

# Model of Immersive Educational Instruments of Behavioral Analysis and Management in Distributed Educational Teams

Iurii Volk  
Faculty of Electronics and Information  
Technology  
Sumy State University  
Sumy, Ukraine  
y.volk@mss.sumdu.edu.ua

Artem Artyukhov  
University of Economics in Bratislava  
Bratislava, Slovakia  
WSEI University  
Lublin, Poland  
artem.artiukhov@euba.sk

Nadiia Artyukhova  
Research Department  
Sumy State University  
Sumy, Ukraine  
n.artiukhova@pohnp.sumdu.edu

Oleksandr Dluhopolskyi  
West Ukrainian National University  
Ternopil, Ukraine  
WSEI University  
Lublin, Poland  
dlugopolsky77@gmail.com

Tetiana Dluhopolska  
Department of International Economic  
Relations  
West Ukrainian National University  
Ternopil, Ukraine  
tetianadluhopolska@gmail.com

Anzhela Kuznyetsova  
Department of Financial Technologies  
& Entrepreneurship  
Sumy State University  
Sumy, Ukraine  
angelkuzn@gmail.com

**Abstract**—Current work presents an attempt to model a process of comprehensive behavioral analysis of immersive educational tools to develop a clear method of their classification and application guidelines. The research question posed by current study is the following: “What elements of immersive education tool are associated with the highest amount of student learning engagement?”. The hypothesis which we test to answer the research question is formulated as “Salient elements of visual representation of immersive educational instrument are engaging most of respondents on pre-attentive processing stage”. Key aims of the study include development of a model of implementing immersive educational instruments into conventional educational setup and discussion along with analysis oriented on distributed educational environments. We developed a comprehensive study design allowing to perform behavioral experiments on reaction to stimuli which represent the core elements of immersive educational tools. Presenting a design of multimodal behavioral experiment including eye-tracking, facial expression analysis and biometrical data analysis we indicate key factors providing evidence of immersion effectiveness for various classes and types of educational instruments. The discussed component-based model not only serves as an organizational tool for establishing a digital infrastructure for innovative distributed universities but also offers a novel framework for understanding the underlying architecture of immersive educational tools. Furthermore, the behavioral study design presented in this article goes beyond conventional approaches by focusing on identifying the specific elements of immersive educational tools that lead to the highest levels of learner engagement, thus contributing to a deeper understanding of the mechanisms underlying immersive learning experiences. The results of current study will be of interest to a wide range of educational institutions utilizing innovative educational techniques in their practice.

**Keywords**—immersive education, innovative university, behavioral analysis, eye-tracking

## I. INTRODUCTION

Modern higher education systems are facing several challenges posed by dynamically changing political, social, and economic situations. Even though traditional teaching and learning techniques can be transformed to use in various educational setups, the use of immersive instruments requires additional effort from educational management. The current situation in higher education worldwide is welcoming towards various innovative technologies aimed at addressing several

challenges posed by dynamically changing political, social and economic situations [1; 2]. The viability of modern higher education system can be tied to a configuration of an “educator’s toolbox” employed in the learning process. Diversity and effectiveness of learning tools forming such a toolbox define the competitiveness of the higher education system. This is especially applicable to modern distributed educational systems when tutors and learners are forced to use information and communications technologies and traditional teaching/learning techniques are less applicable. Immersive learning tools such as AR, AR+, VR, etc. are offering an overhaul of the educational landscape by introducing a completely new level of learner’s engagement in the educational scenario. Even though traditional teaching and learning techniques can be transformed to use in various educational setups, the use of immersive instruments requires additional effort from educational management.

Current study deals with background of distributed educational environments which prevail in modern landscape of higher education. We present a model of distributed university teams functioning and management including behavioral analysis interface between university management and e-learning system. We came up with behavioral experiment design template allowing to keep learners’ engagement level controlled in distributed educational environments. The research question we pose in proposed behavioral study template is the following: “What elements of immersive education tool are associated with the highest amount of student learning engagement”? The hypothesis which we propose to test to answer the research question is formulated as “Salient elements of visual representation of immersive educational instrument are engaging most of respondents on pre-attentive processing stage”. Presented model of distributed university might be recommended for implementation for Ukrainian universities forced to work in conditions of relocated personnel and online learning due to continued Russian aggression against Ukraine [3; 4]. Behavioral study design template will be interesting for all educational institutions implementing immersive learning instruments in their workflow.

## II. LITERATURE ANALYSIS

The landscape of modern literature on topic highlights the inevitable digitalization of all educational processes, as well as corporate environments [5; 6; 7; 8; 9]. Innovative and

digital economies require rapid reaction to challenges presented by constantly developing counteragents [10]. Current educational systems are aimed at transferring from “spoon-feeding” learning towards immersive learning and building bridge communications allowing learners to be actively engaged in the educational process [11; 12; 13; 14]. Among immersive tools allowing to create a new generation of educational environment, virtual reality (VR) tools are particularly promising [15; 16; 17; 18]. However, as stated by J.Radianti, T.Majchrzak, J.Fromm, I.Wohlgenannt, “the majority of authors treated VR as a promising learning tool for higher education, however, the maturity of the use of VR in higher education is still questionable” [19].

Immersive instruments have no competition in providing online capabilities in skill-based learning, where practical application of manual skills is required but cannot be implemented due to various reasons [20; 21]. Such situations can often occur in medical education when the learning team is forced to work remotely [22; 23]. Evidence suggests that immersive VR tools facilitate effective learning through simulated real-life context [24]. Widely applied is the eye-tracking technology to measure the engagement level through visual attention distribution of learners [25; 25; 27; 28]. Sources indicate, that behavioral analysis of immersive learning tools tend to be the most effective metric to evaluate the learners engagement in immersive learning scenario. Questions of immersive educational systems management have been a point of interest for some researchers [29; 30; 31] as well as authors of current work [16; 32]. Evidence suggests that modern education management tend to lean towards various agile models that offer quick and effective decision making process for distributed educational teams [33; 34; 35].

We supplement conventional literature review with bibliometric analysis conducted using VOSviewer software presented in Figure 1. We use Scopus database, query to analyse is “immersive education”, years of publication 2020-2023, number of articles – 2000. The results presented are grouped into 5 thematic clusters with total 15830 links between items. The largest cluster containing “virtual reality” item with 344 links and 975 occurrences indicate that immersive education tools such as virtual reality are used in various learning and research scenarios. Item “e-learning” with 307 links and 472 occurrences indicate that modern e-learning environments largely incorporate immersive learning techniques and are incorporated across various knowledge fields (Figure 2).

The articles [36; 37] explores an integrated approach for implementing immersive learning at the university level. This approach includes the establishment of a specialized laboratory equipped with virtual and augmented reality technologies, the incorporation of immersive learning methodologies into university curricula, the development of software and hardware solutions for immersive learning, and the assessment of the effectiveness of these immersive learning techniques. The authors also describe products designed to fulfill the university's third mission – ensuring the well-being of citizens. AR/VR technologies offer significant promise in the educational technology space due to their immersive capabilities, innovative information-sharing methods, and potential to provide virtual experiences that overcome cost and distance barriers [38]. In higher education, AR/VR facilitates the understanding of abstract concepts and offers hands-on experience in low-risk virtual environments.

The paper [39] introduces a socially immersive learning (SIL) pedagogy, addressing the need for a new skill set in a fragmented socio-economic landscape, emphasizing connectivity and collaboration. Current HEIs systems are predominantly designed for on-campus students, often neglecting the unique needs and experiences of online learners, thus overlooking the potential relational strengths of e-learning communities. The evolving educational landscape requires permeable departmental silos and increased collaboration to address complex global issues, challenging traditional education designs and fostering student-centric engagement and new learning opportunities.

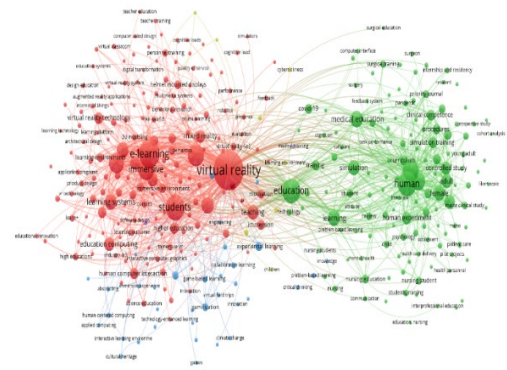


Fig. 1. Bibliometric landscape by query “immersive education”

Source: original research, VOSviewer

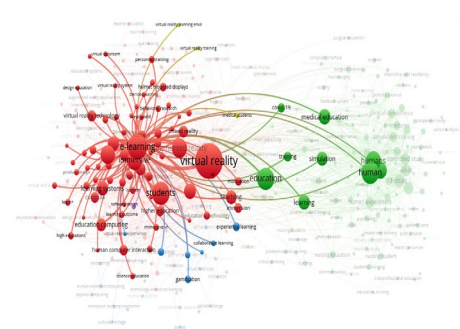


Fig. 2. “e-learning” item links to other items in landscape

Source: original research, VOSviewer

Various sources [40; 41; 42; 43] have examined different methods of utilizing immersive learning in the contemporary world. Immersive role-playing and simulations have long been foundational components in learning and development programs globally. Based on the analysis of the research landscape in the area, we clearly recognize additional effort required from educational management for the successful integration of immersive instruments into higher education systems. This suggests potential challenges in terms of resource allocation, training, and infrastructure development. Despite the promising potential of virtual reality (VR) tools in enhancing learning experiences, there remains a gap between theoretical discussions and practical implementation in higher education. Bridging this gap requires targeted efforts such as establishing interdisciplinary collaborations between educators, technologists, and researchers thus fostering a culture of experimentation and innovation within educational institutions. This work proposes a comprehensive set of tools to set grounds for such collaboration through providing a clear organizational setup and experimental study design for using multimodal behavioral analysis.

### III. METHODOLOGY

Considering the results of literature review and bibliometric analysis, the aim of the article is set on proposing a comprehensive model of immersive learning tools implementation and effectiveness assessment in distributed educational environments. For the full systematic description of such model, we use UML component diagram to present a workflow incorporating distributed university concept along with behavioral engagement assessment interface. The methodological choice of UML component diagram not only facilitates a clear delineation of the model's components but also affords a practical tool for stakeholders seeking to establish a digitalized infrastructure open to the realization of innovative distributed universities.

As indicated by literature review, one of the most popular modalities allowing the studies of visual attention in educational materials is eye-tracking [24; 44]. Study design proposed in the current article focuses on defining the elements of immersive education tool that are associated with highest levels of learner engagement. For a minimal-scale focus group providing relevant results it is best to use at least 20 participants with even gender and age distribution. All participants should have no or corrected vision defects. All participants should have no exposure to the purpose of the study and/or study design. After completing the full experiment, the purpose of the study is disclosed to each participant. Participants must provide verbal informed consent before commencing the experiment. Trials should be performed in normal working conditions: during daylight, no artificial lighting, no flares on the computer screen. Participants sit on a chair in pose instructed by equipment operator. Equipment necessary to conduct presented study design: eye-tracker, webcam for collecting face expression data, galvanic skin response kit and controlling software suite for presenting stimuli and collecting data. Supposedly, salience of visual representation elements will be the defining factor in attracting learners' attention during the immersive scenario. Utilizing presented study design as a deliverable, educational institutions that are forced to operate in distributed manner can seamlessly incorporate the behavioral studies as the part of the management process.

### IV. RESULTS

Figure 3 depicts a comprehensive component diagram illustrating the operational framework and managerial structure of distributed university teams. Within this diagram, the Distributed University component is prominently featured, showcasing its pivotal role in the network. Notably, the Distributed University component exhibits a port facilitating communication connectivity with the Stakeholders Pool, thereby establishing a crucial dependency relationship with external stakeholders affiliated with the university. Upon closer examination of the Distributed University component, it becomes apparent that it comprises subordinate components, functioning as integral subsystems within the university's operational architecture.

Internal Faculty Team as the component describes the operation of internal university team not affected by relocation of personnel. However, the austerity of working conditions might affect the operation of internal team. This component is interfaced with University Management component through Direct Communication Interface. This direct communication includes face-to-face contacts as well as mailing, messaging, etc., and features low-latency management-faculty responses

and vice versa. Internal Faculty Team component features self-explanatory dependency on University Management component. Functioning of Internal Faculty Team is ensured by following ground-level components: Research Staff and Teaching Staff that operate depending on Department Level Management. Department Level Management in the internal team setup provides the level of independence from higher-level decision making thus liberalizing providing friendly and agile working environment. Educational and scientific content along with standard operational deliverables are supplied onto the outgoing port connected to the Direct Communication Interface. The Internal Faculty team retains full access to ICT System interface and, hence, E-learning system in order to provide learners with educational content. External Faculty Team component models the operation of faculty not included to the internal team due to relocation or any other reasons. This component is interfaced with E-learning system component through ICT System interface. Distributed teams are forced to operate mainly through means of digital communication, therefore, using proprietary ICT system for access to e-learning environment might pose a challenge due to the issues of accessibility. On the other hand, proprietary ICT offers customization abilities that allow us to tailor the system to the needs of particular educational disciplines. External Faculty team operates in a manner like Internal Faculty Team, however, establishing Department Level Management in a remote office-less setup is nearly impossible. Therefore, the proposed model offers operation based off regulatory framework that provides guidance for remote Research and Teaching Staff. Outputs of these components are communicated to the outgoing port of External Faculty Team component and then supplied towards the ICT System interface.

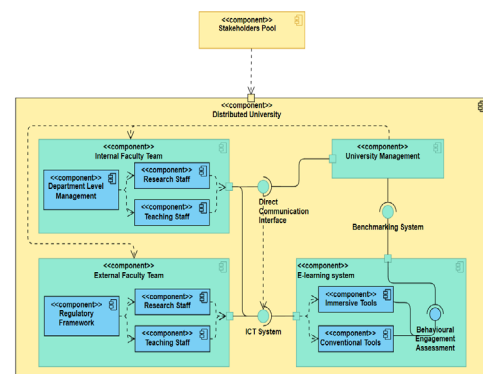


Fig. 3. Component diagram of distributed university teams functioning and management

Source: original research, Visual Paradigm online

E-learning System component include sub-systems that realize the educational process through conventional learning tools ("spoon-feeding" teaching, seminars, webinars, lectures, etc.) as well as immersive learning tools (VR-simulations, immersive problem-solving scenarios, feedback-based lectures, etc.). Operation of these components is governed by Research and Teaching Staff through ICT System. In the proposed model both conventional and immersive learning instruments are subject to behavioral analysis aimed at assessing learners' engagement level. Multimodal behavioral experiments can be used to assess the distribution of visual attention and emotional response towards presented stimulus. Modalities that serve this purpose include eye-tracking, facial expression analysis, galvanic skin response (GSR) analysis, heart rate signal tracking, etc.

Figure 4 presents the template of a study design allowing to measure learners' engagement in the immersive educational environment. In the framework of the proposed model, immersive and conventional learning tools are subjected to regular behavioral assessment of engagement which is realized through corresponding interface within E-learning System component. Results of such assessments are supplied to the output port of E-learning System component and to Benchmarking System interface. From this interface, the behavioral analysis reports are accessed by University Management and incorporated into the decision-making process regarding forming an overall educational landscape.

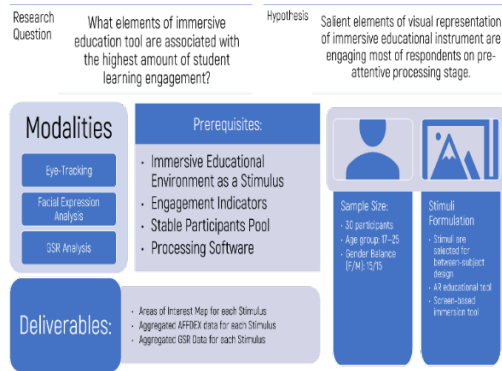


Fig. 4. Study design for behavioral analysis of immersive education tools

Source: original research, MS Powerpoint

University Management components operate as conventional management units in any project. However, a recommendation can be offered within the proposed model to incorporate agile methodologies for managing distributed educational teams. This approach allows for effective and timely decision making that serves the needs of all system components as well as external stakeholders. Figure 4 presents the study design for behavioral analysis of immersive education tools. In this template oriented towards research question and hypothesis stated above, we propose to use multimodal behavioral experiments as the assessment framework for immersive learning tools. Deliverables stated by current study design allow to obtain necessary data to use in decision making by university management. Areas of interest map allow to modify visual representation of a stimulus to keep learners engaged even at the opening experience with learning tools. Aggregated data from facial expression analysis and GSR data allow to define learner's initial emotional response when interfacing with immersive stimulus. Note that current study design focuses on the preattentive processing stage. This stage of perception defines the further experience with visual stimulus [45; 46] and must be considered in the learning tool design. Next, we attempt to present a context for operation of proposed model in Ukrainian educational landscape. We investigate Global Innovation Index (GII) data to illustrate the level of innovation in Ukrainian education and compare it to peer economies in the same income group. Table 1 provides a comparison of GII indicators across top-5 countries in lower middle-income group as defined by GII: Ukraine, India, Viet Nam, Iran, and the Philippines. Table covers the following innovation input indicators: expenditure on education as a percentage of GDP; graduates in science and engineering as a percentage of the total number of graduates; researchers as a full-time equivalent (FTE) per million population; QS university ranking within the top 3 universities; access to ICT (information and communication technology).

The Table 1 presents the rank and score for each of these indicators for each country and we analyze this data from Ukrainian perspective. Ukraine ranks 27<sup>th</sup> in indicator "Expenditure on education" with a score of 49.5, indicating that the country spends a moderate amount of its GDP on education. However, there is room for improvement in this area as there are many countries that spend a higher percentage of their GDP on education.

TABLE I. GII INNOVATION INPUT INDICATORS ACROSS TOP 5 COUNTRIES IN LOWER MIDDLE-INCOME GROUP

GII Indicator	Ukraine		India		Viet Nam		Iran		Philippines	
	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Expenditure on education, %	27	49.5	60	37.9	75	32.9	94	27.3	83	30.7
Graduates in science and engineering, %	41	50.0	11	82.0	54	44.6	2	99.8	52	45.1
Researchers, FTE/mn pop.	54	9.6	82	2.7	60	8.5	47	18.9	84	1.8
QS university ranking, top 3	48	20.3	24	46.0	66	8.1	43	25.8	48	20.3
ICT access	66	86.6	99	70.4	41	90.5	63	88.0	100	69.4

Source: Global Innovation Index, indicators selected, and table composed by authors

There are a few factors that could potentially contribute to Ukraine's higher expenditure on education: 1. Historical emphasis on education: Ukraine has a long history of emphasizing the importance of education, with high literacy rates and a strong tradition of academic excellence. This cultural emphasis on education may translate into a higher level of investment in education. 2. Economic policies: Ukraine government made a conscious decision to prioritize education spending as part of its economic policies. Investing in education has long-term economic benefits, such as increasing productivity, promoting innovation, and reducing poverty. 3. International assistance: Ukraine receives international assistance in the form of education aid, which could contribute to its higher expenditure on education.

Ukraine ranks 41<sup>st</sup> in indicator "Graduates in science and engineering" with a score of 50.0, indicating that the country has a moderate percentage of graduates in science and engineering fields. While Ukraine has a long history of excellence in STEM education, the country could focus on increasing the number of graduates in these fields to improve its ranking in this category. The contrast is particularly notorious comparing Ukraine's scores with India (rank 11, score 82) and Iran (rank 2, score 99.8). However, such high



indicators of graduates in science and engineering fields may indicate disbalance in country educational policies. Ukraine ranks 54<sup>th</sup> in indicator “Researchers” with a score of 9.6, indicating that there are relatively few researchers in the country. This suggests that there is a need for greater investment in research and development to increase the number of researchers and improve the quality of research in Ukraine. However, comparison to other economies of lower middle-income group suggests that Ukraine possess stronger research infrastructure, with a higher number of researchers per million population compared to all countries listed in the table except Iran. However, there are factors that influence a country's research capabilities, such as the quality of research institutions, availability of research funding, and the level of collaboration between academia and industry. Regarding the indicator “QS university ranking” we can see that India and Iran have the highest scores in the QS university ranking indicator across top 5 countries in lower middle-income group, ranking 24<sup>th</sup> and 43<sup>rd</sup> in general GII respectively. Ukraine and the Philippines have the same score, ranking 48<sup>th</sup>. Vietnam has the lowest score in this indicator, ranking 66<sup>th</sup>. This suggests that India and Iran have stronger university systems, with more universities ranked among the top 3 in their respective fields, than Ukraine and the other countries listed in the table. However, it's worth noting that QS university rankings are just one measure of a university's quality and should be interpreted with caution. There are many other factors that could influence a country's higher education system, such as the availability of research funding, the quality of teaching and research, and the level of international collaboration. Finally, comparison across indicator “ICT access” suggests that Vietnam has the highest score in the ICT access indicator, ranking 41<sup>st</sup> out of the 128 countries listed, followed by Ukraine and Iran with relatively high scores as well, ranking 66<sup>th</sup> and 63<sup>rd</sup>, respectively. It is evident that Ukraine, Vietnam, and Iran have better access to ICT infrastructure and services, such as internet connectivity and mobile phone usage, compared to India and the Philippines. However, one should note that measures of a country's digital readiness are not limited to ICT access. Overall digital competitiveness of a country can be also influenced by factors such as the level of digital skills, innovation capacity, and government policies supporting the digital economy.

## V. DISCUSSION

This article proposes a comprehensive model for implementing and assessing the effectiveness of immersive learning tools in distributed educational environments, based on the results of a literature review and bibliometric analysis. To fully describe this model, we use a UML component diagram to illustrate a workflow that includes the distributed university concept and a behavioral engagement assessment interface. Current study aims to create a model for integrating immersive educational tools into traditional educational settings and explores their effectiveness in distributed learning environments. To achieve this, we developed a comprehensive study design that includes behavioral experiments using stimuli that are central to immersive educational tools. Our multimodal approach involves eye-tracking, facial expression analysis, and biometric data analysis to identify key factors that contribute to the effectiveness of immersion in different types of educational tools and classes. We provide a contextual overview of the proposed model's applicability in the Ukrainian educational landscape. To achieve this, we analyze data from the Global Innovation Index (GII) to illustrate the

level of innovation in Ukrainian education and compare it to other economies in the same income group. Specifically, we compare Ukraine's GII indicators to those of the top five countries in the lower middle-income group as defined by GII: India, Vietnam, Iran, and the Philippines.

## VI. CONCLUSION

The model proposed in current research represents a comprehensive approach that allow to incorporate immersive educational instruments into workflow of universities that are facing challenges of working in distributed fashion. Behavioral analysis techniques are proposed as a tool to supplement decision-making process on the management level with hands-on data about educational process outcomes. Discussed component-based model can serve as an organizational chart for establishing a digital infrastructure for innovative distributed universities. Behavioral study design presented in this article focuses on identifying the elements of immersive educational tools that lead to the highest levels of learner engagement. Discussed findings will be relevant to a wide range of educational institutions that incorporate innovative educational techniques into their teaching practices.

## REFERENCES

- [1] I. Pozovna, S. Arhipov and A. Kuzior, “Determinants of Leadership in Higher Education in European Countries,” *Business Ethics and Leadership*, 2023, Vol. 7(4), pp. 210-224, doi: 10.61093/bel.7(4).210-224.2023
- [2] M. Habenko, V. Koibichuk, D. Krawczyk, T. Mayboroda and A. Samoilikova, “Implementation of knowledge economy and innovation through business education,” *SocioEconomic Challenges*, 2023, 7(4), pp. 211-222, doi: 10.61093/sec.7(4).211-222.2023
- [3] A. Artyukhov, I. Volk, T. Vasylieva and S. Lyeonov, “The role of the university in achieving SDGs 4 and 7: a Ukrainian case,” Paper presented at the E3S Web of Conferences, 2021, 250, doi: 10.1051/e3sconf/202125004006
- [4] R. Benghebrid and M. Sahnouni, “Telework: What is impact on the Algerian employee?” *SocioEconomic Challenges*, 2023, 7(3), pp. 55-62, doi: 10.61093/sec.7(3).55-62.2023
- [5] G. Kibrit, F. Altinay, G. Dagli, Z. Altinay, R. Sharma, R. Shadiey and M. Bastas, “Evaluation of sustainability and accessibility strategies in vocational education training,” *Sustainability*, 2022, 14(19), 12061, doi: 10.3390/su141912061
- [6] S. Mariam, K. F. Khawaja, M. N. Qaisar and F. Ahmad, “Blended learning sustainability in business schools: role of quality of online teaching and immersive learning experience,” *The International Journal of Management Education*, 2023, 21(2), 100776, doi: 10.1016/j.ijme.2023.100776
- [7] S. K. Sharma, S. C. Palvia and K. Kumar, “Changing the landscape of higher education: From standardized learning to customized learning,” *Journal of Information Technology Case and Application Research*, 2017, 19(2), pp. 75-80, doi: 10.1080/15228053.2017.1345214
- [8] M. Hara, “Educational reform for middle-income trap under digitalization: Culprits, challenges, and strategies in the Philippines,” *SocioEconomic Challenges*, 2023, 7(3), pp. 200-218, doi: 10.61093/sec.7(3).200-218.2023
- [9] M. Melnyk, A. Blyznyukov and J. Cieřlik, “The impact of digital education initiatives,” *SocioEconomic Challenges*, 2023, 7(3), pp. 1-9, doi: 10.61093/sec.7(3).1-9.2023
- [10] O. Sour, S. B. Maliki and A. Benghalem, “Modelling the Interconnection Between Technological Leadership and the Level of Use of Information and Communication Technologies,” *Business Ethics and Leadership*, 2023, 7(3), pp. 62-72, doi: 10.61093/bel.7(3).62-72.2023
- [11] W. Li, J. Zhu, P. Dang, J. Wu, J. Zhang, L. Fu and Q. Zhu, “Immersive virtual reality as a tool to improve bridge teaching communication,” *Expert Systems with Applications*, 2023, 217, 119502, doi: 10.1016/j.eswa.2023.119502

- [12] V. Barvinok and T. Pudlo, "Formation of Online Content Patterns of Higher Education Based on Trends to Preserve Intellectual Capital Quality Decreasing in Ukraine During Wartime," *Business Ethics and Leadership*, 2023, 7(2), 109-127, doi: 10.21272/bel.7(2).109-127.2023
- [13] C. J. Ninassi and D. N. Burrell, "Teaching business leadership skills to professionals in healthcare cybersecurity, biodefense and biotechnology through experiential learning methods," *Health Economics and Management Review*, 2023, 4(3), pp. 82-94, doi: 10.61093/hem.2023.3-07
- [14] H. Kaya, J. S. Kwok and J. LaTurner, "Experiential Learning Through the Creation of an Investment Lab," *Financial Markets, Institutions and Risks*, 2023, 7(1), pp. 16-25, doi: 10.21272/fmir.7(1).16-25.2023
- [15] O. Dluhopolskyi, A. Simakhova, T. Zatonatska, I. Oleksiv and S. Kozlovskiy, "Potential of virtual reality in the current digital society: economic perspectives," 11th International Conference on Advanced Computer Information Technologies (September 15-17, 2021). Deggendorf, Germany, 2021, pp. 360-363, doi: 10.1109/ACIT52158.2021.9548495
- [16] A. Artyukhov, I. Volk, O. Dluhopolskyi, E. Mieszajkina and A. Myśliwiecka, "Immersive university model: a tool to increase higher education competitiveness," *Sustainability*, 2023, 15, 7771, doi: 10.3390/su15107771
- [17] I. Onopriienko, K. Onopriienko and S. Bourekadi, "Immersive Technologies in Adult Learning as an Innovative Marketing Tool in the Educational Market," *Business Ethics and Leadership*, 2023, 7(2), pp. 63-72, doi: 10.21272/bel.7(2).63-72.2023
- [18] J. K. Ogunleye, C. S. Afolabi, S. O. Ajayi and V. A. Omotayo, "Virtual Learning as an Impetus for Business Education Programme in the Midst of COVID-19 in Nigeria," *Health Economics and Management Review*, 2023, 4(2), pp. 83-89, doi: 10.21272/hem.2023.2-08
- [19] J. Radianti, T. A. Majchrzak, J. Fromm and I. Wohlgenannt, "A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda," *Computers & Education*, 2020, 147, 103778, doi: 10.1016/j.compedu.2019.103778
- [20] J. D. Larsen, R. O. Jensen, P. I. Pietersen, N. Jacobsen, C. Falster, A. B. Nielsen and O. Graumann, "Education in focused lung ultrasound using gamified immersive virtual reality: a randomized controlled study," *Ultrasound in Medicine & Biology*, 2023, 49(3), pp. 841-852, doi: 10.1016/j.ultrasmedbio.2022.11.011
- [21] J. Qiao, C. R. Huang, Q. Liu, S. Y. Li, J. Xu, L. Li and Y. Q. Ouyang, "Effectiveness of non-immersive virtual reality simulation in learning knowledge and skills for nursing students: meta-analysis," *Clinical Simulation in Nursing*, 2023, 76, pp. 26-38, doi: 10.1186/s12909-023-04662-x
- [22] N. Aghaei, H. Babamohamadi, M. R. Asgari and N. Dehghan-Nayeri, "Barriers to and facilitators of nursing students' adjustment to internship: a qualitative content analysis," *Nurse Education Today*, 2021, 99, 104825, doi: 10.1016/j.nedt.2021.104825
- [23] N. L. Andersen, R. O. Jensen, S. Posth, C. B. Laursen, R. Jørgensen and O. Graumann, "Teaching ultrasound-guided peripheral venous catheter placement through immersive virtual reality: an explorative pilot study," *Medicine*, 2021, 100(27), e26394, doi: 10.1097/MD.00000000000026394
- [24] R. Shadiev and D. Li, "A review study on eye-tracking technology usage in immersive virtual reality learning environments," *Computers & Education*, 2023, 196, 104681, doi: 10.1016/j.compedu.2022.104681
- [25] M. L. Lai, M. J. Tsai, F. Y. Yang, C. Y. Hsu, T. C. Liu, S. W. Lee and C. C. Tsai, "A review of using eye-tracking technology in exploring learning from 2000 to 2012," *Educational Research Review*, 2013, 10, pp. 90-115, doi: 10.1016/j.compedu.2022.104681
- [26] G. E. Raptis, C. Fidas and N. Avouris, "Effects of mixed-reality on players' behaviour and immersion in a cultural tourism game: a cognitive processing perspective," *International Journal of Human-Computer Studies*, 2018, 114, pp. 69-79, doi: 10.1016/j.ijhcs.2018.02.003
- [27] M. Rubin, S. Minns, K. Muller, M. Tong, M. Hayhoe and M. Telch, "Avoidance of social threat: Evidence from eye movements during a public speaking challenge using 360°-video," *Behaviour Research and Therapy*, 2020, 134, 103706, doi: 10.1016/j.brat.2020.103706
- [28] C. Sharma, P. Bhavsar, B. Srinivasan and R. Srinivasan, "Eye gaze movement studies of control room operators: A novel approach to improve process safety," *Computers & Chemical Engineering*, 2016, 85, pp. 43-57, doi: 10.1016/j.compchemeng.2015.09.012
- [29] M. J. D'Souza and P. Rodrigues, "Extreme pedagogy: an agile teaching-learning methodology for engineering education," *Indian Journal of Science and Technology*, 2015, 8(9), 828, doi: 10.17485/ijst/2015/v8i9/53274
- [30] J. Y. Ito, F. F. Silveira and A. C. Akkari, "Lean-Agile Education: A Bibliometric Analysis," In: Y. Iano, O. Saotome, G. L. Kemper Vásquez, C. Cotrim Pezzuto, R. Arthur and G. Gomes de Oliveira (Eds.), *Proceedings of the 7th Brazilian Technology Symposium (BTSym'21)*, Cham: Springer International Publishing, 2023, pp. 378-385, doi: 10.1007/978-3-031-04435-9\_38
- [31] A. López-Alcarria, A. Olivares-Vicente and F. Poza-Vilches, "A systematic review of the use of agile methodologies in education to foster sustainability competencies," *Sustainability*, 2019, 11(10), 2915, doi: 10.3390/su11102915
- [32] A. Artyukhov, I. Volk and T. Vasylieva, "Agile methodology in higher education quality assurance system for SDGs 4, 8 and 9 achievement: national experience," *CTE Workshop Proceedings*, 2022, 9, pp. 81-94, doi: 10.55056/cte.105
- [33] R. Glassey, P. Haller and M. Wiggberg, "Agile and adaptive learning via the ECK-model in the software development academy," In: *CEUR Workshop Proceedings*, 2018, 2193, <https://ceur-ws.org/Vol-2193/paper8.pdf>
- [34] D. Parsons and K. MacCallum, "Agile education, lean learning," In: D. Parsons and K. MacCallum (Eds.), "Agile and Lean Concepts for Teaching and Learning," Singapore: Springer Singapore, 2019, pp. 3-23, doi: 10.1007/978-981-13-2751-3\_1
- [35] P. Salza, P. Musmarra and F. Ferrucci, "Agile methodologies in education: a review," In: D. Parsons and K. MacCallum (Eds.), "Agile and Lean Concepts for Teaching and Learning," Singapore: Springer Singapore, 2019, pp. 25-45, [https://link.springer.com/chapter/10.1007/978-981-13-2751-3\\_2](https://link.springer.com/chapter/10.1007/978-981-13-2751-3_2)
- [36] V. Liubchak, Y. Zuban and A. Artyukhov, "Immersive learning technology for ensuring quality education: Ukrainian university case," *CTE Workshop Proceedings*, 2022, 9, pp. 336-354, <https://ceur-ws.org/Vol-3085/paper12.pdf>
- [37] H. Yarovenko, Y. Bilan, S. Lyeonov and G. Mentel, "Methodology for assessing the risk associated with information and knowledge loss management," *Journal of business economics and management*, 2021, 22(2), pp. 369-387, doi: 10.3846/jbem.2021.13925
- [38] E. Dick, "The promise of immersive learning: Augmented and virtual reality's potential in education," *ITIF* 2021, <https://euagenda.eu/publications/2021-ar-vr-education>
- [39] R. Gurbutt, B. Smith, D. Gurbutt, J. Duckworth and H. Partington, "Socially immersive learning: a new pedagogy," In: *INTED 2019 Proceedings. 13th International Technology, Education and Development Conference*, 11-13 March, Valencia, Spain, 2019, pp. 405-411, doi: 10.21125/inted.2019.0181
- [40] Digital Learning Institute. What is immersive learning? The future of online learning, 2024, <https://www.digitallearninginstitute.com/blog/what-is-immersive-learning>
- [41] IXR Labs. Immersive education: Unlocking new possibilities with XR, 2024, <https://www.ixrlabs.com/blog/immersive-education-with-extended-reality>
- [42] N. Potkalitsky, "Creating immersive learning experiences with AI tools," 2024, LinkedIn, <https://www.linkedin.com/pulse/creating-immersive-learning-experience-ai-tools-nick-potkalitsky-phd-fwyge>
- [43] N. Krueger, "How immersive learning prepares students for the future," *ISTE*, 2023, <https://iste.org/blog/how-immersive-learning-prepares-students-for-the-future>
- [44] P. Beach and J. McConnel, "Eye tracking methodology for studying teacher learning: a review of the research," *International Journal of Research & Method in Education*, 2019, 42(5), pp. 485-501, doi: 10.1080/1743727X.2018.1496415
- [45] A. Erickson, G. Bruder and G. Welch, "Analysis of the saliency of color-based dichoptic cues in optical see-through augmented reality," *IEEE Transactions on Visualization and Computer Graphics*, 2022, pp. 1-16, doi: 10.1109/TVCG.2022.3195111
- [46] K. Cherry, "How we use selective attention to filter information and focus," *Verywell Mind*, 2023, <https://www.verywellmind.com/what-is-selective-attention-2795022>



2024 14TH INTERNATIONAL CONFERENCE ON

# ADVANCED COMPUTER INFORMATION TECHNOLOGIES



CESKE BUDEJOVICE, CZECH REPUBLIC  
19-21 SEPTEMBER 2024

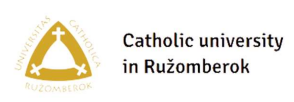
**PART NUMBER:**  
CFP24S92-PRT

**ISBN:**  
979-8-3503-5003-6

**ISSN:**  
2770-5218



**ORGANIZERS:**



ACIT.WUNU.EDU.UA



WEST UKRAINIAN NATIONAL UNIVERSITY, UKRAINE  
UNIVERSITY OF SOUTH BOHEMIA, CZECH REPUBLIC  
WROCLAW UNIVERSITY OF ECONOMICS AND BUSINESS, POLAND  
DEGGENDORF INSTITUTE OF TECHNOLOGY, GERMANY  
CATHOLIC UNIVERSITY IN RUŽOMBEROK, SLOVAKIA  
CZECHOSLOVAKIA SECTION IEEE \ COMPUTER CHAPTER, C16

2024 14th International Conference on  
**ADVANCED COMPUTER  
INFORMATION TECHNOLOGIES  
ACIT'2024**

Conference Proceedings

Ceske Budejovice, Czech Republic  
19-21 September 2024



# INTERNATIONAL TECHNICAL PROGRAMME COMMITTEE

## Honorary Chairmen

- **Desyatnyuk Oksana** – Rector of West Ukrainian National University, Ukraine
- **Kozák Pavel** – Rector of University of South Bohemia, Czech Republic

## Co-Chairmen

- **Dyvak Mykola** – West Ukrainian National University, Ukraine
- **Dostálek Libor** – Czech Technical University in Prague, Czech Republic
- **Rudolf Vohnout** – University of South Bohemia, Czech Republic
- **Rot Artur** – Wroclaw University of Economics and Business, Poland
- **Dorner Wolfgang** – Deggendorf Institute of Technology, Germany

## Programme Committee

- |  |  |
|--|--|
| • <b>Aizenberg Igor</b> , USA              | • <b>Konstantinos Spinthiropoulos</b> , Greece |
| • <b>Belikov Juri</b> , Estonia            | • <b>Kuznetsov Oleksandr</b> , Italy           |
| • <b>Baranek Ladislav</b> , Czech Republic | • <b>Lange Tatjana</b> , Germany               |
| • <b>Berl Andreas</b> , Germany            | • <b>Liashenko Olena</b> , Ukraine             |
| • <b>Bodyanskiy Yevgeniy</b> , Ukraine     | • <b>Lubchik Leonid</b> , Ukraine              |
| • <b>Bukovský Ivo</b> , Czech Republic     | • <b>Lupenko Serhii</b> , Ukraine              |
| • <b>Buyak Lesia</b> , Ukraine             | • <b>Markovic Vera</b> , Serbia                |
| • <b>Czarnowski Ireneusz</b> , Poland      | • <b>Martsenyuk Vasyl</b> , Poland             |
| • <b>Dimitrov Georgi</b> , Bulgaria        | • <b>Melnyk Anatoliy</b> , Ukraine             |
| • <b>Eisner Jan</b> , Czech Republic       | • <b>Melnyk Andriy</b> , Ukraine               |
| • <b>Evaggelos Saprikis</b> , Greece       | • <b>Melnyk Viktor</b> , Poland                |
| • <b>Fesl Jan</b> , Czech Republic         | • <b>Mukerji Abhimanyu</b> , USA               |
| • <b>Fischer Andreas</b> , Germany         | • <b>Mukherjee Amrit</b> , Czech Republic      |
| • <b>Fiser Petr</b> , Czech Republic       | • <b>Nikitchenko Mykola</b> , Ukraine          |
| • <b>Górecki Krzysztof</b> , Poland        | • <b>Novak Milan</b> , Czech Republic          |
| • <b>Grebennik Igor</b> , Ukraine          | • <b>Osowski Stanislaw</b> , Poland            |
| • <b>Haider M. al-Khateeb</b> , England    | • <b>Owedyk Jan</b> , Poland                   |
| • <b>Hernes Marcin</b> , Poland            | • <b>Panić Stefan</b> , Serbia                 |
| • <b>Ioannis Antoniadis</b> , Greece       | • <b>Paprzycki Marcin</b> , Poland             |
| • <b>Ivanek Jiri</b> , Czech Republic      | • <b>Pasichnyk Roman</b> , Ukraine             |
| • <b>Janecek Jan</b> , Czech Republic      | • <b>Patel Nikhil</b> , USA;                   |
| • <b>Karpinski Mikolaj</b> , Poland        | • <b>Peleshko Dmytro</b> , Ukraine             |
| • <b>Kasianchuk Mykhailo</b> , Ukraine     | • <b>Petlenkov Eduard</b> , Estonia            |
| • <b>Klymash Mykhailo</b> , Ukraine        | • <b>Prochazka Ales</b> , Czech Republic       |
| • <b>Komar Myroslav</b> , Ukraine          | • <b>Pukas Andriy</b> , Ukraine                |
| • <b>Kornilowicz Artur</b> , Poland        |  |

- **Rasheed Jawad**, Turkey
- **Rihova Zora**, Czech Republic
- **Romaniuk Oleksandr**, Ukraine
- **Roushdy Mohamed**, Egypt
- **Shakhovska Natalia**, Ukraine
- **Skrbek Miroslav**, Czech Republic
- **Smilic Marko**, Serbia
- **Stakhiv Petro**, Ukraine
- **Starzyński Jacek**, Poland
- **Stepashko Volodymyr**, Ukraine
- **Svata Vlasta**, Czech Republic
- **Szczepaniak Piotr**, Poland
- **Vojtech Josef**, Czech Republic
- **Yatskiv Vasyl**, Ukraine

### **Organizing Committee**

- **Dyvak Andriy** (West Ukrainian National University, Ukraine);
- **Dyvak Mykola** - chairman of the editorial board (West Ukrainian National University, Ukraine);
- **Kulish Vladimir** – member of the local organizing committee (University of South Bohemia, Czech Republic);
- **Manzhula Volodymyr** (West Ukrainian National University, Ukraine);
- **Melnyk Andriy** - co-chairman of the organizing committee, member of the editorial board (West Ukrainian National University, Ukraine);
- **Mukherjee Amrit** - member of the local organizing committee (University of South Bohemia, Czech Republic);
- **Papa Olexander** (West Ukrainian National University, Ukraine);
- **Pukas Andriy** - member of the editorial board (West Ukrainian National University, Ukraine);
- **Romanets Ihor** (West Ukrainian National University, Ukraine);
- **Shevchuk Ruslan** - co-chairman of the organizing committee, vice-chairman of the editorial board (West Ukrainian National University, Ukraine / University of Bielsko-Biala, Poland);
- **Vohnout Rudolf** - chairman of the local organizing committee (University of South Bohemia, Czech Republic).

## Reviewers

- Andriychuk Mykhaylo
- Belikov Juri
- Beranek Ladislav
- Bodyanskiy Yevgeniy
- Buiak Lesia
- Dimitrov Georgi
- Dostálek Libor
- Dyvak Mykola
- Eisner Jan
- Fischer Andreas
- Grebennik Igor
- Hoholyuk Oksana
- Honchar Lyudmyla
- Ivánek Jiří
- Karpinski Mikolaj
- Kasianchuk Mykhailo
- Krepych Svitlana
- Kovalchuk Olha
- Koval Vasyl
- Komar Myroslav
- Liashenko Olena
- Lo Man Fung
- Lupenko Serhii
- Lyubchuk Leonid
- Manzhula Volodymyr
- Melnyk Anatoliy
- Melnyk Andriy
- Melnyk Bohdan
- Melnyk Viktor
- Nikitchenko Mykola
- Panic Stefan
- Pasichnyk Roman
- Petlenkov Eduard
- Pitsun Oleh
- Porplytsya Natalia
- Pukas Andriy
- Říhová Zora
- Romaniuk Oleksandr
- Rot Artur
- Segin Andriy
- Shevchuk Ruslan
- Skrbek Miroslav
- Spivak Iryna
- Stakhiv Petro
- Stasiv Iryna
- Stepashko Volodymyr
- Tymchyshyn Vasyl
- Walaszczyk Ewa
- Yakymenko Igor
- Yatskiv Vasyl

# CONTENTS

## SECTION 1

### Mathematical Models of Objects and Processes

<b>Software Architecture for Process Simulation in Biogas Plants .....</b>	<b>1</b>
Andriy Melnyk, Yuriy Maslyiak, Pavlo Popovych, Taras Sitkar, Evhenii Momotiuk, Bohdan Kostyk.	
<b>Software for Implementing the Directed Cone Optimization Method .....</b>	<b>6</b>
Bohdan Melnyk, Petro Stakhiv, Nataliya Melnyk, Yuriy Franko, Bohdan Seniv, Yevgeniya Martsenyuk	
<b>Reliability and Continuity of Hybrid Power Supply Systems Included Renewable Energy Sources .....</b>	<b>13</b>
Dmytro Sobchuk, Lubov Dobrovolska, Nadiia Kuts, Andrii Hadai, Mykola Romaniuk, Ihor Kundyra	
<b>Assessment of Probabilistic Characteristics for the Fire Initial Stage Detection Using Thermal Detectors .....</b>	<b>19</b>
Gennadii Sokolov, Maksym Zaliskyi, Yuliia Petrova, Ivan Yashanov	
<b>Enhancing Mood Detection in Textual Analysis through Fuzzy Logic Integration .....</b>	<b>23</b>
Halyna Melnyk, Vasyl Melnyk	
<b>Realisation of a Given Trucks Loading Logic using a Fuzzy Decision Making Model.....</b>	<b>27</b>
Igor Grebennik, Oleksii Kovalenko	
<b>Computer Modeling of the Dynamics of Epidemiological Processes .....</b>	<b>32</b>
Ihor Kosovych, Igor Cherevko, Tetiana Shchur, Dmytro Shkilniuk	
<b>Mathematical Modeling of Biomass and Carotenoid Accumulation in Microalgae .....</b>	<b>36</b>
Iryna Dorosh, Andrii Dorosh, Igor Cherevko, Mykhailo Marchenko, Larysa Cheban	
<b>Modeling Dynamic Properties of an Alkaline Electrolyzer .....</b>	<b>40</b>
Krzysztof Górecki, Przemysław Ptak	
<b>Mathematical and Fuzzy Model for Slag Thickness Control Automation in Gas-stirred Ladle .....</b>	<b>45</b>
Kyrylo Krasnikov	
<b>An Integrated Agent-Based Modelling and Machine Learning Framework for Enhancing the Digital Service Access of Minority Ethnic Communities .....</b>	<b>49</b>
Mennan Guder, Nazmiye Balta-Ozkan	
<b>Modeling the Radiation Characteristics of a Set Chaotically Placed Microparticles .....</b>	<b>55</b>
Mykhaylo Andriychuk, Borys Yevstyhneiev, Yarko Kuleshnyk	
<b>Modeling the Interaction of Unmanned Aerial Vehicles in a Swarm as an Object with Distributed Parameters.....</b>	<b>60</b>
Mykola Dyvak, Iryna Spivak, Taras Dyvak, Oleksandr Kindzerskyi	
<b>Interval Model of pH Dynamics of the Fermentation Medium.....</b>	<b>67</b>
Mykola Dyvak, Natalia Porplytsya, Roman Pasichnyk, Vladimír Kulish, Yaroslav Voytyuk, Bohdan Ihnatiuk	
<b>Implementation of Parallel Computation for Identification of Interval Models based on Multi-core Parallelism and CUDA Technology .....</b>	<b>72</b>
Mykola Dyvak, Oleksandr Kindzerskyi	
<b>Inductive and Deductive Approaches to Modeling the Daily Cycle of Carbon Monoxide Concentrations Due to Air Pollution by Motor Vehicles .....</b>	<b>77</b>



Mykola Dyvak, Roman Pasichnyk

<b>Identification of the Mathematical Model of the pH Environment in the Biogas Plant Based on the Application of the Swarm Intelligence Method .....</b>	<b>83</b>
Mykola Dyvak, Svitlana Krepych, Volodymyr Manzhula, Tsovka Yurii, Pavlo Popovych, Vadym Zabchuk	
<b>A Cloud-Based Software Architecture for Mathematical Modeling Based on Interval Data Analysis.....</b>	<b>89</b>
Mykola Dyvak, Volodymyr Manzhula, Andriy Melnyk, Libor Dostalek, Mykhailo Ozhha, Oleksandr Papa	
<b>Fuzzy System of IT-Project Works Priority .....</b>	<b>94</b>
Nadia Vasylykiv, Lesia Dubchak, Mikolaj Karpinski, Iryna Turchenko, Liubomyr Flud, Tetiana Nadvynychna	
<b>Machine Learning Algorithms Application for Fixed-Income Market Analysis: Cross Countries Comparisons.....</b>	<b>99</b>
Natalia Chernova, Olena Serhiienko, Maryna Mashchenko, Iryna Lisna, Olha Haponenko	
<b>Forecasting Key Indicators of EU International Trade Based on Hybrid Models that Combine SARIMAX and ANN .....</b>	<b>103</b>
Nataliia Dziubanovska, Andrii Aliluiko, Andrii Tymkiv	
<b>Simulation of Gas Filtration Processes in Fractured-Porous Media .....</b>	<b>107</b>
Nazariy Lopuh, Yaroslav Pyanylo	
<b>Mathematical Modeling of the Influence of Natural Factors on the Durability of Critical Structural Elements.....</b>	<b>112</b>
Oleksandr Andreykiv, Iryna Dolinska, Sviatoslav Nastasiak, Mykola Liubchak, Serhii Kozibroda	
<b>The Investigation of the Long-Term and Short-Term Cointegration Effects between GDP and Migration .....</b>	<b>116</b>
Olena Rayevnyeva, Kostyantyn Stryzhychenko, Olha Brovko	
<b>Analysis and Modeling of Structural Changes in Ukrainian Higher Educational System.....</b>	<b>122</b>
Olena Rayevnyeva, Silvia Matusova, Olha Brovko	
<b>Mathematical Methods for Reducing the Search Space for Solutions in “Big Data” Analysis and Management.....</b>	<b>129</b>
Olena Syrotkina, Ziad Kobti, Mykhailo Aleksieiev, Dmytro Moroz, Iryna Udovych, Andrii Martynenko	
<b>Quantitative Analysis of Recurrent Plots for Assessing the State of Dynamic Systems .....</b>	<b>136</b>
Olga Ivanets, Mikle Burichenko, Maryna Arkhyrei, Iryna Morozova, Pavlo Kulakov, Salimov Rynat	
<b>Neuro-Fuzzy System With Adaptive Membership-Activation Functions For Pattern Recognition.....</b>	<b>140</b>
Olha Chala, Ivan Izonin, Iryna Pliss, Yevgeniy Bodyanskiy	
<b>Association Rules Mining in Crime Data Analysis.....</b>	<b>144</b>
Olha Kovalchuk, Serhiy Banakh, Mariia Masonkova, Andrii Kolesnikov, Pavlo Chopyk, Pavlo Basisty	
<b>Application of Neural Networks in Digital Data Processing .....</b>	<b>150</b>
Olha Sushchenko, Yurii Bezkorovainyi, Oleksander Salyuk, Oleksander Zhdanov	
<b>Modelling of the Operation Algorithm for Inertial Navigation Systems Assigned for UAVs.....</b>	<b>154</b>
Olha Sushchenko, Yurii Bezkorovainyi	
<b>Correlation Matrix for Analysis of the Covariance and Spectral Structures of PNRP .....</b>	<b>158</b>

Roman Yuzefovych, Ihor Javorskyj, Oleh Lychak, Yury Torba, Yevgen Sbrodov, Bohdan Komarnytskyi	
<b>Recognition Pattern Analysis of Astronomical Object Forms Using the Analytical Model.....</b>	<b>162</b>
Sergii Khlamov, Vadym Savanevych, Volodymyr Troianskyi, Igor Grebennik, Yehor Bondar, Yuriy Netrebin	
<b>Speech Recognition System for Ukrainian Language .....</b>	<b>166</b>
Serhii Migel, Maksym Zaliskyi, Roman Odarchenko, Zarina Poberezhna, Alina Osipchuk, Oleksandr Lavrynenko	
<b>Convolutional Neural Network with Optimized Learning Parameters .....</b>	<b>170</b>
Serhiy Sveleba, Ivan Katerynychuk, Ivan Kunyo, Volodymyr Brygilevych, Volodymyr Franiv, Oleksandr Krychevets	
<b>System Modeling of Physical and Mechanical Properties of a Casting on its Chemical Composition.....</b>	<b>174</b>
Serhiy Yefimenko, Yevheniya Savchenko-Syniakova, Volodymyr Stepashko	
<b>High-Frequency Filtration for the Brightness Alignment of the Astronomical Frame Background .....</b>	<b>178</b>
Vladimir Vlasenko, Sergii Khlamov, Vadym Savanevych, Tetiana Trunova, Iryna Tabakova, Mariia Mendeleva	
<b>Optimal Planning of Operation Modes of Gas Transmission Systems.....</b>	<b>182</b>
Yaroslav Pyanylo, Nazar Prytula, Olga Khymko, Myroslav Prytula, Zoia Prytula	
<b>The Spectral Methods of Investigation the Processes of Heterodiffusion in the Terms of Fractional Derivatives .....</b>	<b>186</b>
Yaroslav Pyanylo, Sofiya Tvardovska, Halyna Pyanylo	

## SECTION 2

### Information in Economy and Management

<b>Finfluencer: Exploring the Untapped Influence of Financial Influencers .....</b>	<b>190</b>
Aditi Rajput, Aradhana Gandhi	
<b>ICT Investment Impact on Economic Growth: Comparing Developing and Advanced Economies.....</b>	<b>197</b>
Andrii Oliinyk, Tetiana Melnyk, Kateryna Kovtoniuk, Liudmyla Huliaieva, Ellana Molchanova, Ianina Tkachenko	
<b>Application of the Apparatus of Fuzzy Logic for Assessing the Development of Human Capital in Ukraine .....</b>	<b>203</b>
Andrii Trach, Vasyl Pryimak, Olga Holubnyk	
<b>Contemporary Trends in the Information Space of Fiscal Policy .....</b>	<b>209</b>
Andriy Krysovatty	
<b>Information Support for Property Tax Administration: Ukrainian Realities and European Experience .....</b>	<b>213</b>
Andriy Krysovatty, Fedir Tkachyk, Tetiana Iefymenko, Volodymyr Dmytriv	
<b>Transformation of the Financial Sector in the Context of the Digital Economy .....</b>	<b>220</b>
Andriy Krysovatty, Olena Ptashchenko, Viktoriia Adamyk	
<b>Practical Comparison of UiPath and Power Automate by Creating an Automation Use Case from Logistics .....</b>	<b>224</b>

Bernhard Axmann, Sevgin Ahmed, Dzhelil, Asna Najeeb	
<b>Barriers to Trust in AI: A Study of the Explainability Technologies Adoption in Banks.....</b>	<b>230</b>
Bogdan Adamyk, Vladlena Benson, Oksana Adamyk, Bożena Fraczek, Anitha Chinnaswamy	
<b>Building an Intellectualized Analytical Module for Evaluating the Effectiveness of Public Spending on Corruption Prevention Using an Ontological Approach .....</b>	<b>235</b>
Bohdan Malyniak, Andriy Melnyk, Olha Kyrylenko, Andrii Derlytsia, Volodymyr Trush, Roksolana Malyniak	
<b>AI and Big Data in Analyzing Family Business Governance: Non-Family CEOs' Impact on Accounting Irregularities .....</b>	<b>240</b>
Deng Dejun, Li Xiaoqing, Nataliia Pochynok	
<b>Model of Product Displacement from the Market: Market Failure under Complete Information .....</b>	<b>246</b>
Dmytro Sokolovskyi	
<b>Integration of Digital Economy, Knowledge Economy and Circular Economy in the conditions of Industry 5.0 .....</b>	<b>250</b>
Inna Chaikovska, Pavlo Hryhoruk, Nila Khrushch, Svitlana Grygoruk, Taras Tkach, Maksym Chaikovskiy	
<b>Fuzzy Model for Complex Assessment of the Risk of Enterprise Bankruptcy.....</b>	<b>254</b>
Inna Chaikovska, Pavlo Hryhoruk, Nila Khrushch, Svitlana Grygoruk, Taras Tkach, Maksym Chaikovskiy	
<b>Artificial Intelligence as an Organized Assembly of Information Technologies for the Goals of Sustainable Development .....</b>	<b>259</b>
Inna Sysoieva, Andriy Pukas, Oleh Pohrishchuk, Borys Pohrishchuk, Olena Tsikhanovska, Maria Lyzun	
<b>Optimization of Renewable Energy Development Strategies in Ukraine.....</b>	<b>264</b>
Iryna Fedorenko, Galyna Chornous, Iryna Didenko, Liudmyla Anisimova, Snizhana Mohyl	
<b>Fiscal Policy Activity for Digital Sustainable Development Support .....</b>	<b>270</b>
Iuliia Gernego, Oleksandr Tymoshenko, Mykhailo Dyba, Svitlana Urvantseva, Oleksandr Dyba	
<b>Digitalization in Venture Capital Relocation in Wartime .....</b>	<b>275</b>
Iuliia Gernego, Oleksandr Tymoshenko, Mykhailo Dyba, Svitlana Urvantseva, Liudmyla Petrenko	
<b>Cost-effectiveness of Digitalisation in Europe.....</b>	<b>280</b>
Kateryna Kovtoniuk, Ellana Molchanova, Andrii Oliinyk, Liudmyla Hulciaeva, Yuriy Kulyk, Yuliya Demkiv	
<b>The Use of Hypergraph for Collaborative Filtering Recommendation Method .....</b>	<b>284</b>
Ladislav Beranek, Radim Remes, Klara Vocetkova, Jan Fesl, Michal Konopa, Tereza Capkova	
<b>Digital Transformation of the Process of Monetary Evaluation of Agricultural Land .....</b>	<b>288</b>
Lesia Buiak, Kateryna Pryshliak, Oksana Bashutska, Andriy Buiak, Mykola Shynkaryk, Yurii Semenenko	
<b>Optimization of Marketing Department Activities using Machine Learning Technologies .....</b>	<b>293</b>
Lesia Buiak, Mykola Shynkaryk, Yurii Semenenko, Kateryna Pryshliak	
<b>Modeling in the Processes of Assessment and Forecasting of Technological Aspects of Sustainable Enterprise Development.....</b>	<b>299</b>
Lesia Buiak, Serhii Matiukh, Olga Gonchar, Liudmyla Yemchuk, Larysa Dzhulii, Lesia Bilorusets	
<b>Methods and Models in Organizational Management of Production Environmental Friendliness .....</b>	<b>304</b>

Lesia Buiak, Viktor Lopatovskyi, Liudmyla Yemchuk, Volodymyr Dzhulii, Larysa Dzhulii, Valentyna Bobrovnyk	
<b>Workplace Changes in the Bulgarian Translation Industry in Conditions of Digitalisation of Labour .....</b>	<b>309</b>
Magdalena Parcheva	
<b>Economic Efficiency of the Newest Technologies of the Distance Institutionalization of Inclusive Education in the Conditions of a Special Educational Environment.....</b>	<b>314</b>
Marian Tripak, Yaroslava Toporivska, Amantius Akimjak, Joachim Nowak, Tetiana Lebid, Olena Vasylykiv	
<b>Optimisation of SVD++ Method based on Adam's Algorithm for Small E-commerce Platforms ..</b>	<b>318</b>
Mykola Pylypchuk, Natalia Porplytsya, Iryna Stasiv, Lyudmyla Honchar, Viktor Sopiha, Ievgen Bondarenko	
<b>Comparative Analysis of Governance Quality's Impact on FDI in EU Countries: Insights from Regression and Panel Models .....</b>	<b>322</b>
Nataliia Dziubanovska, Vadym Maslii, Julia Novak, Viktor Rusin	
<b>Energy Landscape of the European Union: Assessing Convergence and Import Dependency .....</b>	<b>326</b>
Nataliia Dziubanovska, Vadym Maslii, Iryna Hural	
<b>Synergistic Aspects of Achieving a High Level of Efficiency in Personnel Management of Organizations to Ensure Sustainable Development .....</b>	<b>330</b>
Nazar Podolchak, Volodymyr Martyniuk, Natalia Tsygulyk	
<b>Impact of Digitalization on Financial Systems and Services .....</b>	<b>334</b>
Oksana Desyatnyuk, Olena Ptashchenko	
<b>Digital Entrepreneurial Potential: Assessing Business Models of Internet Companies.....</b>	<b>338</b>
Oleksandr Shulha, Valentyna Lavrenenko, Liudmyla Petrenko, Olga Mozgalli, Yulia Tereshchenko, Bohdan Tishkov	
<b>Development of the Ukrainian E-commerce Market in the Face of Uncertainty and Risks .....</b>	<b>345</b>
Oleksandr Shulha, Valentyna Lavrenenko, Liudmyla Petrenko, Olga Mozgalli, Yulia Tereshchenko, Bohdan Tishkov	
<b>Stock Price Forecasting using Sentiment Analysis of Stock Tweets .....</b>	<b>351</b>
Olena Liashenko, Tetyana Kravets, Vladyslav Plushchov	
<b>Information Support for Assessing the Potential of Implementing Resource-Saving Technological Changes in Enterprises.....</b>	<b>355</b>
Olexandr Yemelyanov, Kateryna Petrushka, Viktoriya Voytsekhovska, Tetyana Petrushka, Yuliya Voytsekhovska	
<b>Information Potential and Marketing Innovations in the Enterprise Management System.....</b>	<b>361</b>
Olga Gonchar, Irina Zakryzhevskaya, Andrii Bitiy, Irma Dikhaminjia, Anton Berdychevskyi, Halyna Nahorniak	
<b>Factors that Shape Business Efficiency in the Conditions of the War.....</b>	<b>365</b>
Olga Gonchar, Vasyl Brych, Serhii Moroz, Liudmyla Bohatchyk	
<b>Modeling Country Economic Security: A Machine Learning Approach.....</b>	<b>370</b>
Olha Kovalchuk, Kateryna Berezka, Ludmila Babala, Roman Ivanytskyy, Nataliia Karpysheva, Natalia Zhuk	
<b>Method and Software for Managing HR Processes of a Company using the Wolf Pack Algorithm.....</b>	<b>376</b>



Rostyslav Mukha, Natalia Porplytsya, Iryna Stasiv, Andriy Kovalets, Roksolana Mukha, Zoriana Pushkar	
<b>Improvement of the System Company's Employee Estimation and Motivation .....</b>	<b>380</b>
Serhii Spivak, Tetyana Korolyuk, Lesia Halyniak, Iryna Spivak, Svitlana Krepych, Uliana Tkach	
<b>Enhancing the Informativeness of Managing Mentoring Activities based on Simulation Modeling .....</b>	<b>384</b>
Sviatoslav Kniaz, Vasyl Brych, Nelli Heorhiadi, Sergey Shevchenko, Roman Dzvonyk, Ruslan Skrynkovskyy	
<b>Informational-Reflective Management of Mentoring Activities Development in the Enterprise ....</b>	<b>389</b>
Sviatoslav Kniaz, Vasyl Brych, Nelli Heorhiadi, Sergey Shevchenko, Roman Dzvonyk, Yuriy Tyrkalo	
<b>Savings and Gross Domestic Product in Ukraine: Cointegration and Causal Relationships Analysis .....</b>	<b>393</b>
Svitlana Plaskon, Svitlana Shevelova, Olesya Martyniuk, Ruslana Ruska, Oksana Lesyk, Svitlana Korendii	
<b>Analysis of the Influence of Socio-economic Processes on the Formation of Human Capital in the Western Region of Ukraine using the Apparatus of Fuzzy Logic .....</b>	<b>397</b>
Svitlana Pryima, Nataliia Mishchuk, Oksana Huhul	
<b>Analysis of the Financial State of Enterprises: a Complex Approach and Formalization of Evaluation for the Management System .....</b>	<b>402</b>
Svitlana Zhukevich, Vita Semaniuk, Nazar Marchyshyn, Volodymyr Shpak, Natalia Zhuk, Andriy Papinko	
<b>The Use of Power BI in the Analysis and Visualization of the Results of the Admission Campaign at Lviv University .....</b>	<b>408</b>
Taras Panchyshyn, Nataliia Mishchuk, Rostyslav Mykhailyshyn, Oleh Vatslavskyi	
<b>An Examination of the Impact of Institutional Environment on Socio-economic Development in Candidate Countries for EU Membership using Canonical Correlation Analysis .....</b>	<b>414</b>
Tetiana Cherkashyna	
<b>Industrial Development in the Era of Digital Technologies: A Comparative Analysis of EU States .....</b>	<b>419</b>
Tetiana Polozova, Yuri Romanenkov, Iryna Sheiko, Lilia Buiak, Olena Murzabulatova, Stanislav Ponomarov	
<b>Information Provision of Assessment of Achievements in The Decent Work in Ukraine Using Microdata .....</b>	<b>423</b>
Tetiana Stepura, Olena Kuzmak, Oleksandra Mrykhina	
<b>Digitalization as a Tool for Healthcare System Resilience .....</b>	<b>427</b>
Tetiana Zheliuk, Dmytro Shushpanov, Alina Zhukovska, Viktor Ostroverkhov, Oleksandr Brechko, Volodymyr Matsyk	
<b>Advantages of Blockchain for Efficient Electronic Documents Flow in the Enterprise Accounting System .....</b>	<b>434</b>
Tetyana Korolyuk, Serhii Spivak, Bohdan Seniv, Mykola Stetsko, Mykola Horodetsky, Anna Ivanova	
<b>Economic and Mathematical Simulation Model of Production in the Crisis Environment Condition .....</b>	<b>439</b>
Viacheslav Dzhezdzhula, Iryna Yepifanova, Vasyl Brych	
<b>Money Supply vs Inflation Expectations: What Better Explains Inflation Behavior in Ukraine ....</b>	<b>443</b>
Viktor Koziuk, Nataliia Dziubanovska, Volodymyr Uhryn	

<b>Application of Factor Analysis in Information Support of Participatory Budget Management in an Inclusive Economy .....</b>	<b>449</b>
Volodymyr Horyn, Kateryna Berezka, Zoryana Lobodina, Tetyana Kizyma, Andriy Kizyma	
<b>Strategic Diagnostics of Business Processes of Enterprises using Information Technologies in the Context of Modern Challenges .....</b>	<b>455</b>
Zarina Poberezhna, Oleksandr Truhan	
<b>Unmanned Aerial Vehicles in Individual Mapping and Accounting of the Use of Land Resources .....</b>	<b>460</b>
Zenovii-Mykhailo Zadorozhnyi, Oksana Desyatnyuk, Volodymyr Muravskyi, Oleg Shevchuk, Marian Zadorozhnyi	
<b>Aerial Visual Monitoring in accounting of Smart Construction .....</b>	<b>465</b>
Zenovii-Mykhailo Zadorozhnyi, Volodymyr Muravskyi, Oleksandr Kundeus, Marian Zadorozhnyi, Vasyl Muravskyi	

### SECTION 3 Cyber Security

<b>Navigating IoT Security Assessment: Current Methods, Challenges and Future Directions .....</b>	<b>471</b>
Alhassan Abdulhamid, Sohag Kabir, Ibrahim Ghafir, Ci Lei	
<b>Enhancing Cryptographic System Security Based on Finite Fields .....</b>	<b>476</b>
Alina Davletova, Vasyl Yatskiv, Stepan Ivasiev, Serhii Kulyna, Taras Tsavolyk, Volodymyr Drapak	
<b>A Dynamically Selected GPT Model for Phishing Detection.....</b>	<b>481</b>
Alp Barış Beydemir, Ulaş Sezgin, Umutcan Doğan, Burak Engin Aşıklar, Fahri Anıl Yerlikaya, Şerif Bahtiyar	
<b>A Method of Detecting Anomalies in IP Phone Traffic Based on Ontology of Voip Messages.....</b>	<b>485</b>
Andriy Melnyk, Ruslan Shevchuk, Ihor Romanets, Igor Yakymenko, Serhiy Voznyak, Vasyl Luchykh	
<b>A McEliece-type Cryptosystem Using a Random Inverse Matrix and an Error Vector With Large Hamming Weight.....</b>	<b>490</b>
Farshid Haidary Makoui, T. Aaron Gulliver, Mohammad Dakhilalian	
<b>Hierarchical Encryption in a Residual Number System.....</b>	<b>496</b>
Igor Yakymenko, Olesya Martyniuk, Serhii Martyniuk, Andrii Martyniuk, Yurii Yakymenko, Mykhailo Kasianchuk	
<b>Construction of Nonlinear Cryptographic Protocol based on Multiple Linear Cryptosystems .....</b>	<b>500</b>
Ihor Muliar, Volodymyr Anikin, Vasyl Yatskiv, Serhii Kulyna, Petro Humennyy, Halyna Kulyna	
<b>Enhancing Side-Channel Attacks Prediction using Convolutional Neural Networks .....</b>	<b>505</b>
Khalid Alemerien, Sadeq Al-Suhemat, Fadi Alsuhimat, Enshirah Altarawneh	
<b>Human Cyber Security: Experience of Ukraine and Lithuania .....</b>	<b>511</b>
Mariia Pleskach, Valentyna Pleskach, Ievgen Zaitsev	
<b>Latent Semantic Analysis for Feature Selection: A Proposed Approach for Anomaly Detection in Network Traffic .....</b>	<b>517</b>
Moemedi Lefoane, Ibrahim Ghafir, Sohag Kabir, Irfan-Ullah Awan	
<b>Non-Negative Matrix Factorisation for Feature Selection: A Proposed Approach for the Detection of Multi-Stage Attacks.....</b>	<b>523</b>
Moemedi Lefoane, Ibrahim Ghafir, Sohag Kabir, Irfan-Ullah Awan	

<b>A Cryptographic Encryption Scheme based on a Pythagorean Triplets Manufacturing Formula .....</b>	<b>529</b>
Nadav Voloch, Noa Voloch - Bloch	
<b>Crypto-Steganographic System based on the Solver of the Square Root of a Prime Number.....</b>	<b>535</b>
Nataliia Kukharska, Andrii Lagun, Oleksandr Yashchuk	
<b>Method for Countering Attacks on the GNSS System in Maritime Transport.....</b>	<b>539</b>
Oleksiy Polikarovskiykh, Mykola Malaksiano, Ihor Hula	
<b>Research Hotspots and Trend Analysis of Social Media Security on CiteSpace Knowledge Graph .....</b>	<b>543</b>
Ruslan Shevchuk, Vasyl Martsenyuk, Andriy Melnyk	
<b>Encryption using Residue Number System: Research Trends and Future Challenges.....</b>	<b>552</b>
Ruslan Shevchuk, Igor Yakymenko, Mykhailo Kasianchuk	
<b>The Built on Feistel Network Architecture Block Ciphers Modification .....</b>	<b>560</b>
Serhii Naumenko, Inna Rozlomii, Andrii Yarmilko	
<b>Assessing Network Security Risks: A Technological Chain Perspective.....</b>	<b>565</b>
Tetiana Korobeinikova, Illia Tachenko, Olexandr Romanyuk, Sergey Romanyuk, Oleksii Stakhov, Olexandr Reyda	
<b>Towards UAT Methodology on Cryptographic Library Assessment.....</b>	<b>571</b>
Yevgen Kotukh, Oleksandr Marukhnenko, Gennady Khalimov, Maksym Korobchynskiy, Serhii Khamula, Myhailo Rudenko	

## SECTION 4

### Specialized Information and Computer Systems

<b>Augmented Reality Simulator for Recurrent Laryngeal Nerve Identification during Thyroid Surgery.....</b>	<b>576</b>
Andriy Pukas, Vitalii Smal, Andriy Dyvak, Iryna Voytyuk, Ihor Deikalo, Nadiia Hrynkiv	
<b>SGD: Smart Gas Leakage Detection System for Home Safety.....</b>	<b>581</b>
Eiman M. Saleh, Tariq Imbarak, Salwa Elakeili, Abdul Ghafar Faraj	
<b>Configuration Tool for CI/CD Pipelines and React Web Apps .....</b>	<b>586</b>
Filip Cák, Pavle Dakić	
<b>Navigation and Communications Protocols for Autonomous Intelligent Mobility .....</b>	<b>592</b>
Ignat Myroshnychenko, Dmytro Kucherov, Serge Dolgikh, Vasyl Kondratyuk	
<b>Vehicle Positioning with Geospatial Indexing.....</b>	<b>597</b>
Ivan Ostroumov	
<b>Airplane Trajectory Data Processing with Actual Weather Data .....</b>	<b>601</b>
Ivan Ostroumov, Tamara Galabir	
<b>Determination of Survivability Indicator of Unmanned Aerial Vehicle Acoustic Detection System .....</b>	<b>605</b>
Leonid Ozirkovskyy, Bohdan Volochiy, Nazar Prymak, Yurii Zhuk	
<b>Fuzzy System of Wind Turbine Defect Image Processing .....</b>	<b>610</b>
Lesia Dubchak, Anatoliy Sachenko, Carsten Wolff, Nadia Vasylyuk	
<b>Optimization of Precision and Speed in ADCP .....</b>	<b>614</b>

Lesya Mychuda, Zynowij Mychuda, Tetiana Korobeinikova, Ihor Zhuravel, Olexandr Romanyuk, Sergii Kotlyk	
<b>Switched-capacitor ADC Error and Performance Analysis Optimization of Precision and Speed in ADCP .....</b>	<b>618</b>
Lesya Mychuda, Zynowij Mychuda, Tetiana Korobeinikova, Ihor Zhuravel, Olexandr Romanyuk, Oksana Romanyuk	
<b>Method and Algorithm of Successive Approximation Analog-to-Digital Conversion of Information in Management Systems.....</b>	<b>622</b>
Lubomyr Petryshyn, Mykhailo Petryshyn	
<b>Algorithm and Hardware for Automatic Adjustment of Electric Signal to Identify the Recurrent Laryngeal Nerve.....</b>	<b>626</b>
Mykola Dyvak, Volodymyr Tymets, Andriy Dyvak, Viktor Shidlovsky, Dmytro Osadchuk, Volodymyr Bukata	
<b>Algorithm for Enterprise Greenhouse Gas Emissions Control and Management System.....</b>	<b>631</b>
Mykola Striletskyi	
<b>Machine Learning-based Approach to Transcribing Language Units.....</b>	<b>636</b>
Oksana Kovtun, Viacheslav Kovtun	
<b>Accelerated Vector Normalization for Rendering Tasks.....</b>	<b>640</b>
Olexandr Romanyuk, Yevhen Zavalniuk, Pavlo Mykhaylov, Roman Chekhmestruk, Nataliia Titova, Sergey Romanyuk	
<b>Method for Improving the Performance of Linear Interpolation Implementation using the Formation of Two-step Movements .....</b>	<b>645</b>
Olexandr Romanyuk, Yevhen Zavalniuk, Oksana Romanyuk, Anatoliy Snigur, Oleksandr Reshetnik, Volodymyr Maidaniuk	
<b>Adaptive Random Field Scanning System .....</b>	<b>649</b>
Orest Ivakhiv, Markiyan Nakonechnyi, Oleksandr Viter, Yurii Nakonechnyi, Rostyslav Deyneka	
<b>Visualization of Code Metrics for Code Quality and Assessment of Breach of Standards .....</b>	<b>654</b>
Peter Demeter, Pavle Dakić	
<b>Software System for Supporting Art Therapy Processes Using Augmented Reality Technologies</b>	<b>660</b>
Roman Tykhyi, Yaroslav Tsapiv, Mykola Dyvak, Dariya Popovych, Andrii Havrylenko, Tetiana Husieva	
<b>A Context-Aware Approach and Software for Notifications about Personal Safety .....</b>	<b>665</b>
Ruslan Shevchuk, Mikolaj Karpinski, Tetiana Yurchyshyn, Ihor Lishchynskyy, Maria Lyzun, Andriy Melnyk	
<b>Enabling Cloud-based Data Analysis for Analog Metal Detectors using Microcomputer Systems</b>	<b>670</b>
Serhii Robotko, Oleksandr Susak, Andrii Topalov, Oleksandr Gerasin, Artem Buznyk, Oleksiy Zivenko	
<b>Computerized Lathe Control System Based on Internet of Things Technology .....</b>	<b>674</b>
Valentyn Khoda, Nadiia Leshchuk, Andrii Topalov, Serhii Robotko, Oleksandr Klymenko, Serhii Nekrasov	
<b>Data Management Service Architecture of the Software for Modeling Harmful Emissions in Soil.....</b>	<b>678</b>
Vasyl Tymchyshyn, Andriy Melnyk, Bohdan Tymchyshyn, Vasyl Faifura, Ivan-Stanislaw Mazur, Lyudmyla Honchar	
<b>Efficient OAM-Based Programmable Hardware Accelerator Architecture .....</b>	<b>683</b>



Viktor Melnyk, Anatoliy Melnyk, Mohammad Rahma

<b>Modeling of Improved Solar Energy Installation for Efficient Power Systems .....</b>	<b>688</b>
Viktor Satsyk, Oleksandr Reshetylo, Lyudmila Markina, Nataliia Khrystynets, Nataliia Bahniuk, Yuliia Melnychuk	

<b>Concept of Radars Synthesis Theory for Creating Phantom Objects in SAR Images .....</b>	<b>695</b>
Volodymyr Pavlikov, Valerii Volosiuk, Denys Kolesnikov, Volodymyr Kosharskyi, Hlib Cherepnin, Pavlo Malashta	

## SECTION 5

### Artificial Intelligence and Cognitive Systems

<b>One Hot Encoding and Hashing_trick Transformation – Performance Comparision .....</b>	<b>699</b>
Agata Kozina, Michał Nadolny, Marcin Hernes, Ewa Walaszczyk, Artur Rot	

<b>Synthetic Training-Data Generation for ML-based Process Mining Tools .....</b>	<b>705</b>
Anjali Singh, Zineddine Bettouche, Andreas Fischer	

<b>Deep Learning in Underground Mines – A Review .....</b>	<b>710</b>
Artur Skoczylas, Agnieszka Rosa, Wiesława Gryncewicz, Michał Nadolny	

<b>Analysis of Methods and Means of Identifying Infrastructure Anomalies using Unmanned Aerial Vehicles within the Scope of a Smart City .....</b>	<b>715</b>
Bohdan Zozuliak, Mikolaj Karpinski, Pawel Sawicki, Maria Stadnyk	

<b>Predicting Prosumption Survey Response using Machine Learning.....</b>	<b>720</b>
Ewa Walaszczyk, Michał Nadolny, Agata Kozina, Marcin Hernes, Artur Rot	

<b>A Smart Video Surveillance Technique using Artificial Intelligence to Detect Forgery and Violence in Real-Time Videos .....</b>	<b>725</b>
Himani Sharma, Navdeep Kanwal	

<b>FKD-YOLO: A Lightweight Student Classroom Behavior Recognition Algorithm.....</b>	<b>729</b>
Jinquan Yang, Zexi Chen, Orest Kochan, Olha Fedchyshyn	

<b>The Importance of Clustering in Word-Sense Induction .....</b>	<b>735</b>
Johannes Reisinger, Andreas Fischer, Christoph Goller	

<b>Design and Implementation of Road Monitoring System using Embedded System and IoT .....</b>	<b>739</b>
Md Mehedi Hassain, Md. Fakwer Uddin Mazumder, Kazi Mohammad Abdullah, Md Reyad Arefin, Md. Arafatur Rahman	

<b>Design and Implementation of a SCADA Based Boiler Monitoring and Controlling System .....</b>	<b>744</b>
Muaz Muhammad, Md Mehedi Hassain, Md. Khaled Hossain Jahin, Md. Ariful Islam, Md. Arafatur Rahman, Kazi Mohammad Abdullah	

<b>A Federated Learning-Based Approach for Classification of Histopathology Images .....</b>	<b>749</b>
Musa Yenilmez, Ilhan Aydin	

<b>Fuzzy Control System of Arc Furnace Modes With Phase Load Equalization .....</b>	<b>753</b>
Oksana Hoholyuk, Yaroslav Paranchuk, Petro Stakhiv, Yuriy Shabaturo, Oleksiy Kuznyetsov, Taras Rudy	

<b>A Method of Constructing Ensemble Classifiers for Recognizing Audio Data of Various Nature .....</b>	<b>758</b>
Oleksandr Andronati, Svitlana Antoshchuk, Oksana Babilunha, Olena Arsirii, Anatolii Nikolenko, Kyrilo Mikhalev	

<b>Machine Learning Models for Information Support in the Justice System.....</b>	<b>762</b>
Olha Kovalchuk, Vladyslav Teremeckiy, Andrii Kolesnikov, Nataliia Chudyk, Valerii Kaniuka	

<b>Automatic Delineation of Burned Forest Areas from Satellite Imagery to Analyze and Manage Wildfires .....</b>	<b>766</b>
Peter Hofmann, Nichita Trofanisin, Sebastian Wöllmann	
<b>Group Recommendation Method for Hypergraph Message Passing Meta-path Mask.....</b>	<b>772</b>
Sheng Qi, Rong Gao, Xiongkai Shao, Donghua Liu, Xiang Wan, Orest Kochan	
<b>Revolutionizing Contact Center Knowledge Management: The Game-Changing Role of AI Large Language Models And Autonomous Agents in Text Organization and Optimization .....</b>	<b>778</b>
Vladyslav Holubiev, Bohdan Pushkar, Anton Shevchuk, Roman Mudrak, Oksana Gomotiuk, Nataliia Livitska	
<b>Application of Mutual Information Estimation Methods for Feature Selection in Regression Problems of Aviation Traffic Forecasting .....</b>	<b>784</b>
Volodymyr Lytvynenko, Oleksandr Naumov, Mariia Voronenko, Olha Naumova, Iryna Lurie, Petro Radovenchuk	
<b>RUCARDAS: Retinex-inspired Unrolling with Channel Attention Residual Dense Cooperative Prior Architecture Search for Low-light Image Enhancement.....</b>	<b>790</b>
Xizhi Deng, Siwei Wei, Zexi Chen, Serhii Mokhun	
<b>An Improved Bayesian Learner Based On Weighted Beta Kernel Density Estimation .....</b>	<b>796</b>
Yuanhu Liu, Zhiwei Ye, Wanfang Bai, Orest Kochan, Yuquan Zhang, Donglei Xu	
<b>Traffic Flow Prediction Model Based on Gated Temporal Attention and Down-sampling Convolutional Network .....</b>	<b>802</b>
Zuhua Li, Siwei Wei, Zexi Chen, Lei Yu, Beier Luo, Haibo Wang	

## SECTION 6

### Information Technology in Education

<b>Employers' Expectations of students' generative AI skills: A Student Perspective .....</b>	<b>809</b>
Anatolijs Prohorovs, Olga Tsaryk, Levs Fainglozs	
<b>Automatic Generation of Problem Scenarios for Assessment of Methodological Knowledge .....</b>	<b>815</b>
Andriy Melnyk, Andriy Hirnyak, Halyna Hirnyak, Mariya Mudrak, Ihor Hevko, Yuriy Popovych	
<b>Methods and Tools of Automatic Generation of Practical Tasks for Checking the Assimilation of Programming Knowledge .....</b>	<b>820</b>
Andriy Melnyk, Andriy Hirnyak, Halyna Hirnyak, Iurii Shcherbiak, Olena Shevchenko, Volodymyr Nemeryshyn	
<b>Automated Reporting Module in the Academic Staff Performance Appraisal System.....</b>	<b>824</b>
Andriy Pukas, Andrii Simak, Andriy Yushko, Sergiy Nadvynychnyy, Serhii Shandruk, Oleh Vatslavskyi	
<b>The Information-Intellectual System for Evaluating Scientific and Scientific-Pedagogical Activities of the Academic Community .....</b>	<b>828</b>
Andriy Yushko, Mykola Dyvak, Uliana Koruts, Martin Taraj, Edit Hrabar, Vasil Sprinsyan	
<b>Digital Competence of Specialists: Development Technology in a Higher Education Institution ...</b>	<b>834</b>
Halyna Henseruk, Serhii Martyniuk, Oksana Vasylenko, Yuliia Henseruk, Viktor Henseruk, Valerii Habrusiev	
<b>Method of Formation of Basic Practical Skills of Data Analysis using Google Services .....</b>	<b>838</b>
Iryna Lutsyk, Illia Lutsyk, Olha Potapchuk, Halyna Havryshchak, Roman Zahorodnii, Volodymyr Rak	

<b>The Conceptual Information Model for Enhancing Social Mobility among Students through the Digitalization of the University's Educational Space .....</b>	<b>842</b>
Iurii Shcherbiak, Kateryna Binytska, Dmytro Kostenko, Svitlana Krupko, Andrii Kolesnikov, Sviatoslav Gerchakivsky	
<b>Model of Immersive Educational Instruments of Behavioral Analysis and Management in Distributed Educational Teams .....</b>	<b>848</b>
Iurii Volk, Artem Artyukhov, Nadiia Artyukhova, Oleksandr Dluhopolskyi, Tetiana Dluhopolska, Anzhela Kuznyetsova	
<b>Image Processing Techniques in a Python Course based on Ancient Manuscript Processing.....</b>	<b>854</b>
Paulina T. Tsvetkova, Georgi P. Dimitrov, Iva Kostadinova, Katia Rasheva–Yordanova, Lyubomir Gotsev, Pavel S. Petrov	
<b>The Concept and Role of Digitalization in the Realization of the Human Right to Education: A Comparative Legal Perspective .....</b>	<b>858</b>
Mariia Pleskach	
<b>Principles for Constructing the Architecture of Information Ecosystems in Education .....</b>	<b>866</b>
Yevhen Palamarchuk, Olena Kovalenko	
<b>AUTHOR’S INDEX.....</b>	<b>871</b>