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**Zakharchenko V.E., Kiselev V.S., Tsvetkov V.V.** Data structures in information models of process scheduling systems in digitization conditions

The paper discusses the design of data structures for information models of process scheduling systems in digitization conditions and the need for its optimization subject to the number of tags. It proposes possible approaches to this task, such as data aggregation, compression, or encoding, application of buffer memory. Detailed analysis of advantages and limitations of buffer modules is presented. Application results are included.

**Keywords:** scheduling, process control system, human-machine interface, SCADA, information models.

**Vinogradov A.N.** Automated water treatment stations of cold water supply of Mayak educational center of the Ocean All-Russian Children's Center

The automatic control system for a cold-water treatment unit is presented. The artesian groundwater is used for drinking and utility purposes of the children's camp based in Russian Primorye Territory. The paper describes the system's key elements, ensuring both the compliance with water quality requirements and the remote control of water treatment process based on the increasing measurement history.

**Keywords:** automated control systems, process monitoring, water treatment

**Vildanov A.G., Gilmanov A.F., Demianov D.N.** Parametrizable multi-mass truck model

The paper presents a methodology for developing a parametrizable multi-mass model of a truck based on its representation as a set of connected homogeneous elements. The model features an iterative procedure of sequential simplification of the composition and the geometry of the model's elements with subsequent verification of results. Key phases of the procedure are expounded, its termination conditions ensuring the optimal combination of accuracy and computational efficiency are formulated. An example of methodology application for developing parametrizable multi-mass model of KAMAZ K5 Series truck is cited. The minimum level of model detail sufficient for carrying out virtual vibration resistance and durability tests is established. The results of comparative analysis of calculation and experimental data confirming the operability and efficiency of the methodology are included.

**Keywords:** computer simulation, multi-mass parametrizable model, vibration resistance, autotruck.

**Levitin A.V.** The analysis of the efficiency of textural features in flaw detection of semi-finished leather

The paper analyzes the efficiency of a number of features for texture classification on semi-finished leather images. Such tasks may arise in product quality control, where the detection of semi-product texture flaws may be required. For various abnormality and texture types, comparative analysis of application efficiency of various textural features is undertaken. These include statistical characteristics of grey level co-occurrence matrix (GLCM), local binary patterns (LBP), and the eigenvalues of Hesse matrix. The results of experimental investigation of texture classification methods using linear discriminant analysis (LDA) and gradient boosting (GB) on decision trees and of the selected textural features are presented.

**Keywords:** texture classification, leather texture, machine learning, textural features, machine vision.

**Nenashev V.A.** Airborne control of ground objects based on neural network processing of video frames

The paper describes a solution for recognizing ground physical entities on a sequence of radar video frames based on machine vision technology and a neural network. It demonstrates the capabilities of machine vision enabling the recognition of ground entities of interest and the calculation of their coordinates and parameters from a small aircraft. The scientifically significant results obtained are important for further development of fast high-precision airborne monitoring systems based on machine vision technology and integrated processing of digital video frame sequences obtained from airborne small-size radar sources; they contribute to further functionality enhancement of such systems. The study results demonstrate high recognition accuracy with the possibility of estimating the number of ground entities and their coordinates when airborne machine vision with high-resolution radar video frames is applied.

**Keywords:** small-size airborne radar systems, airborne control, radar video frames, machine vision, small aircraft, neural networks, ground physical entities, coordinates.

**Degtyareva A.N., Sapelkin M.E., Golubev O.V., Kamonichkin D.T.** Investigating of the effect of generative design on the production of steel products using additive technologies

The application of generative design for metal 3D printing by selective laser melting (SLM) technique is shown. SLM application results in time and material savings. A set of 30 3D models of traditional design was chosen, generative design was applied to these models, and the topology of the articles was changed. The results demonstrate significant reduction of 3D printing time (average 28.5 %) and powder metal consumption (average 31.09 %wt.). The study fixed the average 38% increase in the consumption of support material ensuring effective 3D printing. This was the anticipated consequence caused by the specificity of generative model formation. Notwithstanding the encouraging study results, the prerequisites for effective implementation of generative design in additive technologies are further software market development and the increase in the number of qualified staff for developing 3D models, which comply 3D printing quality standards.

**Keywords:** generative design, metal 3D printing, metal powder, additive technologies, 3D printing, innovations in manufacturing, environmental stability, resource management.

**Mustafae Yu.K., Butenko N.E., Kvaratskhelia O.V., Surai A.A., Alexandrov A.I.** Accelerometer signal processing for flat detection on wheel tread

On-line state monitoring of freight cars is being performed by track diagnosis systems scattered over the railway network. This approach is necessary and justified because freight cars are not electrified. However, it does not provide ubiquitous diagnosis and near real-time monitoring. Therefore, track systems are supplemented by on-board devices installed on the vehicles. Such devices can improve the efficiency and safety of the transportation process by detecting current and potential predictable failures. Standalone telemetry systems meeting low-power requirements, in particular, during the measuring process, are considered as such on-board devices. Against this background, the paper offers a method for evaluating freight car condition by means of accelerometers employed in CGV-1 standalone telemetry systems. It offers a mathematical model for detecting wheel flaws based accelerometer readings and an algorithm for continuous monitoring of the whole car fleet. Typical approaches to the development of such mathematical models and algorithms are discussed as well as the problems of field data acquisition for verification and validation of such models.

**Keywords:** remote diagnosis system, data analysis, physical and mathematical modeling, condition-based maintenance, freight car maintenance system.

**Shestakov A.L., Galyshev D.V., Ibrayeva O.L., Ereemeeva V.A.** Estimating induction motor state based on current signals in the conditions of limited data set using recurring images

The paper examines the diagnostics of rotor bar breakage in induction motors using electric current signals in the conditions of limited data set. The available failure detection procedure is based on the filtering of the current around the seventh harmonic of the supply voltage frequency with subsequent development of an envelope underlying the scalograms. Instead of scalograms, the paper offers recurrent graphs, which demonstrate higher computational efficiency. It also proposes the modeling of the lacking abnormal operation data that is typical for real-life operating conditions. The paper shows that a convolutional neural network (CNN) model taught on both design operation data obtained at various operation modes and the abnormal operation data from a single mode poorly detects the defect in case of operation mode changes. This is caused by the change of specific defect frequencies dependent on the operation mode. To overcome this challenge, the paper offers a data augmentation method based on spectrum restructuring. The spectrum of a real-life defective signal is reshaped in view of its structure, and synthetic data are developed, which simulate the lacking defect signals for other operation modes. Experimental testing showed that data augmentation based on spectrum reshaping significantly improves CNN model performance under insufficient volume of defect-mode training data.

**Keywords:** induction motor, defective rotor bar, scalogram, convolutional neural network, recurrent graphs, spectrum reshaping, Hilbert transform, data augmentation.

**Agafonov D.V., Dozortsev V.M., Slastenov I.V.** Process modeling systems: historical examples and domestic reality

The paper overviews the development history of chemical process modeling systems and discusses the role of governmental institutions and industrial companies in the formation of chemical modeling and simulation market. The approaches to replacing world's established process modeling software in domestic industry are outlined.

**Keywords:** first-principles process modeling, import replacement, the role of government and industrial companies.

**Shumilina M.A., Dorner M.G.** Correspondence analysis technique for improving the efficiency of business processes

The paper shows the possibility of applying process mining technique for assessing the existing business processes, compare real-life events against reference ones, and reveal bottlenecks for further improvements. It describes the mathematical model of a business process of approving equipment process charts at a mining and metallurgical enterprise, where the logs of production information systems are used as input data. The analysis results in the current correspondence estimate along with the recommendations on the optimization process chart approval process.

**Keywords:** correspondence analysis, business processes, process charts.

**Kozhevnikov I.S., Dubrovskiy V.F.** Comparative analysis of the effectiveness of natural language processing models for educational program adaptation to labor market requirements

The paper reviews the existing approaches to the adaptation of educational programs and labor market requirements as well as present-day NLP models used for automated comparison of graduates' competences against job vacancy requirements. A procedure for comparative analysis of the effectiveness of various NLP models (TF-IDF, Word2Vec, FastText, BERT, and RuBERT) in the semantic correspondence task is presented. The paper substantiates the choice of RuBERT model as the most effective one for the Russian language. It concludes that the RuBERT-based decision support system enables the detection of gaps in educational programs and formulate recommendations for their updating.

**Keywords:** decision support system, educational programs, labor market, natural language processing models, educational program adaptation, textual analysis of job vacancies.

**Arstetmavi Q.K., Ahmed T.R., Avsievich A.V.** Improving the security of virtual reality platforms: deep learning technology for detecting SQL injection attacks

Augmented reality platforms are being extensively implemented of educational and professional contexts. However, the application of such systems expose educational environment to critical vulnerabilities, such as SQL injection (SQLi) attacks, which jeopardize data integrity and user confidentiality. Traditional security measures are often not able to handle the evolving attack patterns, thus leaving confidential data vulnerable for usage and undermining platforms' confidence. In this context, the paper proposes to develop a deep learning-based tool for effective classification of SQLi attacks in AR environments. For identifying malicious SQL queries in AR platforms, the paper offers a model of a 1D convolutional neural network (1D-CNN). The model was taught and evaluated on a modified dataset, which contained both legitimate and malicious SQL queries. The implementation of SQLi detection tool is an important step to higher AR security owing to proactive detection of complex attacks, user data protection, and ensuring platform reliability.

**Keywords:** augmented reality, SQL injections, deep learning, 1D convolutional neural network, infinity.

#### Список основных сокращений, используемых в журнале "Автоматизация в промышленности"

АРМ – автоматизированное рабочее место  
АСКУЭ – автоматизированная система контроля и учета энергоресурсов  
АСУ – автоматизированная система управления  
АСУП – АСУ производством  
АСУТП – АСУ технологическими процессами  
БД – база данных  
ДП – диспетчерский пункт  
ИВК – информационно-вычислительный комплекс  
ИВС – информационно-вычислительная система  
ИМ – исполнительный механизм  
ИУ – исполнительное устройство  
КП – контролируемый пункт  
КТС – комплекс технических средств  
ЛВС – локальная вычислительная сеть  
МРВ – монитор реального времени  
ОЗУ – оперативное запоминающее устройство  
ОС – операционная система

ПАЗ – противоаварийная защита  
ПЗУ – постоянное запоминающее устройство  
ПИ регулятор – пропорционально-интегральный регулятор  
ПИД регулятор – пропорционально-интегрально-дифференциальный регулятор  
ПК – персональный компьютер  
ПЛК – программируемый логический контроллер  
ПО – программное обеспечение  
ПТК – программно-технический комплекс  
ПЭВМ – персональная ЭВМ  
РВ – реальное время  
РМВ – реальный масштаб времени  
РСУ – распределенная система управления  
САПР – система автоматизированного проектирования  
СУБД – система управления БД  
ТЗ – техническое задание

ТИ – телеизмерение  
ТМ – телемеханика  
ТП – технологический процесс  
ТЭК – технико-экономический комплекс  
ТЭП – технико-экономический показатель  
УПД – устройство передачи данных  
УСО – устройство связи с объектом  
УСПД – устройства сбора и передачи данных  
ЦДП – центральный ДП  
ЧМИ – человеко-машинный интерфейс  
ЭС – экспертная система