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TRANSFORMER-BASED MODELS APPLICATION FOR BUG DETECTION IN SOURCE CODE

pages 6–15

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This paper explores the use of transformer-based models for bug detection in source code, aiming to better understand the capacity of these models to learn complex patterns and relationships within the code. Traditional static analysis tools are highly limited in their ability to detect semantic errors, resulting in numerous defects passing through to the code execution stage. This research represents a step towards enhancing static code analysis using neural networks.

The experiments were designed as binary classification tasks to detect buggy code snippets, each targeting a specific defect type such as NameError, TypeError, IndexError, AttributeError, ValueError, EOFError, SyntaxError, and ModuleNotFoundError. Utilizing the "RunBugRun" dataset, which relies on code execution results, the models – BERT, CodeBERT, GPT-2, and CodeT5 – were fine-tuned and compared under identical conditions and hyperparameters. Performance was evaluated using F1-Score, Precision, and Recall.

The results indicated that transformer-based models, especially CodeT5 and CodeBERT, were effective in identifying various defects, demonstrating their ability to learn complex code patterns. However, performance varied by defect type, with some defects like IndexError and TypeError being more challenging to detect. The outcomes underscore the importance of high-quality, diverse training data and highlight the potential of transformer-based models to achieve more accurate early defect detection.

Future research should further explore advanced transformer architectures for detecting complicated defects, and investigate the integration of additional contextual information to the detection process. This study highlights the potential of modern machine learning architectures to advance software engineering practices, leading to more efficient and reliable software development.

Keywords: transformers, large language models, bug detection, defect detection, static code analysis, neural networks.

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ASSESSING THE IMPACT OF MULTICHANNEL SALES INTEGRATION ON THE EFFICIENCY AND COMPETITIVENESS OF UKRAINIAN RETAIL IN THE CONTEXT OF DIGITAL COMMERCE

pages 16–23

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One of the most significant changes the business world is currently experiencing is the progressive development and adoption of digital commerce. Taking into account the rapid development of web and Internet technologies, e-commerce is increasing volumes on a global scale and is being formed as a separate branch of the economy. Every year from 30 % to 70 % businesses of all countries (regardless of their level of development) are moving to the online environment. This is especially true for business entities that carry out trading activities.

The object of the study is the process of integrating multichannel sales in retail trade in Ukraine, with a focus on its impact on the efficiency and competitiveness of enterprises in the market. The problem under consideration is to determine the most effective methods and strategies for implementing e-commerce in the Ukrainian economy, which is under the influence of martial law and other socio-economic factors.

The main results of the study show that the integration of online and offline sales channels significantly increases business productivity. It was found that the use of omnichannel platforms can significantly improve customer interaction and increase sales. In particular, the analysis showed that properly integrated sales channels can increase the efficiency of enterprises by 20–30 %.

These results can be explained by the high level of adaptability of Ukrainian companies to new technologies and their ability to quickly integrate digital platforms into their business processes. The study also confirmed that businesses that actively use omnichannel strategies achieve higher levels of efficiency and competitiveness.

In practice, these results can be applied to the real-life conditions of Ukrainian retailers. This is especially true for small and medium-sized enterprises seeking to increase their market presence through the introduction of modern technologies and the integration of various sales channels. Using the data obtained will allow companies to optimise their business models, develop effective marketing campaigns and improve customer interaction. The findings can also be applied to the analysis of omnichannel retailing and digital commerce in other countries at different stages of retail development. This study also provides practical recommendations that may be useful for international companies and academics interested in improving retail performance.

Keywords: e-commerce, omnichannel sales, channel integration, retail competitiveness, digital platforms, Ukrainian retail, business efficiency.

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SIMULATION MODELING OF ARTILLERY OPERATIONS IN COMPUTER GAMES: APPROACH BASED ON MARKOV PROCESSES

pages 23–28

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The object of this research is an approach to simulating the combat operation of artillery in computer games based on Markov processes. In modern computer games, an important role is played by the realism and plausibility of combat simulation. One of the most difficult and at the same time most interesting tasks is the modeling of artillery operations, where it is necessary to take into account numerous factors affecting the effectiveness of combat work.

The research was aimed at improving the methods and models of controlling the combat work of artillery under the conditions for the firing position change and the presence of external disturbances. The use of stochastic models allows more accurate modeling of the behavior of artillery units, taking into account the random nature of many parameters, such as projectile speed, reload time, and the probability of detection by enemy forces.

The proposed approach includes the development of a simulation model that allows determining optimal strategies to achieve maximum effectiveness of combat work. The model is based on Markov processes, which allows taking into account possible system states and probable transitions between them. This allows not only to simulate combat operations, but also to predict the results depending on different scenarios.

The results of the study show that the use of Markov processes in the simulation of combat operations can significantly increase the realism and efficiency of artillery operations in computer games. This opens up new opportunities for game developers to create more immersive and authentic gaming experiences.

The proposed model can be used as a basis for further research and improvement of combat simulation methods in computer games. It can also be used in military simulators and simulators where realistic combat conditions must be taken into account.

Keywords: simulation modeling, computer games, artillery operations, Markov processes, stochastic models.

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DEVELOPMENT OF A REGRESSION MODEL FOR EFFECTIVE LABOUR MANAGEMENT OF AN IT PROJECT

pages 29–38

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The object of the study is human resource management in IT projects, where the diversity of cultural characteristics and communication practices can affect the efficiency of task performance. The main problem addressed in this study is to identify the key factors that affect the effectiveness of human resource management in IT projects and to identify problem areas that need to be adjusted to improve the productivity and quality of teamwork. The study findings showed that the effectiveness of human resource management in IT projects largely depends on four main aggregate indicators: communication and interaction, cultural factors, leadership and management, and technical and professional skills. In particular, the model found that improved communication and interaction, as well as leadership and management, have the greatest positive impact on overall performance. Instead, cultural differences can create barriers that negatively affect teamwork performance. The findings are explained by the fact that effective communication and interaction are fundamental to coordinating teamwork, ensuring clarity of tasks, and timely information exchange. Leadership and management determine team motivation, conflict resolution strategies, and the overall direction of activities. The negative impact of cultural factors is explained by language barriers, differences in work approaches, and other cultural characteristics that can make it difficult to understand and cooperate. These findings can be used in practice in IT projects where multicultural teams work. They provide valuable guidance for leaders and managers on which aspects of management to focus on to improve team effectiveness. In particular, effective communication practices should be implemented, leadership skills and strategic planning should be developed, and cultural sensitivity should be taken into account, as well as training and development of technical and professional skills of team members. This will help overcome cultural barriers, improve collaboration, and increase the overall productivity of IT projects.

Keywords: human resources, regression model, IT project, problem tree, decision tree, effective management of the IT project team.

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DEVELOPMENT OF AN INTELLIGENT MODEL FOR MANAGEMENT OF THE REQUIREMENTS OF MARKETING PROJECTS OF THE PHARMACEUTICAL INDUSTRY

pages 39–43

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The object of research is the processes of managing the requirements of the marketing project using means of intelligent data analysis and artificial intelligence systems. Marketing projects include a large number of projects of various types, formats and scales. The work considers projects that are initiated at an existing pharmaceutical enterprise that produces drugs for the local market. Over a period of time, the company needs to introduce new dosage forms to the market. It is not about the development of new innovative drugs. Usually, these are new mixtures of known components, but according to the results of global research, adding new components to the formulation gives a new, additional effect. Also, it can be a new form, for example, a spray or syrup for children, etc. Nevertheless, in order to produce such a new product and bring it to the market, to make a profit, it is necessary to conduct a study of the local market in order to find analogues, consumer expectations and predict future cash flows from sales of new drugs. In order to form requirements for the project of creating and manufacturing a new medicinal form, the company initiates marketing projects. Such marketing projects are the subject of research.

As a result of the marketing project of the analysis of the drug market, it is necessary to form the contours of a new product and the requirements for the project of creating this product – a new medicinal product. Collecting and forming requirements is not a trivial task. Therefore, in the work, it is proposed to apply means of intelligent data analysis, which will be implemented on artificial intelligence systems. As a result, an intelligent model for managing

the requirements of marketing projects of the pharmaceutical industry was developed. The non-triviality of the task of requirements formation is based on the fact that it is multi-criteria. The desired requirements and, accordingly, the future product of the project depend on: the lack of a similar dosage form on the local market, the presence of theoretical and practical pharmacological developments in this direction, the technical and financial capabilities of the enterprise, the expectations of stakeholders and consumers of the product. The use of intelligent tools will allow to avoid a conflict of requirements and to develop a medicine that will not only meet the expectations of all participants of the local pharmaceutical market, but also provide profit to the developing company.

Keywords: marketing project, pharmaceutical industry, product requirements, requirements management, intelligent model.

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DEVELOPMENT OF A METHOD FOR PREDICTING HAZARDOUS SHIP TRAJECTORIES UNDER UNCERTAINTY OF NAVIGATOR ACTIONS

pages 44–55

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The object of the research is the automation processes in maritime navigation to ensure the safety of ship movement by predicting their trajectories in complex aquatic areas, such as narrow passages, straits, and ports. The research applied six key stages to create a comprehensive method for clustering and predicting ship trajectories based on ECDIS data.

In the first stage, ship movement trajectories were constructed according to risk categories, using the LCSS and DTW algorithms to compare planned and actual trajectories. This allowed for the accurate identification of course deviations and the determination of potentially dangerous sections of the trajectory. The second stage implemented clustering using the DBSCAN and GMM algorithms. DBSCAN was used to identify the density of points in space, and GMM provided modeling of cluster probabilities, allowing for better risk zone determination. The third stage applied the Douglas-Peucker compression algorithm to reduce the number of points in the trajectories, which preserved key characteristics and optimized data processing. In the fourth stage, ship movement stability was assessed using the Fourier transform, which allowed the detection of high-frequency oscillations that may indicate movement instability caused by changes in course or speed. The fifth stage included fuzzy clus-

tering of trajectories using the Gaussian Mixture Model (GMM), which allowed modeling the probabilities of dangerous trajectories, considering the uncertainty of navigational parameters. At the final stage, a multilayer neural network (MLP) was used to predict future points of ship trajectories. The model accurately predicted the ship's coordinates, enabling timely trajectory adjustments.

Experimental results showed that the developed method increased the accuracy of ship trajectory prediction to 72–81 % and also significantly reduced the final error, ensuring effective risk management during complex navigation.

Keywords: maneuvering in confined waters, emergencies, operational reliability, optimization of control processes, steering control, automatic control module.

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APPLICATION OF PROBABILISTIC AND STOCHASTIC MODELS AND DATA MINING FOR FORECASTING THE CONTINGENT OF OLD AGE PENSION RECIPIENTS IN THE CONTEXT OF SYSTEMIC UNCERTAINTY

pages 56–62

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The object of the research is mathematical models for forecasting the contingent of pension recipients in conditions of uncertainty caused by both the reform of the pension system and the impact of armed aggression. Based on the study of statistical information on the structure and dynamics of the contingent of pension recipients, an approach to uncovering systemic uncertainty in the task of forecasting the contingent of pensioners is proposed. This work is part of a study of the application of data mining methods of intellectual data analysis and mathematical modeling in information technology intended for use in the pension system. The main focus of this work is on forecasting the dynamics of the contingent of pension recipients by age, in particular, forecasting the number of newly appointed pensions. The difficulty of forecasting the contingent of pension recipients, in particular by age, is connected with the fact that it is necessary to ensure the representativeness and variability of data sets. In addition, it should be taken into account that a significant number of factors must be included in the model in accordance with the requirements of regulatory documents. Another problematic issue is that the time series of the investigated indicators, such as data on the insurance experience of insured persons (based on the results of a sample survey), may contain significant (more than 40 %) gaps that can be filled only on the basis of primary (paper) documents. Therefore, the input data sets are formed with assumptions about the probability of the accumulation of insurance experience in various groups of insured persons. The paper proposes an analytical toolkit based on the use of probabilistic and statistical models in the form of Bayesian networks, intended for use in specialized decision-making support systems of the Ukrainian pension system. In the course of the study, a number of numerical experiments were carried out, in which the correctness of the proposed method was investigated. The proposals presented in the paper will improve the stability of the pension system of Ukraine, including through a more accurate definition of the dynamics of the contingent of pension recipients and, accordingly, the costs of pension payments. The proposed models and methods can be used as part of decision-making support systems of state and public administration bodies to analyze the results of reforming the pension system.

Keywords: Bayesian network, uncertainty, pension reform, data mining, probability-statistical models, pension recipients.

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