM COMPUTER EMULATION AND SUPPORT WITH A HIGH LEVEL PROGRAMMING LANGUAGE

Tomasz BAYER

Polska-Japońska Akademia Technik Komputerowych, Warsaw, Poland
t.bayer@pjwstk.edu.pl

ABSTRACT

Quantum computing is a new paradigm, where the laws of quantum mechanics create a new expectation to revolutionize the way we compute. For now, physical quantum hardware computing remains in its infancy stage, facing challenges like limited qubit coherence and high error rates, which hinder scalability. Therefore, research into emulating quantum computations using classical hardware (e.g., CPUs, GPUs, and FPGAs) is essential to prototype and test quantum algorithms, given the current lack of fully realized quantum computers. In this paper we survey the recent works incorporating FPGAs with GPUs and CPUs to form a hybrid architecture, and the concluding section of this review provides an outlook on future quantum operations emulation.

FPGAs are used for parallel matrix multiplications necessary to execute quantum gates, and GPUs handle intricate, floating point-heavy calculations needed for multi-qubit gate executions. The CPUs can be used to arrange the movement of data, control memory resources and schedule gate sequences among different types in the system. This approach can handle computational tasks taking into consideration different hardware capabilities. It can thus be able to emulate quantum circuits with greater performance than CPU-only or GPU-only solutions. This article presents the challenges of inter-device communication, synchronization, and memory management and offers overview strategies to improve throughput and minimize latency in large-scale quantum emulation. This work also highlights the potential of FPGA-GPU-CPU architectures as scalable solutions for advancing quantum computing research and prototyping quantum algorithms in classical environments. Until a fully functional quantum computer emerges and even beyond, this architecture can also be expanded to an FPGA-GPU-CPU-QPU device driven by a high-level programming language available to the end user.

CONCLUSION (SUMMARY)

Quantum computing is still in its early stages, constrained by decoherence, noise, and low qubit counts. In the NISQ era, algorithm prototyping relies on emulation using classical hardware.

A hybrid CPU–GPU–FPGA architecture offers scalable and efficient emulation of quantum circuits. CPUs coordinate control logic; FPGAs enable low-latency parallelism; GPUs handle intensive floating-point calculations.

Pipelined execution and optimized memory management raise general throughput. Including QPUs into this system lets one selectively offload difficult quantum subroutines.

A high-level quantum programming language boosts accessibility and simplifies development. This system addresses the present constraints and gets ready for the next fault-tolerant quantum computers.

DEDICATED DATABASE FOR PERFORMANCE TESTS OF THE TRAINED NEURAL NETWORK MODEL YOLOV11N

Kamil FELTER

Faculty of Computer Science and Technology, University of Lomza, Poland
kfelter@al.edu.pl[1]

ABSTRACT

This article presents an application of the YOLO algorithm for object recognition. To train the algorithm, images of six types of sweets were collected and categorized. Image enhancement using visual effects was then applied. The effectiveness of the learning process was tested, achieving a precision and recoilprec mAP@0.5 level of (74%).

Key words: YOLO, object detection, convolutional neural network.

CONCLUSION

This article examines the application of artificial intelligence algorithms, in particular the YOLO environment, in the context of object recognition. The analysis carried out demonstrates the growing potential and availability of artificial intelligence methods in everyday applications. As part of the case study, a dataset consisting of photographs of six distinct categories of candy, acquired using a camera embedded in a mobile device, was created. To increase the size of the training samples, the dataset was subjected to a visual augmentation process. The YOLOv11n model was then taught to recognize the defined object classes. The results showed a mAP@0.5 efficiency of (74%). Difficulties were observed for the algorithm to accurately distinguish classes, resulting in confusion with other objects and background elements. Increasing the volume of training data by including additional images and video sequences was identified as a potential solution.

REFERENCES

[1] Tao Y, Li B, Li P, Qian J, Qi L. Improved lightweight YOLOV11 Algorithm for Real-Time Forest Fire Detection. Electronics [Internet]. 2025 Apr 9;14(8):1508. Available from: https://doi.org/10.3390/electronics14081508
[2] Zou X, Hu Y. Hidden Danger Detection and Identification System of Power Transmission Tower based on YOLOV11. Academic Journal of Science and Technology [Internet]. 2024 Nov 6;13(1):224–31. Available from: https://doi.org/10.54097/rs28p954
[3] Ultralytics. YOLO11 🚀 NEW . 2025. Available from: https://docs.ultralytics.com/models/yolo11/
[4] PyTorch documentation — PyTorch 2.7 documentation [Internet]. Available from: https://docs.pytorch.org/docs/stable/index.html
[5] Roboflow: Computer vision tools for developers and enterprises [Internet]. Roboflow. Available from: https://roboflow.com/
[6] Open Source data Labeling | Label Studio [Internet]. Label Studio. Available from: https://labelstud.io/

ADAPTIVE S-BOXES: CONCEPTS AND POTENTIAL IN LIGHTWEIGHT CRYPTOGRAPHY

Wiesław MALESZEWSKI
University of Lomza, Faculty of Computer Science and Technology, Lomza, Podlaskie, Poland
wmaleszewski@al.edu.pl

ABSTRACT

Adaptive S-boxes are dynamic substitution structures that extend the classical nonlinear layer used in symmetric block ciphers. Unlike static S-boxes, which remain fixed throughout the encryption process, adaptive S-boxes vary depending on parameters such as the key, encryption round, time, or environmental inputs. This variability enhances resistance against various forms of cryptanalysis, including linear, differential, and side-channel attacks. Their application is especially important in resource-constrained environments—such as IoT, RFID systems, and embedded devices—where long-term exposure increases the risk of profiling and exploitation of static structures.

This paper introduces a classification of adaptive S-boxes, including key-dependent, session- or round-specific, dynamically updated, context-aware (e.g., using biometric or hardware-based entropy), and plaintext-dependent constructions. Each approach introduces distinct trade-offs between cryptographic robustness and implementation overhead. To be considered secure, any adaptively generated S-box must fulfill strict criteria: high nonlinearity, low differential uniformity, satisfaction of the Strict Avalanche Criterion (SAC) and Bit Independence Criterion (BIC), and balanced output distribution. As highlighted in the literature, poorly constructed adaptive mechanisms may generate substitution boxes with degraded security properties. Therefore, this work proposes a comprehensive framework for evaluating adaptive S-boxes in terms of their cryptographic strength, vulnerability to attacks, and implementation cost.

Key words: adaptive S-box, cryptographic primitives, chaos-based cryptography.

CONCLUSION (SUMMARY)

Adaptive S-boxes offer a promising avenue for enhancing the security of symmetric encryption algorithms by eliminating the static predictability of traditional substitution layers. The article demonstrates that adaptively generated S-boxes especially those derived from key material, chaotic systems, or heuristic optimization can provide strong cryptographic protection even in environments with strict energy and computational constraints. Although such mechanisms require careful design and evaluation, their ability to impede conventional attacks makes them a valuable component of modern lightweight cryptography.

REFERENCES

[1] E. Biham, A. Shamir, Differential cryptanalysis of DES-like cryptosystems, Journal of Cryptology, vol. 4, no. 1, pp. 3–72, 1991. DOI: 10.1007/BF00198466
[2] M. Matsui, Linear Cryptanalysis Method for DES Cipher, Advances in Cryptology – EUROCRYPT'93, LNCS 765, Springer, pp. 386–397, 1994. DOI: 10.1007/3-540-48285-7_33
[3] K. Nyberg, Differentially uniform mappings for cryptography, Advances in Cryptology – EUROCRYPT'93, LNCS 765, Springer, pp. 55–64, 1994. DOI: 10.1007/3-540-48285-7_6
[4] W. Zhang, E. Pasalic, Highly nonlinear balanced S-boxes with good differential properties, IEEE Transactions on Information Theory, vol. 60, no. 11, pp. 7411–7423, 2014. DOI: 10.1109/TIT.2014.2360880
[5] A. H. Zahid et al., Secure key-based substitution-box design using systematic search for high nonlinearity, IEEE Access, vol. 11, pp. 132547–132561, 2023. DOI: 10.1109/ACCESS.2023.3339389

ANN AIDED ILC FOR REPEATABILITY AND ACCURACY CONTROL OF ROBOT MANIPULATOR

Arkadiusz NIECECKI[1], Arkadiusz MYSTKOWSKI [2]

[1]Department of Automation and Robotics, Faculty of Information Technology and Science, University of Łomża, Akademicka 14, 18-400 Łomża, Poland

[2]Departament of Automatic Control and Robotics, Faculty of Electrical Engineering, Bialystok University of Technology, Wiejska 45D, 15-351, Bialystok, Poland

aniecieckі@al.edu.pl [1], a.mystkowski@pb.edu.pl [2]

ABSTRACT:

This thesis discusses the problem of increasing the accuracy and repeatability of robotic manipulators through the use of advanced control strategies. It introduces the concepts of Iterative Learning Control and Artificial Neural Networks as methods for improving precision in repetitive tasks. The paper reviews current research in this area, highlighting the potential of learning algorithms. The preparation of a simulation environment using the UR5 robot, MATLAB, ROS and URSim software, and a testing methodology based on ISO 9283 are described. Preliminary results of trajectory simulations and a dataset of the robot's joint configuration and velocity are presented. Data gathered from offline simulator shows overshoot from desired position. The work indicates the need for further research on AI controllers to fully explore their capabilities in robotic applications.

Key words: Robotic manipulators, Iterative Learning Control, Artificial Neural Networks, Positioning accuracy, ISO 9283

CONCLUSION

Based on the presented examples ANN controllers show encouraging results in possible accuracy improvement but there is still not enough data to state it, certainly. This shows that AI controllers for robotic manipulators are not fully explored field.

Data obtained from the UR5 offline robot performing a given task in URSim shows high consistency with how the polynomial trajectory should look and slight imperfections from restrictions of the robot. A slight deviation from desired positions is visible when comparing Fig 2, 3 to Fig 4, 5. This should be tested to see if there are errors in bsplinepolytraj translation, restriction of virtual model, or delays in connection between ROS and MATLAB. Future development of the project should consist of extensive testing in this field as well as a PID controller and a vast variety of ILC ANN aided controllers tested on an offline simulator and real UR5 robot.

A REVIEW OF THE APPLICATION OF REINFORCEMENT LEARNING METHODS IN THE STABILIZATION OF THE FLEXIBLE MANIPULATOR EFFECTOR

Mateusz ZALEWSKI[1], Arkadiusz MYSTKOWSKI[2]

[1]Department of Automation and Robotics, Faculty of Information Technology and Science, Łomża University, Akademicka 14, 18-400 Łomża, Poland
[2]Departament of Atomatic Control and Robotics, Faculty of Electrical Engineering, Bialystok University of Technology, Wiejska 45D, 15-351, Bialystok, Poland

mzalewski@al.edu.pl [1], a.mystkowski@pb.edu.pl [2]

ABSTRACT

Flexible manipulators, unlike their rigid counterparts, offer advantages such as lower mass, which translates into lower energy consumption. However, their flexibility introduces challenges in the form of reduced precision and susceptibility to vibrations. Reinforcement learning is a promising solution to the problem, enabling the creation of systems capable of reducing vibrations and increasing the precision of the end effector. This paper reviews the applications of RL in the stabilization of flexible manipulator end effectors in recent years, focusing on vibration suppression and trajectory tracking.

Key words: reinforcement learning, flexible manipulator, RL, stabilization

CONCLUSION (SUMMARY)

In summary, the review of the scientific literature in recent years indicates a growing interest and intensive research on the application of reinforcement learning methods in the stabilization of the end effector of flexible manipulators. Various reinforcement learning algorithms, including DQN, DDPG, PPO, and SAC, have shown promising results in the vibration control and trajectory tracking of flexible manipulators. Despite significant progress, challenges such as the complexity of the state and action space, the design of reward functions, and the transfer of learning from simulation to reality still require further investigation. Future research will probably focus on the development of more sample-efficient methods and algorithms requiring less interaction with the environment. Reinforcement learning is a promising approach to solving complex control and stabilization problems, and further development in this field has the potential to significantly expand the capabilities of robotic systems.

POST-QUANTUM CRYPTOGRAPHY
&
ML AUTHENTICATION FOR FINANCIAL INSTITUTIONS

Volodymyr YURCHENKO[1,2], Romuald KOTOWSKI[1,2], Piotr TRONCZYK[1,2], Maryna KAMIENIEVA[1,2], Jan ZIOLKOWSKI[1,2], Olaf OLENSKI[1,2]

Polish-Japanese Academy of Information Technology, Faculty of Computer Science, Warsaw, Poland[1]
AI Quantum Tech, Warsaw, Poland[2]
contact@aiqt.net

ABSTRACT

The advent of quantum computing poses a significant existential threat to the security of current public-key cryptographic systems, which form the bedrock of digital security in financial institutions worldwide. This paper addresses the urgent need for financial organizations to transition to Post-Quantum Cryptography (PQC) to safeguard sensitive financial data, transactions, and communications against future quantum attacks. We discuss the NIST PQC standardization efforts, highlighting the chosen algorithms ML-KEM (Kyber), ML-DSA (Dilithium), and SLH-DSA (SPHINCS+), and outline a strategic framework for their adoption within financial environments. Emphasizing a Rust-oriented microservices approach, this paper proposes a novel architecture that integrates hybrid PQC, robust digital signatures for transactions, and an innovative behavioral machine learning (ML) based authentication system. This approach aims to deliver a fast, adaptive, and compliant quantum-safe solution for fintech, ensuring the long-term integrity and confidentiality of financial operations.

Key words: Post-Quantum Cryptography, PQC, Financial Institutions, Quantum Computing, NIST, Kyber, Dilithium, SPHINCS+, Cryptographic Agility, Hybrid Cryptography, Quantum Security, Cybersecurity.

CONCLUSION (SUMMARY)

Adopting**Post-Quantum Cryptography**is urgent for financial institutions. NIST's Kyber, Dilithium, and SPHINCS+ standards provide a crucial foundation. A strategic approach with crypto inventory, regulatory monitoring, and vendor diligence is key to mitigating quantum risks. Our proposed Rust-oriented microservices architecture, featuring hybrid PQC and ML-based authentication, offers a practical blueprint for securing financial services, ensuring resilience and enhanced user experience in the post-quantum era.

REFERENCES

[1] Sharon Goldberg, Wesley Evans, Bas Westerban, John Engates, (2025), “Conventional cryptography is under threat. Upgrade to post-quantum cryptography with Cloudflare Zero Trust”
[2] NIST Information Technology Laboratory (2025) „Post-Quantum Cryptography PQC” https://csrc.nist.gov/projects/post-quantum-cryptography

SYSTEMATIZATION OF KNOWLEDGE: OPTIMIZATION FOR CLASSICAL MACHINE LEARNING

Volodymyr YURCHENKO[1,2], Romuald KOTOWSKI[1,2], Piotr TRONCZYK[1,2], Andrii KULYZHSKYI[1,2], Nazar KARABYN[1,2], Nazarii KUDRYK[1,2], Maksym POLTAVTSEV[1,2], Dmytro NAKONECHNYI[1,2]

Polish-Japanese Academy of Information Technology, Faculty of Computer Science, Warsaw, Poland[1]

AI Quantum Tech, Warsaw, Poland[2]

contact@aiqt.net

ABSTRACT

This Systematization of Knowledge (SoK) paper evaluates the integration of quantum optimization techniques into traditional machine learning (ML) algorithms. By analyzing research from 2022 to May 2025 we explore Quantum Annealing (QA), variational quantum algorithms, like the Quantum Approximate Optimization Algorithm (QAOA) and Variational Quantum Eigensolver (VQE) Grover style amplitude amplification methods and combined quantum classical workflows aiming to enhance or speed up optimizers. Our study indicates that even though the theory presents a scenario there hasn't been a clear-cut quantum leap ahead of established classical optimizers at problem sizes that matter in practice yet. Progress is limited by the challenges posed by Noisy Intermediate Scale Quantum (NISQ) hardware, which is directing research, towards methods Quadratic Unconstrained Binary Optimization (QUBO) and combinations thereof. Our research presents a classification system for utilizing quantum optimization in machine learning. We also offer a comparison of six popular classical machine learning algorithms; k means clustering, Support Vector Machines, Decision Trees, Random Forests, Linear and Logistic Regression and Markov Decision Processes. In addition, to this analysis we evaluate unresolved research queries and propose pathways for future investigations. Our goal is to offer an assessment of the current status and future prospects of this field.

Key words: Quantum Computing, Machine Learning, Quantum Optimization, Quantum Machine Learning (QML), Quantum Annealing, Variational Quantum Algorithms (VQA), QAOA, VQE, Grover's Algorithm, Support Vector Machines (SVM), k-means Clustering, Random Forests, Markov Decision Processes (MDPS), QUBO, NISQ, Hybrid Quantum-Classical Algorithms

CONCLUSION (SUMMARY)

Quantum optimization for classical machine learning remains an appealing yet experimental concept. Simulations and small-scale hardware runs show potential speed-ups, but only on toy problems; NISQ constraints few qubits, sparse connectivity, and significant noise block large practical tasks. Researchers therefore rely on heuristics, QUBO encodings, and hybrid quantum classical pipelines.

Across the six algorithms analysed, the chief obstacle is translating each method into a quantum-compatible form. QUBO mappings and kernel techniques drive current work in *k*-means and SVMs but have yet to surpass classical baselines on real data. Quantum studies of decision trees and random forests focus on niche subroutines, awaiting progress in quantum-addressable memory. Linear and logistic regression have shifted from HHL-style solvers to variational circuits and annealers, while Markov Decision Processes exploit limited speed-ups in policy evaluation. For realistic instance sizes, classical optimizers still dominate [1].

Key bottlenecks include hardware scale, noise-limited circuit depth, data-loading overheads, and the still-nascent study of fairness and interpretability. Nonetheless, incremental advances in devices and algorithms continue. In the near term, targeted hybrid workflows offer the most credible path to benefit; in the long term, fault-tolerant machines will be essential for broad quantum advantage. Rigorous benchmarking and cautious evaluation, as undertaken here, remain critical to guide research toward applications where quantum computing can deliver genuine impact.

REFERENCES

[1] J. L. Yunfei Wang, (2024), „A comprehensive review of Quantum Machine Learning“ https://arxiv.org/pdf/2401.11351.

SECURITY OF OBJECT DETECTION SYSTEMS UTILIZING STEREOSCOPIC IMAGE PROCESSING TECHNIQUES

Marta CHODYKA[1], Jakub BEDNARCZYK[2]
University of Łomza, Poland [1]
University of Łomza, Poland [2]
mchodyka@al.edu.pl[1], jakub.j.bednarczyk@gmail.com[2]

ABSTRACT

This paper analyzes the security and reliability of a stereoscopic vision-based object detection system for close-range applications (0.60–0.90 m). Four different approaches were compared: classic block-matching StereoBM, semi-global StereoSGBM, a lightweight deep neural network (Fast ACV), and a novel hybrid method combining cascade classifiers with local stereo matching. Tests were performed under ideal and disturbed lighting conditions at varying camera baselines (7.5 cm, 18.5 cm, 23.5 cm). StereoSGBM provided the best balance between accuracy (errors of 3–5 mm) and speed, maintaining map continuity even under photometric disturbances. Fast ACV achieved the lowest errors (<2%) under optimal conditions but struggled with severe overexposure, highlighting the need for additional training on challenging datasets. The hybrid method reduced computational load via selective region processing, reaching real-time performance (≥15 fps) with distance accuracy around 1–2%, though its effectiveness depended on object detection reliability. An optimal camera baseline of 18.5 cm balanced visibility and precision. The study recommends redundancy strategies, combining fast classical methods for initial detection with deep or hybrid methods for verification, expanded deep network training under difficult lighting conditions, and integration of stereo vision with radar to enhance system robustness.

Key words: stereovision, object detection, security, stereo matching algorithms, deep learning, photometric robustness

CONCLUSION (SUMMARY)

This study confirmed that stereovision significantly improves object detection in safety-critical scenarios by providing accurate depth perception and proximity assessment. Deep learning methods (Fast ACVNet) achieved the lowest errors but suffered from instability under poor lighting, suggesting their use mainly for verification purposes. Among classical solutions, StereoSGBM offered the best balance of accuracy and speed, while StereoBM was fastest but struggled under challenging conditions. A proposed hybrid method efficiently combined local accuracy with faster processing but depended heavily on object detection reliability. Optimal camera baseline (18.5 cm) and precise calibration were identified as critical factors. Recommendations include combining deep and classical algorithms for redundancy, employing HDR imaging, and integrating additional sensors such as radar or thermal cameras for enhanced reliability.

REFERENCES

[1] H. Hirschmüller (2008), „Stereo processing by semi-global matching and mutual information”, IEEE Transactions on Pattern Analysis and Machine Intelligence, t. 30, nr 2, s. 328–341.
[2] N. Mayer, E. Ilg, P. Hausser, P. Fischer, D. Cremers, A. Dosovitskiy, T. Brox (2016), „A large dataset to train convolutional networks for disparity, optical flow, and scene flow estimation”, IEEE Conference on Computer Vision and Pattern Recognition (CVPR), s. 4040–4048.
[3] J.C. Rodriguez Quiñonez i in. (2024), „Selective Object-aware Real-time Stereo Matching for Automotive Safety Systems”, IEEE Sensors Journal, t. 24, nr 6, s. 1823–1831.
[4] D. Scharstein, R. Szeliski (2002), „A Taxonomy and Evaluation of Dense Two-Frame Stereo Correspondence Algorithms”, International Journal of Computer Vision, t. 47, nr 1–3, s. 7–42.
[5] B. Sumetheeprasit (2023), „Adjustable baseline stereo for dynamic environments”, Robotics and Autonomous Systems, t. 160, art. 104335.
[6] G. Xu i in. (2022), „ACVNet: Attention Concatenation Volume for Accurate and Efficient Stereo Matching”, IEEE Conference on Computer Vision and Pattern Recognition (CVPR), s. 12977–12986.

INFORMATION SECURITY IN PERSONALIZED LEARNING SUPPORTED BY ARTIFICIAL INTELLIGENCE AND E-LEARNING PLATFORMS

Marta CHODYKA[1], Kamil KOMOROWSKI[2]

University of Łomza, Poland [1]

University of Łomza, Poland [2]

mchodyka@al.edu.pl[1], komorowskikamil@gmail.com[2]

ABSTRACT

The rapid adoption of artificial intelligence (AI) in e-learning enables highly personalized instruction, yet introduces serious information-security challenges. This study evaluates the effectiveness of AI-enhanced platforms—specifically Google Classroom integrated with a GPT language model—for personalized STEM teaching while safeguarding learner data. An experiment comparing AI and control groups combined penetration testing (OWASP ZAP scans), a controlled phishing simulation, and activity-log analysis. AI integration boosted student engagement (~45 % increase in platform activity) and learning efficiency, but doubled susceptibility to tailored social-engineering attacks. Implemented countermeasures—data pseudonymization before model calls, mandatory strong passwords and 2-factor authentication, and a least-privilege access policy—significantly reduced privacy risks. Targeted security training further raised students' cybersecurity awareness by ~26 percentage points. The findings show that AI-driven personalized learning can remain safe provided a security-by-design approach, robust technical safeguards, and continuous user education are applied.

Key words: information security, personalized learning, artificial intelligence, e-learning, data protection, privacy, cybersecurity.

CONCLUSION (SUMMARY)

AI-driven personalized learning can substantially boost instructional effectiveness, but its deployment must explicitly address information-security concerns. Our findings show that higher student engagement, improved performance and greater security awareness need not conflict with data protection, provided adequate safeguards are in place. Risks identified in the experiment—from technical vulnerabilities such as XSS and CSRF to AI-enabled social-engineering attacks—were successfully mitigated through a blend of security-by-design measures, strict data minimisation, regular audits, and targeted cybersecurity training for users. Adhering to encryption, multi-factor authentication, least-privilege access, and GDPR/FERPA-compliant data-protection policies allows schools to reap the full benefits of adaptive AI techniques without exposing the learning community to unacceptable privacy or integrity threats. In sum, effective AI integration in education demands the parallel advancement of innovative pedagogy and robust security controls so that modern e-learning platforms deliver safe, truly personalised learning experiences.

REFERENCES

[1] Fu, Y., & Weng, Z. (2024). Navigating the ethical terrain of AI in education: A systematic review on framing responsible human-centered AI practices. Computers and Education: Artificial Intelligence, 7, 100306.
[2] Jian, M. J. K. O. (2023). Personalized learning through AI. Advances in Engineering Innovation, 5 (1), 16–19.
[3] Mishra, A. (2023). Enhancing personalized learning with artificial intelligence: Opportunities and challenges. Research Review International Journal of Multidisciplinary, 8 (8), 73–80.
[4] Monika, T., Reddy, C. K. K., Ramana Murthy, B. V., & Nag, A. (2024). AI and education: Bridging the gap to personalized, efficient, and accessible learning. In Internet of Behavior-Based Computational Intelligence for Smart Education Systems (Chap. 5). IGI Global.
[5] Tempestini, G., Merà, S., Palange, M. P., Bucciarelli, A., & Di Nocera, F. (2024). Improving the cybersecurity awareness of young adults through a game-based informal learning strategy. Information, 15 (10), 607.
[6] Xiao, H., & Li, J. (2024). Balancing innovation and privacy: Safeguarding personal information in the AI-driven digital era. Applied and Computational Engineering, 118 (1), 23–29.

INFORMATION SECURITY IN ANALYTICAL APPLICATIONS PROCESSING TELEMETRY DATA

Marta CHODYKA[1], Rafał ZAKRZEWSKI[2]
University of Łomza, Poland [1]
University of Łomza, Poland [2]
mchodyka@al.edu.pl[1], rzakeu@gmail.com[2]

ABSTRACT

This work evaluates the security–performance trade-offs in real-time telemetry analytics by benchmarking a 3 × 3 matrix of back-end technologies: Node.js v20, Deno v1.43 and Bun v1.1 combined with PostgreSQL 15, MongoDB 7 and Apache Cassandra 4. A 54-hour load test, driven by 5 000 virtual F1 cars producing up to 6 000 UDP packets per second, measured p95 write latency, throughput and resource utilisation, while residual STRIDE risk was computed via dependency scanning and penetration testing. Bun + Cassandra delivered the highest throughput (≥10 000 writes s^{-1}, p95 = 8.3 ms) but incurred the greatest CPU load. Deno + PostgreSQL achieved the lowest residual risk (Z = –1.04) with moderate latency, whereas Node.js + MongoDB exhibited the highest risk (Z = 1.22), confirming a strong positive correlation between dependency depth and vulnerability exposure (ρ = 0.82). The findings advocate a context-aware co-design approach: Bun + Cassandra for extreme throughput, Deno + PostgreSQL for compliance-driven deployments.

Key words: information security, telemetry analytics, STRIDE risk, JavaScript environments, PostgreSQL, MongoDB, Apache Cassandra, performance–security co-design.

CONCLUSION (SUMMARY)

Experimental results show that architectural decisions in telemetry pipelines must balance performance goals against the expanding security surface created by extensive software dependencies. The Bun–Cassandra pairing excels in latency and horizontal scalability but demands robust DoS counter-measures due to heavy resource consumption. In contrast, the Deno–PostgreSQL stack minimises attack surface through a sandboxed permission model and granular database access control, making it preferable where regulatory compliance and auditability dominate. Node.js with MongoDB remains the most flexible option for rapid prototyping, yet its lengthy dependency chain necessitates stringent patch management and continuous supply-chain monitoring. Future research should extend testing to containerised sandboxes (gVisor, Kata Containers), include energy and maintenance cost metrics, and adopt artefact-signing frameworks such as Sigstore to further mitigate supply-chain risk.

REFERENCES

[1] Decan M., Mens T., Claes M. (2018) On the Impact of Security Vulnerabilities in the npm Package Dependency Network. Proceedings of the IEEE International Conference on Software Maintenance and Evolution (ICSME 2018), pp. 181–190.
[2] Abbadini M., Facchinetti D., Oldani G., Rossi M., Paraboschi S. (2023) Cage4Deno: A Fine-Grained Sandbox for Deno Subprocesses. Proceedings of ACM ASIA CCS '23.
[3] AlHamdan A., Staicu C.-A. (2025) Welcome to Jurassic Park: A Comprehensive Study of Security Risks in Deno and its Ecosystem. NDSS Symposium 2025.
[4] Orman A. (2025) Cyberattack Detection Systems in Industrial Internet of Things Networks in Big Data Environments. Applied Sciences, 15(6), 3121.
[5] Samaana H., Costa D. E., Abdellatif A., Shihab E. (2024) Opportunities and Security Risks of Technical Leverage: A Replication Study on the npm Ecosystem. Empirical Software Engineering, 29 (2).
[6] Dritsas E., Trigka M. (2025) A Survey on Cybersecurity in the Internet of Things. Future Internet, 17 (1), 30.

INDEX OF AUTHORS


IT 2025
INNOVATION TRENDS