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ENHANCING WRITER IDENTIFICATION AND WRITER RETRIEVAL WITH CENSURE AND VISION TRANSFORMERS

pages 6–14

Mykyta Shupyliuk, *PhD Student, Department of Electronic Computers, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine, ORCID: https://orcid.org/0009-0005-3457-9895*

Vitalii Martovytskyi, *PhD, Associate Professor, Department of Electronic Computers, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine, e-mail: vitalii.martovytskyi@nure.ua, ORCID: https://orcid.org/0000-0003-2349-0578*

Yuri Romanenkov, *Doctor of Technical Sciences, Vice-Rector for Scientific Work, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0002-6544-5348*

The object of research is the process of writer identification based on handwritten text. Despite significant progress, existing methods for author identification from handwritten text have limitations that prevent them from achieving maximum accuracy and reliability.

This paper focuses on optimizing and improving the efficiency of writer identification from handwritten text by integrating image preprocessing methods, feature detection, and modern machine learning architectures. To this end, a functional model was developed that uses the CenSurE algorithm to detect key points and extract relevant image areas, and then the Vision Transformer model to identify the writer based on these extracted features. To reduce the variability of the results, experimental validation was conducted using a dual search and classification methodology. The use of the public CVL dataset increases reproducibility and helps in comparative analysis. The findings indicate that the implementation of the proposed approach leads to an improvement in the identification accuracy during retrieval, surpassing the results of other studies. This is evidenced by increased accuracy values of hard top k and soft top k by 1% and mean average precision by 2%. In addition, findings indicate significant performance improvement in the feature detection preprocessing stage. This improvement is quantitatively supported by reductions in both the average time per item and total processing duration by 39%, alongside the increase in total count of patches extracted by 70%.

The results obtained contribute to increasing the reliability of automated handwriting analysis systems, especially for the task of writer identification. This achievement is a valuable tool for graphologists and forensic document experts, supporting such critical tasks as the forensic authorship process.

Keywords: machine learning, writer identification, transformer, image, neural networks, handwriting, preprocessing.

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DEVELOPMENT OF ADAPTIVE RECONFIGURATION METHOD FOR STREAM DATA PROCESSING SYSTEMS USING SYSTEM METRICS

pages 15–22

Artem Bashtovyi, *PhD, Assistant, Department of Software, Lviv Polytechnic National University, Lviv, Ukraine, e-mail: artem.v.bashtovyi@lpnu.ua, ORCID: https://orcid.org/0000-0003-4304-8605*

Andrii Fechan, *Doctor of Technical Sciences, Professor, Department of Software, Lviv Polytechnic National University, Lviv, Ukraine, ORCID: https://orcid.org/0000-0001-9970-5497*

The object of research is the process of adaptive configuration changes for stream processing applications which is focused on improving specific performance properties. The absence of the generalized automated approach for dynamic reconfiguration of state-store in limited hardware environment is the research problem addressed in this paper. The proposed solution helps to avoid a need for manual application reconfiguration from engineers. The implementation is based on Kafka Streams but designed to be portable across other frameworks that use RocksDB as a state store. Static configuration of modern stream processing systems limits efficiency under variable workloads. In this study, an adaptive module is proposed that monitors system metrics in real-time and automatically updates state-store configurations. The module performs deterministic check to derive new configuration based on predefined thresholds or utilizes a fine-tuned Large Language Model (LLM) to select new configuration values when decisions are vague. The method dynamically applies updates to the affected instance. High-load experimental results reveal the fact that adaptive executions eliminated write stalls, increased memtable hit ratio from 2% to 40% and block-cache hit ratio from 15% to 80%, reduced disk I/O by approximately 50%, and improved throughput by around 5%, at the cost of higher memory consumption. To avoid redundant adaptive updates and outlier-based bias a 10-minute observation frequency was selected. The approach is suitable for systems with fixed resources, state-intensive workloads with high key cardinality. Additionally, if covers the need for safe configuration change under operational constraints. The architecture is framework agnostic for the RocksDB-based based stream processing with state stores.

Keywords: distributed systems, stream processing, Kafka Streams, adaptivity, adaptive, dynamic, RocksDB.

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DEVELOPMENT OF CLUSTERING MODELS FOR EXTENDED OPINION HOLDERS BASED ON AGGREGATED STYLOMETRIC AND SENTIMENT FEATURES OF CHAT MESSAGES

pages 23–30

Heorhii Chyzhmak, *PhD Student, Assistant, Department of Computer Engineering and Electronics, Kremenchuk Mykhailo Ostrohradskyi National University, Kremenchuk, Ukraine, e-mail: george.chizhmak@gmail.com, ORCID: https://orcid.org/0000-0001-9284-4195*

Valeriy Sydorenko, *PhD, Associate Professor, Department of Computer Engineering and Electronics, Kremenchuk Mykhailo Ostrohradskyi National University, Kremenchuk, Ukraine, ORCID: https://orcid.org/0000-0002-4449-073X*

The subject of research is the methods and technologies for monitoring holder opinion groups in social media based on stylometric and sentiment

features. One of the most important problems is the increasing complexity of text content, which makes user behavior analysis more difficult because of anonymity, informal language, slang, emojis, and non-standard writing styles. Stable, long-term behavioral patterns are not captured by methods based on single-message evaluation.

This research proposes a holder-level clustering method based on aggregated stylometric and sentiment features taken from several messages per user. The methodology includes agglomerative hierarchical clustering, which is enhanced by decision tree analysis for feature selection and cluster interpretability, quantile normalization, dimensionality reduction via PCA (LiveJournal provided six components explaining 81.7% of the variance, while Instagram provided four components explaining 83.5% of the variance), and data preprocessing (VarianceThreshold, removal of highly correlated features). Ultimately, the majority of users were covered by two clusters for LiveJournal and three clusters for Instagram. The result is a set of clustering models that efficiently group holders into logical, understandable clusters based on their overall communication style and emotional expression. The primary advantages of the proposed approach are as follows: holder-level aggregation ensures stability and consistency in profiling; two-stage clustering with intermediate feature selection enhances explainability; the method demonstrates cross-platform applicability, validated on both LiveJournal and Instagram. As a result, over time, more accurate and dynamic user profiles can be developed, enabling improved sentiment analysis, automated moderation, and customized user interaction. This approach offers significant benefits over conventional single-message analysis methods in terms of results transparency, behavioral insight depth, and profile stability. Customized social media recommendations, automated moderation, and social sentiment analysis can all benefit from the study's findings.

Keywords: clustering models, natural language processing, semantic and sentiment analysis, explainable artificial intelligence.

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A PRIVACY-PRESERVING EDGE DATA AGGREGATION FOR TINYML ENERGY FORECASTING IN HOUSEHOLDS

pages 31–38

Anton Komin, *PhD Student, Department of Information Technologies, Sumy State University, Sumy, Ukraine, e-mail: anton.komin2@gmail.com, ORCID: https://orcid.org/0000-0003-0328-3934*

Olha Boiko, *PhD, Associate Professor, Senior Lecturer, Department of Information Technologies, Sumy State University, Sumy, Ukraine, ORCID: https://orcid.org/0000-0001-8557-2267*

The object of this research is the use of tiny machine learning (ML) forecasting models and low-power edge processing as a part of a hybrid energy management system (HEMS) with a particular emphasis on ensuring end-user data privacy and trust. The research addresses the challenge of the collection, aggregation, and processing of sensitive data in smart grid operational modes decision-making tasks.

An in-depth literature review revealed that failing to meet user expectations for control and privacy often leads to dissatisfaction and disengagement. This study introduced a complex solution that tries to solve the indicated gap and proposes a prototype of a HEMS data aggregation subsystem designed to supply information to an energy consumption forecasting module based on mobile ML models.

The developed LSTM-based household energy consumption forecasting models were converted into CoreML and TensorFlow Lite formats, maintained accuracy with an RMSE of 0.211 kWh, inference time under 0.5 ms, 800 kB size on disk, and up to 20 MB RAM usage. These results confirm their feasibility for deployment in HEMS forecasting subsystems on low-power edge devices.

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To supply these models with data, a prototype of the HEMS data aggregation system was developed. It uses open-source software (Home Assistant, InfluxDB) and a scalable, privacy-centered container architecture that keeps sensitive data at the edge. Tests on Raspberry Pi 5 (16 GB) showed 97.2% availability over 72 hours, with 12% RAM usage, 18% CPU load, and CPU temperatures of 44–51°C when processing 1440 records per sensor daily. This confirms reliable aggregation with low resource demands and good scalability.

Considering the results, the models and prototype can be considered as the sensing and edge computing layers of HEMS, providing the necessary data for operational mode selection in household microgrids.

Keywords: energy management systems, energy efficiency, Internet of Things, smart grid.

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DEVELOPMENT OF STRATEGIES FOR ENHANCING CYBERSECURITY AND DIGITAL TRUST IN AZERBAIJAN'S DIGITAL LANDSCAPE

pages 39–56

Khayala Alasgarova, *PhD, Assistant, Department of Economics and Business, Azerbaijan State University of Economics (UNEC), Baku, Azerbaijan, e-mail: khayala.alasgarova@unec.edu.az, ORCID: https://orcid.org/0009-0003-8489-2025*

Sahib Ramazanov, *PhD, Assistant Professor, Department of Economics and Business, Azerbaijan State University of Economics (UNEC), Baku, Azerbaijan, ORCID: https://orcid.org/0000-0003-2582-3188*

This research focuses on assessing cybersecurity practices and the level of digital trust in Azerbaijan and identifying key weaknesses using real-world data.

The object of the research is cybersecurity practices and digital trust among organizations and users in Azerbaijan.

The research solves the problem of insufficient empirical data on cybersecurity practices and digital trust in Azerbaijan, which contributes to low awareness, weak security implementation, frequent cyber incidents, and limited trust in digital services and legislation.

The research methodology included a quantitative survey of 129 participants, Spearman correlation analysis, and risk heatmap modeling. Data analysis was conducted using a personal computer with Microsoft Excel and (Statistical Package for the Social Sciences) SPSS software.

The results show that 55% of organizations have moderate cybersecurity awareness, 17.8% have low awareness, and 53.5% do not provide cybersecurity training to employees. Although 76% of banks use multi-factor authentication (MFA), 40.3% have experienced fraud incidents. Spearman correlation analysis indicates a negative relationship between awareness and cyber incidents (–0.33) and between training and incidents (–0.29), while MFA usage shows a positive correlation with fraud detection (+0.3446). In addition, 64.3% of users feel somewhat safe, and 41.1% identify public education as the most important area requiring improvement.

The findings demonstrate that insufficient training, incomplete adoption of modern protective measures, and weak public education increase cybersecurity risks even in organizations with moderate awareness. The results can support the State Service for Special Communication and Information Security (SSSCIS) in improving the National Cybersecurity Strategy and assist banks, businesses, and educational institutions in strengthening cybersecurity practices for the period 2025–2030.

Keywords: cybersecurity, digital trust, phishing attacks, data breach, fraudulent activities.

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SYSTEMS AND CONTROL PROCESSES

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EVALUATION OF THE EFFICIENCY OF LARGE LANGUAGE MODELS FOR EXTRACTING ENTITIES FROM UNSTRUCTURED DOCUMENTS

pages 57–67

Oleksandr Shyshatskyi, *PhD Student, Department of Software Engineering, Dnipro University of Technology, Dnipro, Ukraine, ORCID: https://orcid.org/0009-0008-6008-7079*

Borys Moroz, *Doctor of Technical Sciences, Department of Software Engineering, Dnipro University of Technology, Dnipro, Ukraine, ORCID: https://orcid.org/0000-0002-5625-0864*

Maksym Ievlanov, *Doctor of Technical Sciences, Department of Information Control Systems, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine, e-mail: maksym.ievlanov@nure.ua, ORCID: https://orcid.org/0000-0002-6703-5166*

Ihor Levykin, *Doctor of Technical Sciences, Department of Media Systems and Technologies, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0001-8086-237X*

Dmytro Moroz, *PhD, Department of Software Engineering, Dnipro University of Technology, Dnipro, Ukraine, ORCID: https://orcid.org/0000-0003-2577-3352*

The object of research is arrays of unstructured documents located on public websites of rural and urban communities of Ukraine.

The study is devoted to solving the problem of choosing a large language model (LLM), which is the best for applied use in solving named entity recognition (NER) problems during document processing. Modern researchers recognize that such a choice is significantly influenced by the features of the subject area and the language of document creation. However, when studying the feasibility of using LLM to solve NER problems, the features of the operation of such models are practically not taken into account. The issues of evaluating such features remain largely unexplored.

A method for recognizing selected varieties of legal unstructured texts in the Ukrainian language is proposed. Unlike existing ones, this method solves the NER problem for those documents that are subject to recognition/classification. Metrics for the cost of processing input and output tokens are proposed and a methodology for evaluating the cost of using LLM is developed. Based on these results, a comparative evaluation of the application of common LLMs to solve the NER problem on Ukrainian texts that need to be recognized was conducted. According to the evaluation results, it was recognized that: (I) GPT-4o is the best in terms of accuracy and quality of processing (Precision = 0.919; Recall = 0.954; *F*1 = 0.936); (II) GPT-4o-mini with discounts is the best in terms of average document processing cost (0.00045 USD per document); (III) GPT-4.1-mini with discounts is the best in terms of quality/cost ratio (the indicator value is 0.938). The GPT-4.1-mini LLM is recommended as the best for applied application.

The evaluation results obtained allow to significantly simplify the choice of LLM, which is advisable to use for creating information systems and technologies for processing unstructured documents created in Ukrainian.

Keywords: legal unstructured document, structured document annotation, token processing cost, GPT-4.1-mini.

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DEVELOPMENT OF AN OPTOELECTRONIC IMAGE SEGMENTATION METHOD FROM UNMANNED AERIAL VEHICLES BASED ON THE ANT COLONY OPTIMIZATION ALGORITHM UNDER THE INFLUENCE OF SALT-AND-PEPPER NOISE

pages 68–75

Igor Ruban, *Doctor of Technical Sciences, Professor, Rector, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0002-4738-3286*

Hennadii Khudov, *Doctor of Technical Sciences, Professor, Head of Department of Radar Troops Tactic, Ivan Kozhedub Kharkiv National Air Force University, Kharkiv, Ukraine, e-mail: 2345kh_hg@ukr.net, ORCID: https://orcid.org/0000-0002-3311-2848*

Vladyslav Khudov, *PhD, Junior Researcher, Department of Information Technology Security, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0002-9863-4743*

Oleksandr Makoveichuk, *Doctor of Technical Sciences, Associate Professor, Department of Computer Sciences and Software Engineering, Higher Education Institution "Academician Yuriy Bugay International Scientific and Technical University", Kyiv, Ukraine, ORCID: https://orcid.org/0000-0003-4425-016X*

Irina Khizhnyak, *Scientific and Methodological Department for Quality Assurance in Educational Activities and Higher Education, Ivan Kozhedub Kharkiv National Air Force University, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0003-3431-7631*

Ihor Butko, *Doctor of Technical Sciences, Professor, Department of Computer Sciences and Software Engineering, Higher Education Institution "Academician*

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Yuriy Bugay International Scientific and Technical University", Kyiv, Ukraine, ORCID: https://orcid.org/0000-0002-2859-0351

Andrii Hryzo, *PhD, Associate Professor, Head of Research Laboratory, Department of Radar Troops Tactic, Ivan Kozhedub Kharkiv National Air Force University, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0003-2483-5953*

Rostyslav Khudov, *Department of Theoretical and Applied Informatics, V. N. Karazin Kharkiv National University, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0002-6209-209X*

Petro Mynko, *PhD, Associate Professor, Department of Higher Mathematics, National University of Radio Electronics, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0002-2621-8900*

Oleksii Baranik, *PhD, Associate Professor, Head of Department of Aviation Armament Complexes, Ivan Kozhedub Kharkiv National Air Force University, Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0002-1499-7943*

The object of research is the process of segmenting an image from an unmanned aerial vehicle based on the ant algorithm under the influence of salt-and-pepper noise.

"Salt"-and-"pepper" noise occurs due to data transmission errors, failures of digital camera sensors or malfunctions during recording/reading of information. It is characterized by the random appearance of individual pixels in the image, the value of which is equal to the minimum ("pepper") or maximum ("salt") brightness level.

Unlike the known ones, the method of segmenting an optoelectronic image based on the ant algorithm provides image segmentation under the influence of salt-and-pepper noise and involves:

– initialization of initial parameters;
– calculation of the length of the path segment of agents;
– calculation of the attractiveness of the route for the agent;
– updating the pheromone concentration;
– calculation of the probability of transition of agents;
– calculation of the objective function;
– movement of agents;
– determination of the best route of agents.

Experimental studies have shown that the segmentation method based on the ant algorithm provides a reduction in segmentation errors of the first kind on average:

– in the absence of salt-and-pepper noise – 4%;
– at the intensity of salt-and-pepper noise σ = 5–21%;
– at the intensity of salt-and-pepper noise σ = 15–10%.

The segmentation method based on the ant algorithm provides a reduction in segmentation errors of the second kind on average:

– in the absence of salt-and-pepper noise – 3%;
– at the intensity of salt-and-pepper noise σ = 5–15%;
– at the intensity of salt-and-pepper noise σ = 15–6%.

The practical significance of the segmentation method based on the ant algorithm is to ensure high-quality image segmentation under the influence of salt-and-pepper noise.

Keywords: optoelectronic image, segmentation, ant colony optimization algorithm, salt-and-pepper noise.

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DEVELOPMENT OF A SIMULATION MODEL OF A WEB-ORIENTED SERVO DRIVE FREQUENCY CONTROL SYSTEM BASED ON "DIGITAL TWINS" TECHNOLOGY

pages 76–90

Leonid Zamikhovskyi, *Doctor of Technical Sciences, Professor, Head of Department of Information and Telecommunication Technologies and Systems, Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine, e-mail: leozam@ukr.net, ORCID: https://orcid.org/0000-0002-6374-8580*

Mykola Nykolaychuk, *PhD, Associate Professor, Department of Information and Telecommunication Technology and Systems, Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine, ORCID: https://orcid.org/0000-0001-6185-2272*

Ivan Levytskyi, *PhD, Associate Professor, Department of Information and Telecommunication Technology and Systems, Ivano-Frankivsk National Technical University of Oil and Gas, Ivano-Frankivsk, Ukraine, ORCID: https://orcid.org/0000-0001-6538-7734*

The object of this research is the information processes of interaction between virtual components of a WEB-oriented simulation model of a frequency control system for a synchronous servo drive. The research problem lies in the need for a comprehensive solution to the tasks of developing simulation models of control systems for technological objects based on advanced algorithms, procedures, and unified hardware and software tools.

A project of a frequency control system for a SIMOTICS S-1FK2 synchronous servo drive was developed using a PLC S7-1500 and a FC SINAMICS S210 within the TIA Portal environment. Application software for the frequency control system was developed in FBD language with an integrated specialized technological object "SpeedAxis".

During the development of the simulation model, a "Digital Twins" were generated for the frequency converter with an integrated synchronous servo drive. To ensure interaction between the virtual components of the simulation model, procedures for basic parameterization and loading of the TIA Portal project components into the "Digital Twins" were implemented.

Testing and investigation of the information exchange processes between the virtual components of the simulation model were carried out in "on-line" mode using the capabilities of the integrated WEB-server.

The tests were conducted at speeds of 2000 rpm and 4000 rpm, switched periodically every 12 sec. Parameters of the reference and actual speed, as well as the instantaneous voltage, current, torque, and output power of the virtual frequency converter, were measured and analyzed.

Based on the test results, the feasibility and correctness of the joint operation of the simulation model components in an isochronous real-time mode with a 1 ms synchronization cycle were confirmed, demonstrating the effectiveness of the approach based on "Digital Twins" technology.

Keywords: WEB control system, TIA Portal, Digital Twin, simulation model, PLC, frequency converter Sinamics.

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ASSESSMENT OF STRIKE EFFECTIVENESS AGAINST ENEMY LANDING GROUPS CONSIDERING SEQUENTIAL VOLLEYS AND COMBAT POTENTIAL REDUCTION IN COMPUTER SIMULATION

pages 91–96

Oleksii Neizhpapa, *Vice Admiral, Commander of the Ukrainian Navy, Odesa, Ukraine, ORCID: https://orcid.org/0009-0007-0037-0166*

Maksym Maksymov, *Doctor of Technical Sciences, Professor, Chief Researcher, Scientific Research Center of the Armed Forces of Ukraine "State Oceanarium" of the Institute of the Naval Forces of National University "Odesa Maritime Academy", Odesa, Ukraine, ORCID: https://orcid.org/0000-0002-3292-3112*

Oleksandr Toshev, *PhD Student, Department of Computer Technologies of Automation, Odesa Polytechnic National University, Odesa, Ukraine, e-mail: toshev.oleksandr@outlook.com, ORCID: https://orcid.org/0009-0000-4093-2556*

The object of research is a naval landing operations and interactions between anti-ship missiles and naval forces in a variety of simulation scenarios. Computer simulation is an essential tool for modeling and evaluating complex processes. Strategy-oriented video games allow model and interact with multi-layered systems in a modern warfare, in a variety of scenarios. This research presents a framework for modeling naval landing operation in a strategic wargame. The model focused on the interactions between attacking player using transport ships for naval landing, fire-support ships, minesweepers, electronic warfare units, and interceptor aircraft, and defending player which using anti-ship missile launchers and naval minefields. A key objective is to identify optimal defensive strategies under resource constraints, calculation possible unit interactions, to estimate possible outcomes, which can help that determine the best tools to prevent or execute successful naval landing operation.

The methodology was implemented using stochastic mathematical model to estimate the effectiveness of anti-ship missiles against different types of ships with different defensive setups. The methodology proposes different approaches, for the defending side player, targeting the most vulnerable or most important parts of attacking player convoy to ensure the most effective way to prevent naval landing operation.

Experiment results show the importance of dynamic targets prioritization for the defending player, and allows increase the efficiency of the provided resources up to two times compared to the basic targeting algorithm.

The given framework allows to improve realism of naval combat simulations in a video game and offers a scalable foundation for game balance adjustments or potential application in tactical training environments.

Keywords: computer simulations, simulation framework, naval landing, anti-ship missiles, stochastic models.

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IDENTIFICATION OF DANGEROUS SITUATIONS IN THE ROAD INFRASTRUCTURE USING UNMANNED AERIAL VEHICLES

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Nurzhigit Smailov, *PhD, Professor, Institute of Mechanics and Machine Science Named by Academician U. A. Dzholdasbekov, Almaty, Kazakhstan, ORCID: https://orcid.org/0000-0002-7264-2390*

Yerzhan Nussupov, *Doctoral Student in Telecommunication, Department of Electronics, Telecommunications, and Space Technologies, Satbayev University, Almaty, Kazakhstan, ORCID: https://orcid.org/0009-0008-5118-3683*

Kyrmyzy Taissariyeva, *PhD, Professor, Department of Electronics, Telecommunications, and Space Technologies, Satbayev University, Almaty, Kazakhstan, ORCID: https://orcid.org/0000-0002-1949-4288*

Aidar Kuttybayev, *Candidate of Technical Sciences, Professor, Satbayev University, Almaty, Kazakhstan, ORCID: https://orcid.org/0000-0003-3997-8324*

Baigulbayeva Moldir, *Faculty of Chemistry and Chemical Technology, Al-Farabi Kazakh National University, Almaty, Kazakhstan, ORCID: https://orcid.org/0000-0003-4049-4319*

Mukhit Turumbetov, *PhD, Department of Electronics, Telecommunications, and Space Technologies, Satbayev University, Almaty, Kazakhstan, ORCID: https://orcid.org/0000-0002-2477-8875*

Yulian Hryhoriev, *PhD, Associate Professor, Department of Open Pit Mining, Kryvyi Rih National University, Kryvyi Rih, Ukraine, ORCID: https://orcid.org/0000-0002-1780-5759, e-mail: yulian.hryhoriev@knu.edu.ua*

Serhii Lutsenko, *PhD, Associate Professor, Department of Open Pit Mining, Kryvyi Rih National University, Kryvyi Rih, Ukraine, ORCID: https://orcid.org/0000-0002-5992-3622*

The object of the research is the developed automated computational model (AI-driven system) for real-time monitoring and analysis of road traffic, focusing on the identification and assessment of dangerous situations (traffic violations, congestion, and accident risks). This paper examines how the increased number of people moving to cities and their vehicles increases the likelihood of traffic accidents on public roads. It is also noted that traditional inspections are carried out very slowly and do not fully detect violations of traffic rules. To overcome these limitations, it is proposed a novel automated computational model for vehicle and accident tracking, based on UAVs combined with computer vision and artificial intelligence technologies. The proposed model allows for real-time threat detection and evaluation. The study, modeled in the MATLAB environment using real traffic data from drone-captured video. This model demonstrates significant improvements in operational metrics, an average detection achieved accuracy 89% for vehicles and critical events (e. g., congestion, deviations). The model successfully visualizes risk areas with heat maps and predicts short-term traffic pattern changes, increasing the reliability of traffic management and expanding the possibilities of traffic risk forecasting. The results obtained during the simulation can be used in practice by transport services, road, and maintenance organizations, particularly at difficult intersections and on highly accident-prone highways in urban, heavily built-up areas.

Keywords: infrastructure, security, risks, monitoring, traffic, incidents, drones, aircraft, damage, urbanization.

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MATHEMATICAL MODELING

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DEVELOPMENT OF A METHOD FOR STATE ESTIMATION AND OPTIMISATION OF MULTIFACTOR SEMI-MARKOV SYSTEMS

pages 103–108

Lev Raskin, *Doctor of Technical Sciences, Professor, Department of Software Engineering and Management Intelligent Technologies, National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0002-9015-4016*

Larysa Sukhomlyn, *PhD, Associate Professor, Department of Management, Kremenchuk Mykhailo Ostrohradskyi National University, Kremenchuk, Ukraine, ORCID: https://orcid.org/0000-0001-9511-5932*

Viacheslav Karpenko, *PhD, Department of Software Engineering and Management Intelligent Technologies, National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0002-8378-129X*

Dmytro Sokolov, *PhD Student, Department of Software Engineering and Management Intelligent Technologies, National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine, e-mail: sokolovddd@gmail.com, ORCID: https://orcid.org/0000-0002-4558-9598*

Vitalii Vlasenko, *PhD Student, Department of Software Engineering and Management Intelligent Technologies, National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine, ORCID: https://orcid.org/0000-0001-5427-0223*

The object of this research is a method for solving problems of analysis and optimization of semi-Markov systems. The importance of this topic is determined by the following circumstances. First, traditional, standard theoretical and practical problems of stochastic system research are solved analytically only for Markov systems for which the laws of distribution of the duration of stay in each state before leaving are exponential. Clearly, this strict requirement is not met for real systems. Second, a general method of analytical study does not exist for many probabilistic systems. Third, only numerical methods for solving such problems are available and feasible. Moreover, in each case, a solution can only be obtained for the specific system under study, operating under specific conditions. Clearly, such a solution is uninformative and practically useless for optimization problems of multifactor systems. In this regard, the study aims to develop a universal method for solving analysis and optimization problems, suitable for any semi-Markov systems. The proposed method for solving the formulated problem solves it in two stages. In the first stage, a matrix of distribution densities is found by processing experimental data, representing the duration of the system's stay in each state before transitioning to another state. It is crucial that the densities be in the Erlang distribution class of some order. These densities are found using the least-squares method, using histograms obtained by processing the experimental data. In the second stage, the resulting distribution densities are used to construct a system of differential equations for the probabilities of the system's stay in each possible state. This constructively utilizes the unique property of Erlang distributions: any Erlang flow is a sifted simplest Poisson flow. Sequentially completing these two stages yields a solution to the problem of studying any probabilistic (semi-Markov) systems. Thus, the method proposed in this paper for solving problems of analysis and optimization of semi-Markov systems is universal.

Keywords: semi-Markov systems, system analysis and optimization, Erlang distribution, probabilistic modeling.

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