The 2026 International Conference on Computational Intelligence,
Information Technology and Systems Research
CITS'26

Lublin University of Technology
Poland

June 22-24, 2026

About CITS'26

The 2026 International Conference on Computational Intelligence, Information Technology and Systems Research will be held at the Faculty of Electrical Engineering and Computer Science, Lublin University of Technology, Poland, June 22-24, 2026.

There is no doubt that computational intelligence, decision support systems, data mining, granular computing and knowledge discovery have experienced rapid growth and attracted significant interest. These areas naturally exhibit many synergistic linkages, leading to interesting conceptual and application-oriented developments. The key objective of this event is to provide a vibrant forum for communicating and exchanging ideas within this rapidly growing research environment.

Highlights

- artificial intelligence,
- computational intelligence,
- data mining and knowledge discovery,
- medical imaging,
- computer vision,
- image processing,
- computer engineering,
- computational methods in applied physics,
- modeling and identification,
- decision support systems,
- statistics and quality control,
- computers and education and related topics.

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Spis treści

Session I

Generating 3D Models of Historic Architectural Buildings for the Education of the Blind and Visually Impaired Individuals

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Blind and visually impaired people are typically excluded from exploring tangible cultural heritage, especially historic architectural objects. Although they may be touched directly, their size makes this experience only fragmentary. The current solution is to provide descriptions, which often relies on academic art historical terminology unfamiliar to the general public and particularly to beginners. This work proposes sharing architecture by 3D printing scaled-down reconstructions, sized to allow for direct tactile perception of their shapes, by automatic generation of 3D models from single photos. While photogrammetry and similar techniques like Terrestial Laser Scanners (TLS) are popular and powerful, in this approach the authors are proposing the usage of Generative Artificial Intelligence (GAI) for 3D mesh generation models, using models like TripoSG or TRELLIS.2, from a single photo source. This AI based approach is especially valuable for sites that no longer exist, are heavily damaged, or have only a single surviving photograph. Our pipeline consists of: (1) image-to-mesh synthesis using a generative model; (2) geometry simplification to meet printer resolution limits; (3) scaling and orienting the mesh for a hand-sized replica; (4) a validation step where an art-historian checks key architectural features for historical authenticity. We evaluated the method on twelve historic towers with various architectural styles (e.g., Romanesque, Renaissance, Baroque), purposes (church towers, town hall towers, water towers), construction materials (stone, brick, wood), and originating from various cultural regions (Italy, Romania, Poland). The preliminary expert assessment showed that despite the significant simplification of the digital object's appearance (3D model) compared to the original object (2D photo), the characteristic structural elements and architectural details were well reproduced and retained the architectural style represented. This will allow blind people to properly understand the differences between individual objects and the styles they represent. Further work will involve creating actual copies of the 3D models of the towers and conducting pilot studies with blind people, as well as the automatization of the expert pipeline.

Keywords: 3D model generation, 3D printing, 3D mesh reconstruction, Blind people, Cultural heritage, Historic architectural structures

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Cross-Condition Gait-Based Human Identification under Asymmetric Load Carrying

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The study examined how robust gait-based biometric identification systems remain when the data acquisition conditions are subject to variation. The Ground Reaction Forces (GRFs), which constitute one of the most informative, but simultaneously sensitive to biomechanical disturbances walk representations were used here. The deep neural networks were trained on data registered in natural conditions, whereas testing was conducted for walking with a one-sided load, which leads to the disruption of the symmetry of GRFs as well as the displacement of the center of pressure. This phenomenon results in a change of the amplitude and phase of the GRF signals between lower limbs. This configuration mirrors realistic implementation conditions, in which the system operates outside of the data represented in the training set. Unlike classic „in condition" scenarios, the research concentrates on the ability of generalizing representation in the presence of asymmetric biomechanical disturbances. A cohort of 229 people, who participated in the study, repeatedly walked along the measuring path, in which 2 force plates were hidden. At first, these people walked without any external load, and later they carried a hand-held bag (total weight 4.6 kg) in the hand of their choice. In total, 4250 walk cycles with no load and 3658 strides with load were collected. The acquisition of data was carried out at Bialystok University of Technology and at Lublin University of Technology. Data augmentation included: jittering, time shifting, window cropping, jittering + time shifting, jittering + window cropping, time shifting + window cropping, jittering + mixup, jittering + window shifting + window cropping was applied to the training dataset. The following three approaches were compared:

- CNN with an attention mechanism and ArcFace loss function (CNN+Attention +ArcFace),
- InceptionTime,
- EfficientNet architecture adjusted to 1D signals.

In all cases the hyperparameters were tuned with the use of Optuna. The results obtained were very good, CNN+Attention+ArcFace achieved accuracy equal 95.87%, Inception Time model - 97.17%, whereas EfficientNet: 98.11%. These results are better or comparable to those reported in other papers. The results also confirm that despite significant changes in the GRF signals caused by the asymmetric load, the human gait recognition systems based on GRFs retain high quality

Keywords: Human gait recognition, Biometrics, Ground reaction forces, Asymmetric load, Deep learning

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Machine Learning-assisted Design of Inverted Gradient Multiring Optical Fibers for Flat-top Beam Generation

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This work presents a machine-learning-assisted method for designing inverted-gradient multiring optical fibers intended for flat-top laser-beam generation. Flat-top beam profiles are highly desirable in laser material processing, microscopy, sensing, and biomedical applications, as they provide a more uniform power distribution than conventional Gaussian beams and enable improved control of the irradiated area. However, designing fiber structures capable of producing such beam profiles is challenging due to the large number of possible refractive-index configurations and the computational cost of numerical simulations. In this study, three-layer optical fiber structures were analyzed using numerical simulations performed in OptiFibre software. A total of 729 configurations were investigated using different refractive indices for the doped fiber layers. The resulting beam profiles were evaluated using three criteria: beam flatness, edge steepness, and full width at half maximum. In addition to the refractive indices of individual layers, a new set of descriptors was proposed to more effectively represent the geometry of the refractive-index profile. A random forest regression model was used to predict beam parameters from fiber-structure descriptors. The results showed that the proposed descriptors improve prediction accuracy, particularly when combined with the refractive indices of the individual layers. Feature-importance analysis identified the parameters with the strongest influence on beam flatness, edge steepness, and beam width. The model achieved high predictive performance and therefore offers a practical alternative to time-consuming numerical simulations. Finally, two multi-criteria optimization approaches were applied to select fiber configurations that provide a favorable compromise between high beam flatness, steep beam edges, and large FWHM. The results demonstrate that machine learning can effectively support the inverse design of multiring optical fibers and accelerate the development of fiber-based flat-top beam sources. The proposed approach may be extended in future work to optical fibers with a larger number of layers and more complex refractive-index profiles.

Keywords: Machine learning, Random forest, Optical fiber design, Multiring optical fibers, Flat-top beam generation, Refractive-index profile, Beam shaping, Multi-criteria optimization

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Enhanced Minimal Spanning Tree-Based Isolation Forest with Intuitionistic Fuzzy Scoring for Anomaly Detection

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The growing popularity of artificial intelligence systems and the collection of ever-increasing amounts of data have led to growing interest in unsupervised anomaly detection (AD) systems. These AD systems are used to clean and prepare data for analysis. AD is also used to identify elements that do not match the remaining data and are often referred to as anomalies. One highly effective AD technique is the Minimal Spanning Tree-Based Isolation Forest (MSTIF). This method forms isolation trees in an inverted paradigm, i.e., it isolates elements by merging them. For this purpose, MSTIF uses Kruskal's algorithm for constructing a minimal spanning tree. In this paper, we present a new solution that improves the element evaluation technique used in MSTIF. First, structural parameters are obtained from the isolation trees. Second, the obtained parameters are used in the evaluation phase by appropriately normalizing the evaluation factors, i.e., the distance factor and the node depth factor. This allows the proposed solution to achieve greater precision in sample evaluation. The effectiveness of the method was analyzed using ROC AUC and PR AUC measures. Thirty real-world datasets designed for AD tasks were examined. Furthermore, an analysis of the algorithm's hyperparameters was conducted, and optimal hyperparameter values were determined. The resulting solution is also characterized by high speed, which is crucial for unsupervised AD. Finally, to support the interpretability of the obtained results, a mechanism for interpreting the results was developed. This mechanism operates in a fully unsupervised manner, providing not only the raw result but also its certainty and uncertainty.

Keywords: Anomaly detection, Isolation Forest, Intuitionistic fuzzy sets, minimal spanning tree, Outlier detection

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The Use of the Isolation Forest Algorithm for Maritime Traffic Anomaly Detection for Yachts based on Open Automatic Identification System Data

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The article presents the application of the Isolation Forest algorithm for the automatic detection of anomalies in the movement of marine yachts based on open data from the Automatic Identification System (AIS). The objective of the research was to analyze the feasibility of using an artificial intelligence model to identify abnormal behavior of vessels, such as drifting off the designated route, sudden course changes, or navigating at incorrect coordinates. The input data, obtained from the Kaggle platform, comprised 5,690 measurement points containing the yacht's geographical coordinates. The method involves determining a reference route line in the water area and subsequently calculating the geodesic distance of each trajectory point from this line. The Isolation Forest model was trained on these calculated distances, classifying points further than 1 km away as anomalies. The results demonstrate that the proposed approach enables the effective detection of abnormal behavior in marine vessels. Future research will focus on comparison with other AI models (LSTM, SVM, Random Forest, Autoencoders) and integration with real-time AIS data via APIs.

Keywords: Automatic Identification System (AIS), Anomaly Detection, Isolation Forest, Maritime Traffic, Artificial Intelligence, Yachts, GPS Data

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What Users See vs What Users Feel: Eye-Tracking and Survey-Based Interface Evaluation

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User eXperience (UX) plays a crucial role in the design of graphical user interfaces for various IT solutions. A well-designed graphical interface can enhance the usability of the entire solution and increase users' overall subjective perception of the application. Furthermore, the long-term use of a GUI (graphical user interface) can strengthen certain interaction patterns and even lead users to develop certain habits. The study presents research on the usability of GUIs in popular desktop operating systems. Eye-tracking was used to collect objective data, and user surveys were employed to gather subjective data regarding perceived usability and satisfaction of the interaction. Study participants performed a set of tasks, which consisted of typical everyday activities performed within a tested GUI. During the eye-tracking study, behavioural patterns of visual attention were recorded. The questionnaires allowed for the measurement of users' subjective impressions, which formed the basis for the comparative data analysis. The results highlight the discrepancies between objective and subjective metrics in the evaluation of particular interfaces usability. The participants' subjective assessments were not always consistent with the objective differences between the analysed systems. This suggests that users' prior experiences and established patterns of interface use may influence their evaluation. Furthermore, it was observed that visual behaviour patterns were more varied among users of the most popular system, whereas in the other groups they proved to be significantly more stable. The collected data constitute a preliminary step towards further research, in which machine learning methods and non-additive aggregation operators are explored in the context of user behaviour classification.

Keywords: Eye-tracking, user experience, Graphical User Interface (GUI), Operating systems, Usability, Human-Computer Interaction (HCI)

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AI Readiness and Cultural-Psychological Factors in the Adoption of AI-Based Educational Technologies among Students in Uzbek Higher Education

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The adoption of AI-based educational technologies in Uzbek higher education cannot be understood only as a technical question of access to software or institutional infrastructure. It also depends on students' psychological readiness, culturally shaped expectations about learning, and their confidence in using algorithmic systems that increasingly support feedback, tutoring, assessment, and academic decision-making. This paper proposes a conceptual and empirical study of AI readiness among university students in Uzbekistan, linking psychology with computational intelligence, educational technology, and decision-support research. The aim is to examine how digital adaptation, perceived usefulness, perceived ease of use, trust in AI systems, AI anxiety, digital self-efficacy, privacy concerns, language and cultural context, and perceived institutional support shape students' attitudes toward AI-based educational tools. The theoretical basis combines technology acceptance models with psychological accounts of selfefficacy, trust, anxiety, and adaptation to digital learning environments. The proposed method is a structured survey of students in Uzbek higher education, supported by validated or adapted measurement scales and analysed through correlation, regression, or structural equation modelling, depending on data quality and sample size. The study would treat attitudes toward AI-based educational tools and intention to use them as central outcomes, while also considering whether institutional support and digital self-efficacy reduce anxiety and privacy-related resistance. Particular attention is given to the Uzbek context, including multilingual learning environments, local norms of teacher-student interaction, unequal digital experience, and the need for culturally appropriate AI interfaces. The expected contribution is a context-sensitive model of AI readiness that identifies psychological and institutional conditions under which students are more likely to engage with AI-based learning systems in a responsible and confident manner. Practically, the study can inform university policies on AI literacy, student support, privacy communication, teacher training, and the design of decision-support tools that complement, rather than replace, pedagogical judgment.

Keywords: AI readiness, Educational technology, Higher education, Uzbekistan, Digital self-efficacy, AI anxiety, Trust in automation, Technology acceptance

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Is Support Always Beneficial? A Context-Sensitive PCA View on Motivational Dynamics

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This study introduces a context-sensitive extension of principal component analysis (PCA) for modeling motivational structure in educational data. At the conceptual level, the analysis challenges a common assumption in educational data science: that increasing well-being uniformly improves student motivation. At the computational level, building on a geometric reinterpretation of PCA, we represent motivational profiles as positions in a low-dimensional relational space. Extending standard PCA, we allow for variable weighting of dimensions through environment vectors, enabling simulation of shifts in instructional configurations. Our analysis shows that similar instructional conditions may lead to different motivational styles, depending on learners' initial position in the motivational space, ultimately shaping orientations toward future mathematics-related pathways. These findings also raise a broader question: should educational optimization aim at maximizing all comfort-related dimensions, or at balancing comfort with challenge? We argue that motivation is not a static attribute but a context-dependent configuration, and that standard linear models may obscure this dynamic structure. Ultimately, although central to the study–shaping the data itself–the teacher is often a forgotten dimension and appears to play a key role in orchestrating motivational dynamics in mathematics, even in the context of increasingly automated and AI-supported educational environments.

Keywords: Principal component analysis, Computational intelligence, Data mining, Educational data, Latent representations, Context-sensitive modeling, Motivational dynamics

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The Research Potential of Speedcubing: An Interdisciplinary Perspective

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Competitive Rubik's Cube solving, commonly known as speedcubing, has developed into an internationally popular activity that combines entertainment, competition, and learning [1]. Although primarily associated with recreation and sport, it may also contribute to individual and social development, similarly to other cognitively engaging and game-based educational activities [2]. This study examines the extent to which speedcubing can support such development, with particular attention to its educational, psychological, and social dimensions. The research was based on an anonymous online questionnaire completed by 112 individuals associated with the speedcubing community, including competitors, trainers, and parents. The survey consisted of 26 questions, including 22 analytical items and 4 demographic questions. Respondents were asked about the accessibility of speedcubing, its impact on cognitive and interpersonal competences, its educational and social value, and attitudes toward digital tools supporting learning and practice. The conceptual background of the study was drawn from research on education and informal learning [3], cognitive benefits of strategic games such as chess [4], and the role of sport and game-based learning in promoting social inclusion and personal development [2]. The findings indicate that regular participation in speedcubing may support the development of logical reasoning, strategic thinking, perseverance, and emotional self-regulation, which is consistent with previous studies on executive functions and cognitively demanding activities. Such competences are also closely associated with STEM education, particularly in mathematics, engineering, computer science, and problem-solving-oriented learning environments [5]. Participants additionally emphasized the inclusive and motivational character of speedcubing, as well as its capacity to promote cooperation, fair play, and informal learning [6]. These observations suggest that speedcubing may represent a valuable and accessible activity that fosters cognitive development, social interaction, and educational engagement across different age groups and experience levels.

Keywords: Speedcubing, Cognitive competencies, Social competencies, STEM education

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Deferred Processing and Fuzzy Logic Analysis Prototype for User Interest Assessment in VR Environments

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This paper presents a prototype system for user interest assessment in virtual reality (VR) environments, combining deferred processing with fuzzy logic inference. The architecture deliberately separates lightweight real-time data acquisition from computationally intensive analysis, addressing a core constraint in XR applications where rendering performance must not be compromised. The online phase, implemented in Unity with Google VR SDK, serializes per-frame telemetry — timestamp, user position, and head rotation — to on-device CSV files. Since head orientation reliably proxies visual attention without dedicated eye-tracking hardware [1,2], these signals drive all subsequent analysis. In the offline phase, a synthetic session replay reconstructs each trajectory in the original 3D scene, enabling frame-by-frame ETL data enrichment [3] to derive feature vectors covering movement velocity, object distances, and screen-space visibility metrics. These feed a fuzzy logic inference system [4] with linguistic variables and expert-defined rule bases, producing multi-granularity interest scores: per-participant, aggregate, and category-level distributions. Each offline module can be developed and validated independently, improving maintainability and reproducibility. Demonstrated in a virtual museum scenario, this methodology offers a scalable pattern for post-hoc behavioural analytics in VR environments where real-time constraints and deep analysis must be balanced [3].

Keywords: Virtual reality, Deferred processing, Data acquisition, Fuzzy logic inference, ETL data enrichment, Synthetic session replay, Screen-space visibility metrics, User interest assessment

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Google for Research

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Google is powering a new era of scientific discovery by developing AI tools and resources designed to accelerate research and support scientific endeavors. A central component of this initiative is *Gemini for Science*, a collection of tools that enhance the precision and scale of scientific exploration including Google Antigravity, Co-Scientist, Gemini Omni, Google ADK AI Agents, NotebookLM, Alphafold, WeatherNext.

Keywords: Gemini for Science, AI Agents, Google

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Synchronization of Two TPM Neural Networks on the Use of a Combination of Integer and Complex Number Arithmetic

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The idea of using two mutually learning neural networks (Tree Parity Machine, TPM) as an alternative to the Diffie–Hellman algorithm belongs to I. Kanter, W. Kinzel, Kanter E. Learning means that the synaptic weights (w_{ij}, $1 \leqslant i \leqslant K$, $1 \leqslant j \leqslant N$; K – number of neurons in the first layer of the network, N – number of inputs of each neuron; $w_{ij} \in \mathbb{Z}$; $w_{ij} \in \{-L, -L+1, \ldots, L\}$; $K, N \in \mathbb{N}$) of the hidden neurons of both networks (A and B) are adapted according to certain rules for input (x_{ij}, $x_{ij} \in X^A, X^B$; $X^{A/B} \in \{-1, 1\}$)–output (τ^A, τ^B; $\tau^{A/B} \in \{-1, 1\}$) pairs according to certain rules. The training of the networks (TPM$^{A/B}(K{-}N{-}L)$) concludes when the weights become equal, and these weights can be used as a shared cryptographic key. The development of the TPM architecture has been directed toward increasing the complexity of computational arithmetic to ensure a higher level of cryptographic resistance. To date, research results concerning the synchronization of TPM based on the extension of real numbers – specifically complex numbers (TPCM), quaternions (TPQM) and octonions (TPOM) – have been published. The work we present contains the results of a study of the synchronization process of the TPM based on the use of a combination of two arithmetics: $x_{ij}, x_{ij} \in X^A, X^B; X^{A/B} \in \{-1, 1\}$, but $w_{ij}, \tau^{A/B} \in \mathbb{C}$. It follows from this that all intermediate calculations, weighting coefficients, as well as outputs from each of networks A and B are represented by complex numbers. We have conventionally called this architecture ICTPM (Integer–Complex TPM). The ICTPM network is a hybrid of the TPM and TPCM networks. The first-level elements are perceptrons with N-element weight vectors ($[w_{i1}, w_{i2}, \ldots, w_{iN}]$, where $1 \leqslant i \geqslant K$), whose values are complex numbers ($w_{ij} = (a_1)_{ij} + \mathbf{i}(a_2)_{ij}$; $(a_1)_{ij}$ and $(a_2)_{ij} \in [-L, L]$). As in the case of the TPM architecture, the above elements are limited to the range $[-L, L] \times [-L, L]$. The proposed approach ensures the compatibility of the model with classical weight updating rules, including the Hebbian rule and its modifications. To compare the parameters of the network synchronization process based on the proposed ICTPM architecture and TPM, TPCM architectures a software tool based on Python was developed. Using the developed application, experimental simulations of weight coefficient synchronization for networks with different K-N-L (1000 experiments for each architecture) were conducted. Formally, different channels connecting networks A and B were used: the trained networks were hosted on the same computer, and on different ones connected to the same LAN.

Keywords: Neural networks, TPM synchronization, Cryptographic key

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From Handcrafted Features to Deep Learning: Evaluating Weed Detection Pipelines for Precision Agriculture

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Agriculture plays a crucial role in global food production, but crop productivity is often threatened by weed infestation, which competes with crops for essential resources and increases production costs [1]. Traditional weed control methods rely on uniform herbicide application, leading to excessive chemical use, environmental harm, and potential resistance development. Recent advances in computer vision and artificial intelligence, combined with UAV-based high-resolution imaging, enable automated crop monitoring and targeted weed management. However, weed detection in UAV imagery remains challenging due to small object sizes, complex backgrounds, varying lighting conditions, and overlapping vegetation. While traditional approaches based on handcrafted features and classical classifiers offer computational efficiency, their performance is limited by feature design and their inability to generalize in complex environments [2, 3]. Although deep learning models offer improved accuracy, their performance is highly dependent on model capacity and training configuration, which requires further investigation [4]. This study develops a complete end-to-end pipeline using the CampanetaWeed dataset [5], including data preparation, preprocessing, augmentation, and model evaluation. The dataset was split into training, validation, and test sets (70/15/15), with preprocessing steps such as image resizing, normalization, and bounding box validation, and augmentation techniques including horizontal flipping and brightness/contrast adjustments. A classical machine learning baseline is implemented using handcrafted features such as Histogram of Oriented Gradients (HOG) and RGB color histograms to train Support Vector Machine (SVM) [6] and Random Forest classifiers [7]. In parallel, two YOLOv8 [8] models including YOLOv8n and YOLOv8s were trained using different configurations and evaluated using precision, recall, and mean average precision (mAP). The results show that SVM outperforms Random Forest among classical methods but remains limited compared to deep learning approaches. Under initial training settings, YOLOv8n achieved better performance than YOLOv8s (precision 0.559 vs 0.0031), demonstrating faster convergence under constrained conditions. After hyperparameter tuning (increasing epochs, image resolution, and batch size), both models improve significantly, with YOLOv8n reaching mAP@0.5 of 0.0822 and YOLOv8s reaching 0.0413. The improvements are particularly notable for detecting small weed instances, although they come at the expense of increased computational costs and training time. Overall, the study demonstrates that deep learning approaches outperform classical machine learning methods for UAV-based weed detection. Lightweight models such as YOLOv8n provide efficient performance under resource constraints, while larger models like YOLOv8s benefit from enhanced training configurations. The findings highlight the importance of balancing model complexity, accuracy, and computational efficiency, and provide practical insights for deploying AI-based weed detection systems in precision agriculture.

Keywords: AI in health, Deep learning, Network architecture, Computer vision, Green AI, Efficient computation

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Quality Matters: A Systematic Approach to Data Quality Control in Gene Expression Analysis Using RQdeltaCT

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High-quality data constitute a fundamental prerequisite for reliable analytical outcomes, as deficiencies in data quality may lead to substantial inferential errors and misinterpretations. Therefore, rigorous data quality control should be considered an integral component of analytical pipelines across diverse disciplines, including information technology, engineering, and the life sciences. Despite its importance, data quality control procedures are not always sufficiently addressed in practice. One example of an analytical framework that systematically incorporates data quality control procedures is the RQdeltaCT package in R, designed for comparative gene expression analysis using relative quantification methods. This tool integrates multiple data quality control steps, including data structure recognition, assessment of values reliability, selection of samples and genes for filtering, imputation of missing values, identification of appropriate endogenous controls for normalization, data transformation, outlier detection, and implementation of robust statistical analyses. Although these procedures are tailored to gene expression data, their underlying principles are broadly applicable to other data types, e.g., materials testing datasets, image and video analyses, or clinical trial data. Importantly, data quality is not solely determined at the analytical stage but is also influenced by experimental and laboratory conditions. Sources of technical variability may include the quality of input material, instrumentation performance, reagents quality, and operator-dependent factors. Consequently, adherence to established methodological standards is essential to ensure reproducibility and accuracy. In conclusion, comprehensive data quality control is critical for generating valid, unbiased results and supporting robust scientific conclusions. The RQdeltaCT package highlights best practices for data quality control in gene expression studies.

Keywords: Data quality, Gene expression, R package, RQdeltaCT

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Automated Segmentation of the Equine Temporomandibular Joint from Computed Tomography Images: A Preliminary Study

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Manual segmentation of temporomandibular joints (TMJs) in computed tomography (CT) studies is time-consuming and subjective [1]. Implementing automated methods based on artificial intelligence is crucial for standardizing CT image processing required for computer-aided prediction of TMJ diseases [2] and planning treatment [3-4]. This study aimed to develop a fully automated 3D segmentation model of the equine TMJ using deep convolutional neural networks based on a 3D U-Net architecture. The study was performed on CT scans of horse heads (n=42; 84 TMJs) obtained using a multi-row scanner (Revolution CT, GE Healthcare). CT scans were imported into 3D Slicer software [5] and semi-automatically segmented using a previously described protocol [6]. Gray-level mapping was set to a bone window (width 1500, level 300) with a range from -1000 to 2500 Hounsfield units (HU), and histogram normalization was applied across all datasets. The segmentation frame was positioned at the midpoint of the mandibular condyle and cut off below the condyle. The 3D U-Net architecture with residual units was implemented using the MONAI library and evaluated using two image processing variants: (1) a standard approach based on HU range selection (standard 3D U-Net) and (2) an advanced contrast-limited adaptive histogram equalization (CLAHE) method (3D U-Net+CLAHE). The model was configured with four depth levels and filters ranging from 16 to 128 channels, using Dice loss and the Adam optimizer. Segmentation performance was assessed using the Dice Similarity Coefficient (DSC) relative to the semi-automated reference segmentation. The highest DSC (¿0.97) was achieved by the standard 3D U-Net. There was no difference (p=0.15) in DSC values (mean±SD) between the standard 3D U-Net (0.96±0.008) and 3D U-Net+CLAHE (0.95±0.01). The use of the 3D U-Net architecture enabled near-perfect reproduction of joint geometry compared with the reference masks when applied to CT images with a field of view limited to the mandibular condyle. However, adding the CLAHE method to the segmentation protocol did not result in the expected improvement in DSC. The proposed 3D U-Net-based model automatically segmented TMJs with high similarity to semi-automated segmentation while requiring substantially less time. Therefore, the proposed segmentation method represents a feasible image-processing tool that may further support computer-aided diagnosis and treatment of equine TMJ diseases [7].

Keywords: Automation, Segmentation, Convolutional neural network, Image processing, Computed tomography, Computer-aided diagnosis

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Session II

LLM-Based Modeling of Dance Movement from 3D Motion Data for Automated Feedback Generation

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The analysis and learning of complex human movements require precise motion capture, robust data processing, and effective feedback. In domains such as dance, sports, and rehabilitation, translating motion data into meaningful guidance is essential for improving performance and supporting motor learning [1, 2, 7]. Traditional approaches often rely on expert observation or numerical metrics, which may not be intuitive for learners. Therefore, there is a need for systems that bridge the gap between low-level kinematic data and human-understandable feedback [4, 5]. This study presents a pipeline for real-time movement analysis and personalised feedback generation that integrates motion capture with large language models (LLMs). The approach transforms raw motion data into structured representations and generates descriptive, context-aware feedback [3]. Dance data are captured using an 8-camera Vicon system, enabling accurate reconstruction of three-dimensional marker trajectories. Two methods of joint angle computation are applied: a custom real-time approach focused on efficiency and temporal stability, and the Vicon Plug-in Gait model. Extracted features are normalised to ensure consistency across performers and structured into movement patterns representing key elements of choreography. Synthetic performance samples are generated to augment training data, allowing controlled variation in movement quality. These samples support learning relationships between movement characteristics and qualitative feedback. Movement data are converted into textual descriptions and paired with reference feedback for fine-tuning. Models include Gemma 2 9B, Llama 3.1 8B, Mistral 7B, H2O-Danube 3 4B, and Qwen 2.5 3B, in both base and instruction-tuned variants. Two strategies are compared: supervised fine-tuning and causal language modeling with few-shot learning. The models generate descriptive feedback addressing aspects such as posture, timing, coordination, and sequence order. Results show that H2O-Danube 3 Chat 4B achieves a strong balance between accuracy and inference speed, making it suitable for real-time applications. The proposed framework enables intuitive feedback, supports motor learning, and provides a scalable solution adaptable to other domains and immersive virtual reality environments [6].

Keywords: LLM, Motion capture, Motion-to-text generation, User-feedback, Fine-tuning

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Analysis of Websites Generated Using Artificial Intelligence

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As the use of artificial intelligence (AI) continues to expand, questions have emerged regarding its effectiveness, reliability, and appropriate application [1]. Increasing attention is being paid to how accurately AI performs tasks, how its outputs should be verified, and in which areas it can be used most responsibly and efficiently [2-3]. By conducting this study, the authors aimed to contribute to the growing collection of studies examining the effectiveness of large language models in software development. Based on the reviewed literature, the authors concluded that there is a research gap regarding the creation of complete web applications using AI chatbots [4]. For this study, ChatGPT and Google Gemini were selected for comparative evaluation. In order to properly assess the security of the generated code, OWASP ZAP was chosen, while WAVE and Google Lighthouse were selected to evaluate accessibility [5]. After selecting the appropriate tools, the authors designed a project for a simple web application using Node.js, React, Express.js, and MySQL. Subsequently, suitable prompts describing the individual components of the application were prepared. These prompts were then used to generate web applications: one with ChatGPT and one with Gemini. Beyond the project setup, and prompting the chatbots, no human input went into the development of these web applications. Finally, the resulting applications were evaluated using the previously selected research tools. The results confirmed the hypotheses of the authors. The first stated that AI-generated web applications would not contain many serious security or accessibility issues, while the second assumed that Gemini would achieve better results than ChatGPT. In terms of security, both applications achieved good results, however, in the case of ChatGPT, one high-risk issue was identified, whereas no such issues were found in the Gemini-generated application. The examination conducted using the accessibility evaluation tools did not reveal any major accessibility errors in either application. It is also worth noting that the designs of both applications were highly similar. In the future, it would be valuable to further investigate the characteristics of AI-generated web applications, as well as the prompting process used in code generation.

Keywords: Artificial intelligence, Software development, ChatGPT, Gemini, Security, Accessibility

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People Re-identification Utilizing Machine Learning

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Person re-identification is an important component of video surveillance, aiming to correctly match the same individual across different camera views [4]. Since surveillance systems are expected to operate under varying illumination conditions, this task often requires matching observations captured in visible RGB and infrared modalities [1]. Cross-modality person re-identification is particularly challenging because the differences between RGB and IR images significantly reduce feature consistency and make reliable identity matching more difficult [1-3]. Unlike many existing approaches that rely on more complex cross-modality alignment strategies [2], [3], [5], this study focuses on lightweight modifications of a Vision Transformer backbone. The evaluated variants include modality-specific visual prompt tokens inserted into the transformer token sequence, as well as SE and ECA channel-attention modules adapted to token embeddings. This study examines whether these modifications can improve feature discrimination and modality alignment between RGB and IR inputs [5]. The SYSU-MM01 dataset includes images captured by six cameras, including four RGB and two infrared cameras, which makes it suitable for evaluating person matching across modalities in realistic surveillance conditions [1]. Several ViT-based model variants were comparatively analyzed, including a baseline ViT model, a ViT model with modality-specific visual prompts, ViT models with SE and ECA channel-attention modules, and combined prompt-attention variants, in order to assess the effect of the proposed modifications. The obtained results indicate that the evaluated lightweight enhancements affected cross-modal retrieval performance unevenly. The prompt-based ViT variant achieved the best final retrieval result, while SE, ECA, and combined attention-based variants did not provide consistent improvements over the baseline. These findings suggest that modality-specific visual prompts may be a promising lightweight adaptation strategy for RGB-IR person re-identification.

Keywords: Person re-identification, RGB-IR matching, Vision Transformer, Visual prompts, Channel attention, SYSU-MM01

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Analysis of Query Optimization Possibilities in Selected Big Data Environments

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This paper focuses on analysing the impact of selected optimisation techniques on the execution of SQL queries in Big Data ecosystems. The study was conducted using three different tools: Apache Spark, Google BigQuery and DuckDB. The publicly available IMDb Movies dataset was used and underwent basic ETL processing, including file format transformations and key structure optimisation. A number of optimisation techniques were identified and evaluated, including column selection, table join order, the use of CTE expressions, data types in the context of table joins, and data filtering. Additionally, techniques such as limiting and sorting data, data type casting and operations, approximate functions, table copying, data partitioning, broadcast joins, and denormalization were thoroughly examined. These were evaluated in terms of execution speed and – in the case of Google BigQuery – the volume of data processed. Queries incorporating optimisation techniques were compared with their non-optimised versions, resulting in different query performance metrics being obtained for the same output. The results suggest that the selected optimisation techniques can significantly improve query performance; however, their effectiveness varies depending on the specific Big Data environment. Therefore, optimization strategies should be tailored to the characteristics and capabilities of the chosen system.

Keywords: Big Data, Database, Optimisation techniques, Apache Spark, Google BigQuery, DuckDB, SQL, Queries

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Predicting Football Match Results for Sparse Data

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The objective of this study is to investigate the effectiveness of applying advanced data imputation methods in forecasting soccer match outcomes. The primary analytical challenge addressed in this research is the phenomenon of data sparsity, which is highly prevalent when analyzing historical matches or lower-tier leagues where access to detailed statistics is severely limited. For the purpose of this study, a comprehensive dataset encompassing 52 soccer leagues from 1993 to 2023 was integrated and analyzed. To address the information sparsity problem, two advanced feature reconstruction methodsrarely utilized in sports analytics to date-were implemented: a deep neural network model known as a Denoising Autoencoder (DAE) and the Multiple Imputation by Chained Equations (MICE) statistical algorithm. The datasets reconstructed using these methods serve as inputs for the target forecasting models: an XGBoost classifier and a Long ShortTerm Memory (LSTM) recurrent neural network enhanced with an attention mechanism. To objectively assess the effectiveness of the proposed solutions, an evaluation procedure was developed based on comparing them with classical missing data handling techniques, such as listwise deletion, mean imputation, and the k-Nearest Neighbors algorithm. The quality of predictions, with a forecasting horizon of up to two months, is evaluated using the Rank Probability Score (RPS) and the Root Mean Square Error (RMSE), while the model optimization process is supported by Bayesian tuning. The conducted experiments aim to verify the hypothesis that applying nonlinear imputation methods preserves deep dependencies within historical data, which should directly translate into higher predictive accuracy of the models. The obtained results will allow for a critical evaluation of the utility of intelligent feature reconstruction as a key component of a modern sports analytics pipeline.

Keywords: Data sparsity, Sports analytics, Forecasting results, Data imputation, Autoencoders, MICE, LSTM, XGBoost

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Analysis of the Vulnerability and Effectiveness of Multi-Layer Security Methods in ICT Networks

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The resilience of modern Information and Communication Technology networks relies on a comprehensive, defense-in-depth strategy spanning multiple layers of the OSI model. While deploying multi-layer protection methods is essential for mitigating increasingly sophisticated cyber threats, it alters network dynamics. Securing these environments requires a balance between vulnerability mitigation and the processing limitations of network hardware. The primary motivation for this research is the need to balance network security with optimal Quality of Service. Network administrators frequently implement defensive protocols without empirical data regarding how these mechanisms impact the infrastructure's Control Plane and Data Plane during active attack conditions. This thesis investigates the vulnerabilities and effectiveness of multi-layer protection methods by simulating targeted cyberattacks within an isolated environment. The methodology encompasses empirical testing across three distinct OSI layers. At Layer 2, the study evaluates Port Security, IEEE 802.1X authentication, and MACsec encryption. For Layers 3/4, Access Control Lists (ACLs) and stateful Firewalls are tested. Finally, at Layer 7, Deep Packet Inspection (DPI) and Web Application Firewalls (WAF) are analyzed. Network telemetry including CPU utilization, latency, jitter, and packet interception rates is recorded using protocol analyzers. The findings demonstrate that while multi-layer mechanisms successfully preserve data confidentiality and integrity, they introduce distinct operational overheads. At Layer 2, hardware-accelerated Port Security prevents catastrophic Fail-Open scenarios but induces severe, cyclical latency spikes. Implementing 802.1X and MACsec effectively neutralizes spoofing vulnerabilities but demands dedicated cryptographic processing. Layer 3/4 Firewalls and Layer 7 DPI introduce sustained throughput degradation proportional to the depth of traffic inspection, confirming that higher-layer security exponentially increases computational costs. Ultimately, this research quantifies the hidden computational cost of multi-layer network security. By understanding the precise hardware impact of these protection methods, organizations can design resilient topologies that guarantee data security without compromising the high availability required by modern real-time applications.

Keywords: Network Security, Defense-in-Depth, Deep Packet Inspection, OSI model, Port security

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A Comparative Analysis of User Privacy and Security Solutions in VR Social Apps

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The importance of current virtual reality technologies has become evident in recent years. VR applications introduce a completely new concept of communication, but also new challenges in terms of privacy and security. Unlike traditional social media platforms, social VR applications collect completely different user data, such as eye tracking patterns, body movement, and avatar interactions, which can enable user identification with up to 97% accuracy. This work focuses on a comparative analysis of privacy and security solutions implemented in social VR applications. It evaluates the effectiveness of various approaches, including differential privacy, federated learning, consent design mechanisms, and integrated frameworks such as TIPS. The analysis reveals that multi-layered security approaches, combining technical privacy techniques with user-centered design mechanisms, provide excellent protection while maintaining an acceptable level of usability.

Keywords: Virtual Reality, Social VR, Security, Biometric data, Behavioral profiling, Consent design

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A Comparative Analysis of the Use of Large Language Models for UML Generation

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The primary objective of this paper is to conduct a comparative analysis of the precision and utility of selected Large Language Models, such as ChatGPT, Claude, and Gemini, in the process of generating UML diagrams based on textual business requirement descriptions. With the massive adoption of generative artificial intelligence tools in software engineering, questions arise regarding the reliability and compliance of the generated diagrams with OMG standards. The research relies on a specifically designed experiment involving four types of diagrams: use case, class, sequence, and state machine. The methodology evaluates the impact of prompt engineering on the quality of the outcomes by comparing basic, commonly used prompts with more advanced and sophisticated ones. The methodology also compares how well models optimized for short response times perform against advanced reasoning models. In this research, we had to rely on diagram text notation, as the models usually cannot generate images of these diagrams themselves, and when they try, it results in unreadable diagrams that break many UML rules. Therefore, the AI-generated code is rendered into graphical form using PlantUML and Mermaid.js tools. For an objective evaluation, an original method based on a negative scoring system and checklists was developed, verifying compliance with UML notation, completeness, business logic, substantive correctness, and aesthetic readability. The conducted analysis allows for verifying the ability of these models to avoid the phenomenon of hallucination and determining to what extent intentional steering of the model supports the creation of reliable system documentation.

Keywords: Large language models, Software engineering, UML diagrams, Diagram generation, Diagram text notation, Comparative analysis, Prompt engineering

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Computational Approaches to Microbiome and Microbiota Data Analysis Using NGS Technologies

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The rapid development of Next-Generation Sequencing (NGS) technologies has led to an unprecedented increase in the volume and complexity of biological data. As a result, bioinformatics has become an essential component of microbiome research, enabling efficient processing, analysis, and interpretation of high-throughput sequencing datasets.

This research presents selected computational approaches used in microbiome data analysis based on NGS technologies. Particular attention is given to the key stages of microbiome data processing, including quality control, sequence filtering, taxonomic classification, diversity analysis, and the integration of biological information obtained from complex microbial communities. The presented workflow highlights the role of modern bioinformatics tools and databases, such as QIIME2, DADA2, SILVA, and UNITE resources, in supporting reproducible and scalable analyses.

The research also discusses the importance of metagenomic data processing, as well as methods for the visualization and interpretation of biological data, including microbial diversity metrics and taxonomic profiling. These approaches facilitate the identification of meaningful biological patterns within large-scale datasets and support data-driven decision-making in microbiome research.

The integration of NGS technologies, bioinformatics pipelines, and computational methods contributes to the advancement of future diagnostics, microbial biomarker discovery, and personalized medicine. The presented concepts demonstrate the growing importance of interdisciplinary approaches that combine biological knowledge with data analysis and computational technologies to address contemporary challenges in life sciences and healthcare.

Keywords: NGS, Bioinformatics, Microbiome, Quality control, Diversity analysis, Metagenomic data processing, Data visualization

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Analyzing the Utilization of Machine Learning Systems for the Recognition of User Behavior in VR Environments

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This paper presents an analysis of human behavior in a virtual reality (VR) environment in the context of anxiety states. The main objective of the study was to utilize artificial intelligence (AI) algorithms to classify anxiety disorders within the acrophobia spectrum based on the analysis of heart rate fluctuations and galvanic skin response (GSR). To achieve this goal, a neutral scene and a research scene accurately replicating the transparent glass bridge from the Shiniuzhai Geological Park in China were designed within the Unity engine. HTC VIVE headsets were the tool used to expose the participants in a safe environment. A representative group of individuals participated in the experiment. Prior to testing, medical interviews were conducted to rule out any health contraindications (including cardiovascular diseases, the influence of medications, alcohol, or other substances affecting heart rate). Next, participants were evaluated for acrophobia using Cohen's Acrophobia Questionnaire (AQ). Additionally, to monitor the impact of VR on the body, the Simulator Sickness Questionnaire (SSQ) was administered before and after the VR exposure. Upon completion of the session, the Igroup Presence Questionnaire (IPQ) was utilized to verify the users' degree of immersion, i.e., the sense of "presence" in the virtual world and the realism of the replicated scene. Physiological data was collected using a highly precise, custom-built wired device for measuring heart rate and GSR. This system was supported by a wireless MR60BHA2 radar to validate and ensure the maximum accuracy of the readings. Ultimately, the collected and analyzed physiological parameters were used to train a machine learning model capable of classifying the fear of heights in a given participant.

Keywords: Artificial intelligence (AI), Modeling and identification, Virtual reality, Virtual reality exposure therapy (VRET), Acrophobia, Machine learning, Physiological signals

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Evaluating the Effectiveness of Security Protocols and Authentication Mechanisms in Corporate Wireless Networks

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Modern wireless networks in corporate environments face unprecedented challenges arising from the growing popularity of Bring Your Own Device (BYOD) policies and the evolution of advanced attack vectors. In response to these threats, organizations are massively deploying new standards, such as WPA3-Enterprise, IEEE 802.1X authentication protocols, and the Zero Trust Network Access (ZTNA) paradigm. The motivation for this research is the fact that while new cryptographic solutions eliminate many historical vulnerabilities of the WPA2 standard, in practice, they often create an illusion of absolute security, ignoring critical risks associated with backward compatibility issues and insufficient user awareness. The main objective of this study is a critical, empirical evaluation of the effectiveness of these modern protection mechanisms. As part of the research, a series of controlled penetration tests were conducted in an isolated laboratory environment based on OpenWrt routers and a FreeRADIUS server, which closely simulated a typical corporate infrastructure. Four main research scenarios were executed: an analysis of the SAE protocol's resilience to resource exhaustion attacks, verification of 802.1X architecture vulnerability to Evil Twin social engineering attacks, evaluation of the risk of Downgrade attacks in Transition Mode combined with offline dictionary key cracking, and an analysis of the effectiveness of the PMF (802.11w) standard against management frame injection. The achieved results confirm that while a strictly enforced WPA3 standard with an active PMF mechanism effectively eliminates classic session disconnection attacks, the radio infrastructure becomes highly susceptible to DoS attacks targeting the new key negotiation process. Furthermore, it was demonstrated that without forcing clients to verify server certificates, Enterprise systems remain defenseless against credential theft, and transitional modes facilitate the compromise of the handshake protocol. Based on the analysis, a set of recommendations for administrators and companies was formulated, including strictly enforcing a "WPA3-Only" policy for critical network zones, centrally deploying rigorous certificate validation through MDM systems, and integrating 802.1X authorization with a micro-segmentation architecture aligned with Zero Trust principles.

Keywords: WLAN security, WPA3-Enterprise, IEEE 802.1X, WPA Transition Mode, Penetration testing, Zero trust

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Efficiency Analysis of Query Optimizer Embedded in MS SQL Server and Query Optimizer Utilizing Machine Learning Techniques based on the AutoSteer System

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Query optimization has been a topic of extensive research since the early 1970s [5]. Currently, there have been numerous attempts to apply machine learning techniques to enhance the performance of state-of-the-art query optimizers. These approaches have shown promising results, with studies confirming that machine learning algorithms can significantly reduce SQL query execution times [1-4]. This paper presents the results of research that has investigated whether such solutions can be applied in a commercial DBMS, namely Microsoft SQL Server, using AutoSteer [4] as an example of a machine learning–based query optimizer. Prior studies have primarily evaluated ML-based optimizers on Select-Project-Join queries [1-4]. This work extends existing research by examining the performance of more complex queries that include left joins, aggregations, and column expressions. Based on the research results there have been evaluated both optimizers using metrics such as inference time, planning time, and execution time. Additionally, a comparative analysis of the generated query plans has been conducted. These results show that machine learning–based optimizers, such as AutoSteer, can produce query plans with execution times 13% lower on average than those generated by the native Microsoft SQL Server optimizer. For certain queries, execution time reductions of up to 80% has been observed.

Keywords: Query optimization, Learned query optimization, Machine learning, Database performance

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Evaluation of Locally Deployed Open-source Language Models for Business Process Automation

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The rapid development of Large Language Models (LLMs) represents a significant turning point in the digital transformation of business processes and decision-making systems. Although commercial cloud-based models offer high performance, their integration into enterprise environments is often limited by substantial operational costs and major data privacy risks, including potential GDPR compliance issues and reduced control over sensitive corporate data. This study investigates the feasibility of deploying open-source language models on local infrastructure as a secure, cost-effective, and sustainable alternative for modern business applications. The research evaluates the capabilities of selected state-of-the-art open-source models differing in parameter size and architecture – specifically gemma4:26b, gemma4:31b, qwen3.5:9b, qwen3.6:27b, qwen3.6:35b, nemotron-3-nano, glm-4.7-flash, gpt-oss:20b, and mistral-small-3.2:4b – deployed in local execution environments on dedicated consumer-grade hardware. The study applies a structured technical methodology to test these models across five practical business scenarios: handwritten text recognition (HTR), optical character recognition (OCR) of noisy documents, automated text summarization, structured data extraction in JSON format, and the efficiency of Retrieval-Augmented Generation (RAG) compared with long-context processing. Model performance is assessed using objective metrics, including Character Error Rate (CER), Word Error Rate (WER), inference time, and computational resource consumption, such as VRAM usage and power efficiency. The main objective of the study is to verify the hypothesis that local deployment of optimized open-source language models can be economically and operationally viable for medium-sized enterprises, while providing an appropriate balance between automation efficiency and full data sovereignty.

Keywords: LLM inference, Open-source models, Business process automation, Local AI infrastructure, Retrieval-augmented generation, Data security

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Comparative Performance Analysis of Docker and Podman Containers in Kubernetes-Based Web Application

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This thesis presents a comparative performance analysis of Docker and Podman containers in the context of deploying a web application within a Kubernetes environment. The primary objective of the study was to evaluate the impact of containerization tools on various stages of the application lifecycle, including image building, cluster initialization, and runtime performance in a cloud-native setting. To achieve this goal, a web application was deployed on a Kubernetes cluster using container images built with both Docker and Podman. A controlled experimental environment was established to ensure consistency across all test scenarios. The evaluation focused on key aspects such as container image build time, Kubernetes cluster startup time, and application deployment latency. Additionally, performance benchmarking was conducted under varying load conditions to measure response time, throughput, CPU utilization, and memory consumption. The experimental procedure involved generating synthetic workloads to simulate real-world user interactions with the application. Metrics were systematically collected and analyzed to identify differences in efficiency and behavior between the two containerization approaches. Particular attention was given to image compatibility, the influence of container engine architecture, and their interaction with Kubernetes during both initialization and runtime phases. The results of the study provide practical insights into the performance characteristics of Docker and Podman across the full deployment pipeline. The findings contribute to a deeper understanding of trade-offs between these technologies and support informed decision-making in DevOps practices and cloud-native application development.

Keywords: Containerization, Container engines, Docker, Podman, Images, Rootless containers, Deamonless containers, IT Infrastructure, Deployment, DevOps, Kubernetes, Performance benchmarking

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Evaluation of Vehicle Feature Classification in Traffic Images Using Machine Learning Methods

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This study evaluates four convolutional neural network architectures: ResNet18, ResNet50, MobileNetV3-Small, and EfficientNet-B3, for vehicle classification and re-identification using the VeRi-776 dataset. Three tasks were examined: vehicle type classification, color classification, and re-identification. EfficientNet-B3 consistently achieved the highest performance across all tasks, reaching 97.9% accuracy in type and color classification, while a mean average precision (mAP) of 65.77% in re-identification using triplet loss. MobileNetV3-Small offered a favorable trade-off between accuracy and inference time, making it suitable for real-time edge deployment. Gray-World color normalization improved results only for EfficientNet-B3, while degrading accuracy in smaller models. This is an advantage especially in high-capacity architectures. ResNet50 underperformed relative to ResNet18, despite its larger model size, emphasizing the importance of balanced scaling strategies. Overall, results demonstrate that modern CNN architectures can achieve high accuracy (¿97%) in vehicle attribute classification, though vehicle re-identification remains more challenging due to viewpoint and illumination variability.

Keywords: Machine learning, Vehicle re-identification, Vehicle classification

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Vulnerability Analysis of Large Language Models (Gemma 4 and Mistral) to Jailbreak Attacks

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The rapid development of large language models has integrated artificial intelligence into most aspects of daily life. However, this comes with many problems in terms of security. The main challenge is preventing these models from generating harmful, illegal, or unethical content. Despite the advanced defense mechanisms, these models still remain vulnerable to jailbreak attacks involving manipulation of the input prompt to bypass built-in filters. The aim of this study is to analyze the vulnerability of local, open-source language models (specifically Mistral 7B and the Gemma family) to selected attack types, such as Base64 prompt encoding or social engineering based on simulating a research environment (the PAIR method). As part of the experiment, an automated framework was developed to send malicious queries to the targeted models. The resulting responses were given to a fully automated, deterministic evaluation using an independent model (Gemini 3) acting as an evaluator (LLM-as-a-Judge). The primary measurement metric was the Attack Success Rate (ASR), which was compared to a control sample of base prompts with no jailbreak attacks. The results revealed a significant difference in the safety mechanisms of the models. In the base control test, the ASR of Mistral is 73.3%, while Gemma demonstrated complete resilience (0% ASR). With jailbreak techniques applied, the PAIR method escalated Mistral's ASR to 93.3%. Interestingly, the Base64 attack failed entirely on Mistral (0% ASR) due to decoding issues rather than safety filters. Conversely, the Gemma model maintained a strict 0% ASR across all tested attack techniques. These results show a huge contrast in the alignment of open-source models and prove that low-resource heuristic attacks are insufficient against rigorously secured AI systems.

Keywords: Large language model, AI alignment, Jailbreak attacks, Prompt engineering, LLM-as-a-Judge, AI safety

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Multi-Criteria Comparative Analysis of WebAssembly Virtualization and Traditional Containerization Methods

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Serverless and edge computing increasingly emphasize low startup latency, small deployment artifacts and efficient resource usage. Container-based environments such as Docker provide a mature execution model but can incur noticeable cold-start latency and deployment overhead in resource-constrained settings. WebAssembly, and Wasmtime in particular, offers a lightweight and portable alternative for short-lived and isolated workloads. This paper evaluates WebAssembly execution based on Wasmtime runtime and compares it with Docker containers and native execution. The experiment consists of two parts. The first part measures end-to-end startup latency of a minimal C application under cold-start and warm-start conditions. The evaluated environments include Docker, Wasmtime with both JIT and AOT compilation, and native execution as a baseline. The second part evaluates execution overhead using selected kernels from the PolyBench benchmark suite. Each kernel is executed multiple times, and CPU and memory-related counters are collected using `perf stat`, including cycles, instructions, branches, cache references, cache misses, and peak memory usage. The results show that Wasmtime significantly reduces cold-start latency compared to Docker containers. In runtime performance, Wasmtime introduces an execution overhead compared to native execution, primarily due to bounds checking and instruction-lowering strategies. However, Ahead-of-Time compilation reduces this overhead compared to Just-in-Time compilation, narrowing the performance gap. Docker provides near-native runtime performance for long-running processes but lacks the agility of WebAssembly during startup. The analysis reveals that WebAssembly virtualization is suited for short-lived, isolated functions in FaaS and edge scenarios, where startup latency, portability, and artifact size are central concerns. These results can help developers choose an execution environment according to workload characteristics and deployment constraints.

Keywords: WebAssembly, Wasmtime, Docker, Startup latency, Performance benchmarking, Serverless computing

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Multi-feature Comparison of Deep Neural Networks in Brain Tumor Identification

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Effective clinical diagnosis through MRI-based brain tumor classification is often limited by the heavy computational requirements of modern deep learning models. To address this, we introduce TinyHybrid, an exceptionally efficient CNN-Transformer hybrid that maintains a 96.49% accuracy rate using only 89K parameters and 0.047 GFLOPs – a 976-fold reduction in size compared to the Swin Transformer. This architecture merges depthwise separable convolutions for localized feature detection with a streamlined transformer encoder for broad contextual understanding. Notably, TinyHybrid enables real-time edge device processing with a 2.5ms CPU inference time (24 times faster than Swin Transformer) and a minimal 0.37MB storage footprint, eliminating the need for GPU hardware. We also propose a larger Hybrid variant that achieves 97.48% accuracy with 2.25M parameters and 13.3ms CPU latency. Our ablation experiments demonstrate that the transformer encoder is essential for performance, contributing an 11% accuracy gain, whereas specific attention mechanisms can be omitted without loss. In pursuit of Green AI, these models support sustainable deployment in low-resource medical environments by significantly lowering the energy costs of diagnostic inference.

Keywords: AI in health, Deep learning, Network architecture, Computer vision, Green AI, Efficient computation

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A Comparative Analysis of Selected Characteristics of Java and Rust Based on Programs Implementing Equivalent Functionalities

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Choosing the right programming language for implementing a solution to a specific problem is highly important. First, we need to balance application performance and the cost of implementation. Some tasks require fast execution time and limited resources, while others may be implemented with fewer restrictions. One of the most important aspects that should be considered is the cost of development. In particular, a project often has financial and time constraints that must be fulfilled. On the other hand, from the perspective of software engineering, the codebase should be as easily maintainable as possible. Such limitations have a great impact on programming language selection. Therefore, in this study, we perform a comprehensive analysis and comparison of two popular programming languages. Java represents a high level of language abstraction, while Rust, in contrast, constitutes a low-level programming language. In order to compare language features, we implemented various programming tasks for solving different scenarios. For each scenario, we developed applications satisfying identical functionalities in both Java and Rust. In the research, we analyze specific language features, software quality metrics, execution efficiency, and memory usage. The research confirmed that both languages differ in the examined qualities. For example, Rust syntax is more complex in comparison with Java; however, it offers faster execution time and better memory management. On the other hand, Java allows for runtime code manipulation due to its reflection mechanism, which gives developers more flexibility. Finally, it is worth mentioning that each of these languages is compiled differently. Namely, Rust is compiled to native machine code, whereas Java is compiled to bytecode executed by the JVM.

Keywords: Java, Rust, Memory management, Software performance, Feature analysis

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Evaluating the Impact of JPEG Compression on Deepfake Detection

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AI-generated content has become such a significant part of the modern online experience, that synthetic personas are reaching levels of realism that allow them to blend into social media feeds seamlessly. They look convincing enough to bypass users' critical judgment. Within the routine of daily scrolling, the human eye has become conditioned to accept these fake faces as real individuals. The speed of content consumption already makes detection difficult and platform-level compression adds another layer to the problem by degrading the subtle visual details that could otherwise reveal a synthetic origin of the image, effectively masking the presence of deepfakes. This study addresses that challenge by investigating how JPEG compression impacts the reliability of deepfake detection. Using a large dataset of 140,000 real and synthetic face images, we trained a ResNet50 model to test how it works in real-world settings, where media is often compressed. We conducted a cross-evaluation matrix across five quality levels (Original, Q80, Q60, Q40 and Q20) to observe the generalization that occurs when a model encounters the heavy compression. The original model achieved 99.6% accuracy on uncompressed images, but this dropped to 82.5% when tested on heavily compressed images (Q20), representing a 17% performance loss driven purely by compression. Furthermore, models trained on compressed images demonstrated stronger generalization, with the Q40-trained model achieving the highest average AUROC of 0.9966 across all test conditions. These findings highlight that compression level directly influences model generalization and that detection systems must be trained under conditions that reflect the realities of modern digital platforms.

Keywords: Artificial intelligence, Deepfake detection, Computer vision, Image processing, Robustness study, ResNet50, Transfer learning

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Comparative Analysis of Voice Command Interpretation Methods in Web Applications

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Voice-controlled interfaces are becoming an increasingly important component of modern web applications, enabling more natural and accessible user interaction. However, accurate interpretation of user commands remains a significant challenge, particularly in the context of natural language variability. This study presents a comparative analysis of two approaches to interpreting voice commands: a rule-based method and an artificial intelligence-based approach. A prototype web application was developed using the Web Speech API to simulate a voice-controlled environment. The rule-based approach relies on keyword matching, whereas the AI-based approach employs intent recognition mechanisms to capture the underlying meaning of user utterances. An experimental evaluation was conducted using a set of predefined commands, including both simple and more natural language variants. The evaluation focused on interpretation accuracy and system response time. The results allowed us to demonstrate within the conducted experiment that the rule-based approach achieves high effectiveness for simple commands; however, its performance decreases as linguistic complexity increases, mainly due to keyword conflicts and limited context awareness. In the examined scenario, the AI-based approach demonstrated higher effectiveness and greater robustness to linguistic variability, at the cost of slightly longer response times. The obtained results highlight the limitations of rule-based systems and indicate the potential of AI-based approaches for interpreting user intent, while acknowledging the constraints resulting from the adopted experimental setup.

Keywords: Voice command interpretation, Natural language interaction, Rule-based approach, Intent detection, AI-based systems, Voice interfaces, Web Speech API, Web applications

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Analysis of the Effectiveness of Defense Methods Against Ransomware Attacks in a Test Environment

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The dynamic development of information technologies has made the landscape of modern cyber threats extremely volatile, posing a critical challenge to global security. Ransomware occupies a special place in this landscape. Due to its destructive nature and ability to completely paralyze business processes, it currently represents one of the most costly threats to organizations. Modern cybercrime has evolved into sophisticated Ransomware-as-a-Service ecosystems utilizing double extortion, living-off-the-land binaries (LOLBins), and fileless attacks. Since traditional antivirus solutions relying on static analysis are insufficient, this paper presents a comparative analysis of two endpoint defense paradigms: proactive Windows Attack Surface Reduction (ASR) rules and reactive Endpoint Detection and Response (EDR) systems. The evaluation is conducted in a strictly hardened KVM/QEMU virtualized environment to evade modern anti-VM techniques. To ensure objective measurement without in-guest interference, the methodology uses offline disk image analysis based on incremental .qcow2 snapshots. The assessment employs a three-stage analytical approach. First, SHA-256 cryptographic verification filters out untouched files. Second, a signature scanning phase sequentially reads disk blocks to locate predefined file watermarks (REF_ID), countering evasion tactics like file renaming. Finally, a hybrid binary diffing method calculates the exact Damage Metric by evaluating the surviving data. This includes the Longest Common Subsequence (LCS) algorithm for files under 1 MB, and a sliding chunk intersection method for files over 1 MB to guarantee accurate measurement even if ransomware shifts original data offsets. The study investigates specific quantitative parameters: the exact number of lost files, their percentage degree of encryption, Dwell Time (delay before effective mitigation), and overall System Survivability. Findings indicate that implementing proactive approach increases overall security by blocking certain malicious execution pathways. General recommendations suggest organizations adopt a balanced defense strategy, acknowledging that proactive measures must be carefully managed to avoid false positives that disrupt legitimate operations.

Keywords: Ransomware, Endpoint detection and response, Attack surface reduction, KVM, Damage metric

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Usability Evaluation of Virtual Reality Interfaces Using Eye-Tracking: A Case Study of a Cultural Heritage Museum

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The study addressed the usability evaluation of user interfaces in virtual reality (VR) environments, with a particular focus on cultural heritage applications. Two contrasting design approaches were empirically compared: an interface compliant with universal design (UD) principles and one that did not meet these requirements (non-UD), both implemented within a regional museum application developed in the Unity engine and deployed on Meta Quest Pro headsets equipped with a built-in eye-tracking system. The experiment involved 50 participants (28 male, 22 female) aged 23–45 (M = 29.4; SD = 5.8), representing varying levels of VR experience. A counterbalanced design was applied to eliminate order effects. Each participant completed a set of 20 goal-directed tasks in both interface variants, covering UI element localisation, interaction with 3D objects, navigation between rooms, and information reading. Three categories of data were recorded: oculomotor (heatmaps, scanpaths, TTFF, fixation count, dwell time within AOIs), behavioural (task completion times), and subjective (SUS questionnaire administered after each variant). The results clearly indicate the superiority of the UD interface: the mean SUS score was 73.75 compared to 65.31 for the non-UD variant (Z = 4.87; p ¡ 0.001; r = 0.49), corresponding to a large effect size. Participants also completed tasks significantly faster in the UD variant (40.41 s vs. 57.85 s, a reduction of approximately 30%; Z = 5.61; p ¡ 0.001; r = 0.56). Eye-tracking data confirmed these differences: fixations in the UD variant were concentrated around target areas of interest with more direct scanpath trajectories, whereas the non-UD variant produced dispersed gaze patterns indicative of a higher visual search cost. The UD advantage was greatest for visual search tasks (TTFF: 1,024 ms vs. 2,318 ms) and interaction tasks (1,187 ms vs. 1,952 ms), while differences for reading and navigation tasks were comparatively smaller. The findings confirm that applying universal design principles in VR yields measurable usability benefits, and the study's methodological contribution lies in the development of a replicable gaze data logging pipeline for consumer-grade VR headsets.

Keywords: Virtual reality, Eye-tracking, Universal design, User interface usability, System Usability Scale, Cultural heritage, Gaze analysis

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Comparative Analysis of Usability and Quality of Mobile Navigation Applications Using the MARS and IBM-CSUQ Methods

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This study presents a comprehensive comparative analysis of four prominent mobile navigation applications — Google Maps, Waze, HereWeGo, and MAPS.ME — to investigate the relationship between objective technical quality and subjective user satisfaction. It was hypothesized that a high degree of technical perfection, as evaluated by expert heuristics, does not inherently guarantee high user satisfaction (Hypothesis I), that excessive gamification creates cognitive overload (Hypothesis II, the Over-engineering Paradox), and that minimalist interfaces provide higher user comfort (Hypothesis III). The methodology combined objective expert audits using the Mobile App Rating Scale (MARS) with empirical user testing on a focus group of 10 users utilizing the IBM-CSUQ psychometric questionnaire. The scores were harmonized to a 5-point scale, and Gap Analysis was applied to measure the discrepancies. The empirical results strongly supported the hypotheses and led to the rejection of the assumption that technical quality equals usability. Statistical analysis revealed no significant linear correlation between expert technical ratings and end-user comfort (Pearson's r = 0.233, p = 0.148), confirming Hypothesis I. Waze demonstrated a statistically significant negative gap (Gap = -1.53), proving Hypothesis II by showing that its high functional density and gamification led to cognitive overload and decreased usability. Conversely, HereWeGo exhibited near-perfect convergence (Gap = -0.06), validating Hypothesis III by proving that a simplified, minimalist architecture yields high user comfort despite lacking advanced features. Through a UX Positioning Matrix, Google Maps was identified as the absolute leader balancing complexity and intuition, while MAPS.ME was categorized as an outsider requiring a complete interface overhaul. Ultimately, this research concludes that evaluating navigation systems purely on technical heuristics is insufficient; systems must prioritize cognitive ergonomics and simplicity to achieve genuine user satisfaction.

Keywords: Mobile navigation, Usability evaluation, Human-Computer Interaction, MARS scale, IBM-CSUQ, Cognitive load, Gap analysis

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Comparative Analysis of Virtual Private Networks (VPNs) with Automated Deployment in Virtualized Environments

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This paper presents a comparative analysis of remote access solutions for network infrastructure, focusing on two widely adopted open-source Virtual Private Network (VPN) technologies: WireGuard [1] and OpenVPN [2]. Building upon existing scientific literature on VPN performance and efficiency, the study examines not only throughput, latency, and resource utilization, but also the impact of deployment models and automation techniques on overall system effectiveness. The research is conducted in a controlled, virtualized home-lab environment based on Proxmox, enabling reproducible experiments that reflect both laboratory and real-world remote access scenarios described in prior studies [4]. Automation is implemented using scripting, inspired by contemporary approaches to scalable VPN provisioning, allowing consistent configuration and rapid deployment across test instances. Performance evaluation is carried out using standardized tools and monitoring systems, with key metrics and connection stability analyzed under varying conditions. Unlike simplified or single-device benchmarks reported in some studies [5], this work emphasizes a reproducible and extensible testing methodology within a multi-instance virtual environment. The results are compared with findings from recent research, which generally indicate the superior efficiency of WireGuard over OpenVPN in terms of performance and resource consumption [6], while also considering scenarios where implementation details and client environments may influence outcomes. The study further evaluates the role of automation in reducing configuration complexity and operational overhead. The findings contribute to a deeper understanding of the trade-offs between performance, manageability, and deployment complexity in modern VPN solutions, supporting informed decision-making in the design and optimization of secure remote access infrastructures.

Keywords: VPN, WireGuard, OpenVPN, Network automation, Ansible, Performance analysis, Monitoring

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Analysis of Security and Isolation Mechanisms in WebAssembly Compared with Established Sandboxing Approaches

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Modern software platforms increasingly allow external or partially trusted code to be executed inside a controlled environment. This requirement appears in plugin systems, serverless platforms, edge computing, and data-processing pipelines, where the execution mechanism must limit access to host resources while preserving acceptable performance and operational practicality. This work evaluates WebAssembly with WASI/Wasmtime as a modern sandboxing mechanism for such workloads and compares it with established isolation approaches based on containers and microVMs. The analysis combines a review of isolation mechanisms with measurements obtained on an Ubuntu 24.04 x86_64 test system using representative workloads implemented with Wasmtime, Docker, and Firecracker. Native execution was used as a baseline, while repeated benchmark runs were used to observe performance tendencies and stability of the selected sandboxing technologies. The empirical part includes startup measurements, CPU-bound and I/O-bound tasks, file-system access tests, and resource-exhaustion scenarios. The results show practical strengths and limitations of the tested technologies in representative use cases. Wasmtime offers fast startup and explicit host-resource permissions, making it attractive for short tasks and narrowly scoped extensions. Containers provide mature resource management and broad software compatibility, although their performance characteristics vary depending on deployment and invocation model. MicroVM-based isolation provides a stronger boundary by combining virtualization with a minimal virtual machine model, although this increases startup overhead and deployment complexity. The observed differences clarify the conditions under which WebAssembly can serve as a practical sandbox for untrusted code. The comparison relates startup behavior and permission models to the broader compatibility of containers and the stronger isolation boundary of microVMs. The conclusions support selecting an execution environment according to workload lifetime, host-access requirements, resource-control needs, and threat model.

Keywords: WebAssembly, WASI, Containers, MicroVMs, Isolation, Sandboxing

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Analysis of the Effectiveness of Various Indexing and Semantic Search Strategies in Retrieval-Augmented Generation Systems for Academic Documentation

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This paper presents an analysis of the effectiveness of various indexing and semantic search strategies used in the implementation of virtual agents (so-called chatbots). The key strategy of this solution is the selection of a large language model that generates a response in Polish to a question posed via the Ollama and HuggingFace platforms, as well as an embedding model for the ChromaDB vector database. The aim of the analysis is to evaluate the language model's ability to formulate a correct response to a given question in terms of reliability and semantic complexity, using the embedded vector database as the primary knowledge source. Several language models were used in the research, all of which interact with the same database, testing the research hypothesis: "A suitable language model is capable of reliably answering questions in Polish based on the provided data sources". The work was implemented using the Python programming language, utilizing model-supporting tools such as Langchain and Ragas, as well as measurement tools like the Sklearn, Matplotlib, and Pandas libraries. The results are presented in tables along with calculated metrics that confirm the effectiveness of indexing and semantic search. They confirm the correct selection of the language model for the hardware on which the analyses are performed, taking into account the language in which the responses are generated.

Keywords: Semantic search, Vector database, Language models (LLM), Data indexing, Academic documentation

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Multi-Method Usability Analysis of a Mobile Application for Students

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The aim of the paper is to evaluate the usability of a mobile application dedicated to university students. The study focuses on assessing the quality of the user interface and the overall user experience using multiple usability evaluation methods. The application was analyzed using eye-tracking technology, the System Usability Scale (SUS), the User Mobile Application Rating Scale (uMARS), and heuristic evaluation methods based on Nielsen's heuristics. The study was conducted with a group of 30 participants, representing the target user group of the application. The eye-tracking analysis included both quantitative and qualitative approaches. The quantitative analysis was based on fixation count, fixation duration, and saccade count metrics, while the qualitative analysis examined users' scan paths during task execution. Performance evaluation additionally included scenario completion time and scenario execution correctness. The obtained results indicate that the application provides a generally high level of usability. The SUS evaluation achieved a score of 76.7, exceeding the standard usability threshold of 68 points. The uMARS assessment showed high perceived application quality, with an average score of 4.6 for Sections A–D and 4.3 for Section E related to subjective quality evaluation. The mean scenario completion time was 17.6 seconds, while the scenario evaluation correctness reached 100%, indicating efficient and accurate task performance. However, heuristic evaluation revealed several important usability issues related to interface consistency, error handling, and navigation clarity. The analysis indicated inconsistencies in interface terminology and duplicated functionalities, particularly within error-reporting sections, which reduced interface predictability and could confuse users. Additional problems were identified in the system's error prevention and recovery mechanisms, as the application lacked clear feedback and understandable error messages during incorrect form completion. The study also highlighted limitations in interface personalization, including incomplete support for high-contrast mode and the absence of customizable menu layouts. The findings demonstrate that combining quantitative and qualitative usability evaluation methods enables a more comprehensive assessment of mobile applications intended for students and supports the identification of areas requiring improvement.

Keywords: Mobile application for students, Usability, User experience, Eye tracking, System Usability Scale (SUS), User Mobile Application Rating Scale (uMARS), Heuristic evaluation, Nielsen's heuristics

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A Comparative Analysis of Performance and Quality of Unity and Unreal Engine 5 Development Environments in the Context of Three-Dimensional Game Mechanics Implementation

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This paper addresses the comparative evaluation of two leading video game engines – Unity and Unreal Engine 5 – in terms of technical performance, gameplay quality, optimisation capabilities, and developer efficiency. The aim of the study was to empirically analyse both environments in the context of implementing movement and interaction mechanics in three-dimensional space. To this end, two analogous 3D games were developed, equipped with identical systems for movement, climbing, jumping, and object interaction, constituting a controlled testing environment that enabled direct comparison of results. Quantitative data were collected using a custom-designed logging system that recorded key performance parameters in real time, including average frames per second (FPS), input latency, and the load on the central processing unit (CPU), graphics processing unit (GPU), and random-access memory (RAM). Measurements were conducted under unified hardware and scenario conditions to ensure the comparability of the collected data. Qualitative data were obtained through structured questionnaires completed by the research group immediately after each testing session. Combining objective performance indicators with subjective user assessments enabled a multidimensional analysis of the strengths and weaknesses of both tools. The results indicate significant differences between the examined engines in terms of both technical parameters and the experiences of developers and testers. The study contributes to the field of game software engineering by providing practical guidance on the selection of a development environment depending on the nature and requirements of a given production project.

Keywords: Unity, Unreal Engine 5, Game engines, Performance evaluation, Comparative analysis, Game software engineering, 3D mechanics

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CI/CD Pipeline Security: Automation, Vulnerability Detection, and Prevention

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In the era of widespread containerization and cloud solutions, automated Continuous Integration and Continuous Delivery (CI/CD) pipelines have become the foundation of software development. At the same time, due to the drastically increasing number of sophisticated cyberattacks targeting software supply chains and the development infrastructure itself, CI/CD process security has become a critical issue. The traditional approach of verifying security in the final stages of the Software Development Life Cycle proves to be insufficient, forcing organizations to transition towards the DevSecOps methodology. The main objective of this thesis is the analysis, evaluation, and optimization of automated security verification processes in CI/CD environments, utilizing the GitHub Actions platform. The thesis is divided into a theoretical section and a two-stage research section. The literature and technology review characterizes modern attack vectors on infrastructure and discusses leading classes of security tools: from static code and infrastructure analysis (SAST, SCA, IaC) to dynamic runtime testing (DAST). In the first research phase, an empirical comparative analysis of selected tools was conducted. Using standardized benchmarks and vulnerable applications, the effectiveness of individual scanners was examined in terms of detecting real vulnerabilities, the false alarm rate, and the generated time overhead. Based on the conclusions drawn from the comparative analysis, the second research phase involved designing and implementing two proprietary CI/CD pipeline variants: a "fast" variant – optimized for daily developer work and ensuring an immediate feedback loop, and an "accurate" variant – dedicated to final pre-deployment verification, enriched with a full test environment and dynamic attacks carried out by the OWASP ZAP tool. The main subject of the research was evaluating the trade-off between performance overhead and the ultimate degree of code coverage and risk mitigation. The obtained results and evaluation confirm that the appropriate orchestration of analytical tools allows for achieving a high level of security without paralyzing the Continuous Delivery process. This paper provides verified engineering architectural patterns that can serve as a guide for organizations striving for a secure and efficient implementation of the DevSecOps methodology.

Keywords: CI/CD, DevSecOps, GitHub Actions, Automation, Vulnerability prevention, Supply chain security

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Comparative Analysis of Machine Learning Models in Forecasting the Market Behavior of Financial Instruments

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The dynamic digitalization of financial markets and widespread access to historical stock market data provide a strong impulse for implementing advanced predictive algorithms to support investment decisions. The necessity to rapidly analyze this data requires the use of advanced analytical techniques that allow one to uncover hidden market trends, which directly translates into building a measurable advantage over traditional trading methods on the stock market. This study presents a new approach in investment on the stock market that uses machine learning for time-series prediction, which enables one to achieve higher rates of return than the passive "Buy and Hold" strategy. The aim of the conducted research was the verification of the hypothesis assuming the superiority of the XGBoost model over deep neural network architectures. The research has been preceded by a literature review in the field of algorithmic trading, as well as a detailed characterization of the analyzed machine learning models and the utilized technology stack. A comprehensive, end-to-end analytics platform, Microsoft Fabric, has been utilized as the research environment. Its architecture enabled the efficient collection and processing the market data considering prices of financial instruments. The adequately prepared datasets have been utilized to train machine learning models, allowing for the precise identification of nonlinear market trends. The trained models have been subsequently evaluated in a backtesting environment simulating the trading on the stock market. These tests allowed one to compare of the results of prediction generated by particular models and historical quotes of selected financial instruments has been performed. The results of tests have been utilized for models' hyperparameter optimization, aiming to maximize predictive effectiveness. The results of the conducted comparative analysis have been visualized in the form of interactive Microsoft Power BI reports.

Keywords: Algorithmic trading, Machine learning, Deep neural networks, XGBoost, Backtesting, Stock market prediction, Investment strategy

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Analysis of Security Effectiveness and Ethical Testing of Vulnerability Detection in Wireless Networks

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In today's world, wireless networks have become a key element of everyday communication and data exchange, making their security crucial issue. Evaluating the effectiveness of security measures, combined with an ethical approach to vulnerability testing, is necessary for identifying vulnerabilities while ensuring responsible and controlled assessment practices. The master's thesis focuses on the analysis of wireless network security and the evaluation of the effectiveness of the protection mechanisms used within them. The main research objective is to verify the resistance of modern security standards to known attack vectors, as well as to identify potential vulnerabilities in network infrastructure. As part of the study, a theoretical analysis of security mechanisms was conducted, along with a characterization of the most common threats occurring in wireless networks, such as Man-in-the-Middle attacks, DoS attacks, and attempts to compromise authentication mechanisms. A key research element was the development of a detailed security testing methodology and the preparation of a fully controlled test environment with a defined security configuration, ensuring repeatability and comparability of results. Within this environment, a series of ethical penetration tests was carried out, including network reconnaissance, traffic interception attempts, unauthorized access resistance testing, and in-depth analysis of access point configurations. Additionally, the study included an analysis of the impact of conducted attacks on network transmission parameters, such as latency, packet loss, and throughput. The obtained results were thoroughly evaluated in order to analyze detected vulnerabilities and verify the formulated research hypotheses. The possibilities of detecting security incidents using monitoring systems and analytical tools were also analyzed. The thesis concludes with a set of recommendations and best practices aimed at minimizing the risk of security incidents, improving detection mechanisms, and enhancing the overall level of protection of modern wireless networks.

Keywords: Wireless networks, Network security, Network security analysis, Wireless security standards, Penetration testing, Network vulnerabilities

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Analysis of Targeted Attack Scenario Design and the Impact of OSINT Profiling on Their Effectiveness

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In today's digital environment, cyber threats have become more sophisticated and targeted. Attackers leverage publicly available information to create highly convincing scenarios that increase the likelihood of success. Understanding how targeted attack scenarios are constructed and the role of OSINT profiling in increasing their effectiveness is crucial to improving organizational security and user awareness. This study examines targeted cyberattacks in the context of modern threat trends, with a particular focus on how open-source information (OSINT) increases their effectiveness. It highlights threats such as spear-phishing and targeted guessing, which rely on personal data gathered from publicly available sources to create highly personalized and convincing attacks. The work stresses that the growing scale of information sharing significantly raises the likelihood of successful exploitation. The main objective was to empirically assess the relationship between users' cybersecurity awareness and their responses to targeted attacks. Two hypotheses were tested: first, that individuals without cybersecurity training are more vulnerable to such attacks; and second, that users who share large amounts of personal data publicly are at greater risk. To verify these assumptions, an anonymous online survey was conducted among a diverse group of participants varying in age, education, professional status, and technical experience. The survey evaluated declared security practices, online behavior, and reactions to simulated attack scenarios, with responses categorized as safe or unsafe according to current cybersecurity standards. The results confirmed both hypotheses. Users lacking training or experience demonstrated significantly higher vulnerability, often making decisions that increased the risk of data breaches. Similarly, individuals who shared more information publicly were more susceptible to targeted attacks. Overall, the findings emphasize that cybersecurity education is a critical factor in reducing user vulnerability. The study concludes that improving user awareness through training is essential for strengthening organizational security. Based on the findings, practical guidelines were proposed to help mitigate risks related to targeted attacks and OSINT-based profiling.

Keywords: Targeted attacks, Spear phishing, Targeted guessing, OSINT, Information security

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Evaluation of the Effectiveness and Efficiency of Data Encryption Mechanisms in Selected Operating Systems

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In an era of increasing threats related to physical hardware compromise, Full Disk Encryption (FDE) has become a standard for protecting data at rest. This paper presents the results of a comparative study of two leading encryption technologies: the commercial solution BitLocker (Windows) and the open-source standard LUKS/dm-crypt (Linux). The aim of this presentation is to analyze the impact of cryptographic processes on overall operating system performance and to assess the level of security they provide. The theoretical section discusses the architecture of both solutions, including key management mechanisms (VMK in BitLocker vs. Master Key in LUKS) as well as the use of AES-NI hardware acceleration in modern processors. Experimental studies were conducted in a bare-metal environment (Windows 11 Pro and Kali Linux), using AES-256 in XTS mode. The research methodology included measurements of sequential read and write speeds, analysis of input/output operations per second (IOPS) for 4K samples, and monitoring of CPU load during intensive disk operations. The conclusions drawn from the conducted tests allow for precise determination of the performance overhead (encryption overhead) generated by each technology. The results provide valuable insights for system administrators and end users regarding the optimal selection of encryption tools, balancing a high level of security with user comfort and system responsiveness. The results indicate that both solutions introduce minimal performance overhead when AES-NI is enabled, with differences becoming more noticeable under high I/O workloads.

Keywords: BitLocker, LUKS, FDE, AES-256-XTS, Cryptographic performance, Security of operating systems

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From Black Box to Bedside: Explainable Deep Learning for Melanoma Detection Using Gradient-Weighted Class Activation Mapping

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Although deep learning has achieved an accuracy level in identifying cutaneous melanoma that is comparable to that of dermatologists [1], its limited interpretability remains a key obstacle to its adoption in clinical practice [2]. For high-stakes oncological decisions, practitioners require not only reliable predictions, but also a transparent rationale. This study proposes an interpretable diagnostic approach designed to support dermatologists by combining predictive power with visual explanations. Three pre-trained architectures of distinct design philosophies - ResNet152, DenseNet201, and EfficientNet-B4, were fine-tuned on a curated dataset of 17,114 dermoscopic images compiled from the ISIC 2018, 2019, and 2020 archives [3], balanced between benign and malignant lesions. Beyond reporting standard performance metrics (accuracy ranging from 88.30% to 90.40%), the central contribution of this study is a qualitative and structured comparison of the spatial attention patterns generated by Gradient-weighted Class Activation Mapping (Grad-CAM) [4] for each architecture. The visualisations reveal markedly different diagnostic strategies: ResNet152 concentrates on the central, highly pigmented lesion core; DenseNet201 distributes its attention more uniformly across the lesion and adjacent tissue; whereas EfficientNet-B4 attends to irregular borders and asymmetrical pigmentation, which are features clinically aligned with the established ABCDE diagnostic rule [5]. These behavioural differences indicate that architectural choice influences not only accuracy but also the medical plausibility of the model's reasoning. These findings suggest that explainability should be integrated as a first-class evaluation criterion alongside accuracy when selecting CNN architectures for dermatological decision-support systems, and they outline a path toward clinically auditable AI in melanoma screening.

Keywords: Explainable AI, Melanoma, CNN, Skin cancer, Dermoscopy

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Analysis of the Efficiency of CNN Architectures in Hieroglyph Recognition with Data Augmentation Techniques

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The research paper examines the performance and effectiveness of selected convolutional neural network (CNN) architectures in classifying ancient Egyptian hieroglyphs, with a particular focus on the role of data augmentation. The study compares lightweight and standard CNN frameworks under a unified training and evaluation protocol, testing whether augmentation consistently improves generalization in a controlled classification environment. In addition, a two-stage recognition process was considered, in which the You Only Look Once (YOLO) v8 detector provides potential symbol areas and the CNN classifier assigns the final hieroglyph label. The results of the analysis were presented in the form of tables and graphs, enabling a clear comparison of the effectiveness and performance of the architectures under study. Based on the obtained results, conclusions were drawn regarding the most effective model for the hieroglyph recognition task, and the impact of data augmentation on classification quality was evaluated.

Keywords: Hieroglyph recognition, Convolutional neural networks, Data augmentation, EfficientNet-B0, MobileNetV3-Large, ResNet18, YOLOv8, Object detection

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Classification and Effectiveness Analysis of Methods Enhancing Deployment Security of IT Systems Using IaC Tools

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The research paper presents the findings of a research study focused on classifying and analyzing the effectiveness of methods that enhance the security of IT system deployments utilizing Infrastructure as Code tools. The theoretical context, an overview of currently used solutions and technologies, and a literature review form the foundation for determining the current state of knowledge regarding the security of deployments in cloud environments. This made it possible to design a proprietary taxonomy, which was used in an experiment conducted on a practical application project deployed to the Microsoft Azure ecosystem using Terraform technology. The infrastructure code was scanned by selected tools in two different operating modes, and the obtained research results were aggregated and visualized in appropriate charts. The findings identify the most effective scanning solution while demonstrating that a multi-tooling strategy is essential for comprehensive security coverage. The study highlights critical blind spots in static analysis regarding cloud provider defaults and validates a normalization framework for the objective evaluation of diverse security tools in DevSecOps pipelines.

Keywords: Infrastructure as Code (IaC), Terraform, DevSecOps, Microsoft Azure, Policy-as-Code, Static Analysis (SAST), Comparative analysis, Security automation

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Analysis and Simulation of the Effectiveness of Defense Methods Against Selected Social Engineering Attacks

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Phishing remains one of the most prevalent and effective vectors of social engineering attacks, with academic institutions representing a particularly vulnerable target due to their open communication culture, high user turnover, and heterogeneous levels of security awareness. This paper presents the methodology and infrastructure of a controlled phishing simulation conducted within a Polish university, designed to measure the susceptibility of the student population to credential harvesting attacks. The experiment was authorised by university authorities and carried out in compliance with applicable legal and ethical frameworks, including GDPR. The technical infrastructure comprised a cloud-based virtual machine (Microsoft Azure, Ubuntu Server), a reverse-hierarchy spoofed domain (cybersquatting), Nginx with a valid TLS certificate (Let's Encrypt), the Gophish orchestration framework, the Brevo SMTP relay with full SPF/DKIM/DMARC authentication, and Microsoft Clarity for behavioural session analytics. The phishing scenario exploited four documented sociotechnical mechanisms: the scarcity principle, institutional authority, contextual fit, and cognitive friction reduction, using a fictitious free-ticket offer for a university festival as the pretext. The landing page replicated the university's virtual dean's office login interface, with the password field removed and form submission modified to prevent any real credential capture. The campaigns were conducted among students, with activities organized across faculty groups. Behavioural data were collected through event tracking and session analytics, complemented by heatmaps enabling qualitative inter-faculty comparison and analysis of differences observed across departments. These findings are discussed in relation to benchmarks reported in the literature and implications for awareness programme design in higher education.

Keywords: Phishing simulation, Social engineering, Cybersecurity awareness, Academic institutions, Behavioural analytics, Security education

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