ICAC 2025

7TH INTERNATIONAL CONFERENCE ON ADVANCEMENTS IN COMPUTING

THE FUTURE OF COMPUTING: AI, QUANTUM, AND BEYOND

09 – 10 DECEMBER 2025

SLIIT FACULTY OF COMPUTING

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7th International Conference on Advancements in Computing (ICAC2025)

"The Future of Computing:AI, Quantum, and Beyond"

09th and 10th December 2025

Monarch Imperial,

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Sri Lanka

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Faculty of Computing

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7th International Conference on Advancements in Computing

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MESSAGE FROM THE GENERAL CHAIR

It is my great pleasure to welcome you to the International Conference on Advancements in Computing (ICAC 2025), held on the 9th and 10th of December 2025 at the Monarch Imperial, Colombo, Sri Lanka. As the General Chair, I am honoured to host this academic forum where researchers, industry professionals, and students come together to present advances, share insights, and strengthen international collaboration.

This year's theme, "The Future of Computing: AI, Quantum, and Beyond," reflects the rapid evolution of digital technologies and the growing importance of interdisciplinary research in addressing complex societal and industrial challenges. ICAC 2025 highlights the convergence of artificial intelligence, quantum computing, cybersecurity, data systems, and emerging computational paradigms that are reshaping the future of scientific discovery and innovation.

The conference received 462 research submissions from approximately 2,000 contributing authors across 12 technical tracks. All manuscripts underwent a rigorous double-blind review process led by 189 expert reviewers, ensuring research quality, integrity, and originality. From this review, 116 high-quality papers were selected for presentation, representing impactful contributions across diverse computing disciplines.

We are pleased to note increased external and international participation. A majority of submissions originated outside the host institution, and 20% of submissions are affiliated with foreign universities, reinforcing ICAC's position as a globally engaged research platform.

ICAC 2025 is further strengthened through keynote and invited talks delivered by distinguished international experts. I encourage all participants to engage actively in the technical sessions, discussions, and networking opportunities, as these interactions stimulate new ideas, partnerships, and shared learning.

We gratefully acknowledge the support of our sponsors and partners. In particular, MongoDB serves as our Platinum Sponsor, enabling stronger industry–academia collaboration and capacity building.

I extend heartfelt appreciation to the organizing committee, volunteers, and administrative teams whose dedication has ensured a seamless and enriching conference experience.

On behalf of the Organizing Committee, I warmly welcome you to ICAC 2025 and wish you two days of insightful presentations, meaningful collaboration, and a memorable experience.

Dr. Prasanna Sumathipala
General Chair, ICAC 2025
Sri Lanka Institute of Information Technology

KEYNOTE SPEECH BY PROF. IGOR BRAY

Faculty of Science and Engineering, Curtin University, Australia

Igor Bray obtained his PhD in the Department of Mathematical Physics at the University of Adelaide, South Australia, in 1986, entitled "Gravitational Lens effect of Galaxies and Black Holes". In it he predicted an image of a rotating Black Hole when acting as a gravitational lens. However, as there was no interest in such ideas at the time, he switched to the field of Atomic and Molecular Collision Theory pursued at Flinders University, also in Adelaide. During this time, he codeveloped the convergent close-coupling theory, which is uniquely valid at all projectile energies and for all collision processes. Currently, he is at Curtin University in Perth, Western Australia, where he is the Head of the Department of Physics and Astronomy, and runs the HPC Unit, see https://atom.curtin.edu.au/hpc/. He is a Fellow of the Australian Academy of Science, American Physical Society, and the Institute of Physics. In 2022 he was elected to the Western Australian Science Hall of Fame, and in 2025 was made a Member of the Order of Australia.

Tiles: Quantum Mechanics in Action: Calculation of Atomic and Molecular Collisions using High-Performance Computing

Collisions on the atomic scale are ubiquitous throughout the universe and are governed by the Laws of Quantum Mechanics. They have many applications in science and industry, requiring High-Performance Computing (HPC) for their solution. Modern-day computational implementation is based on the hybrid MPI/OpenMP parallelism with GPU acceleration. Implementing large-scale computational parallelism is an important skill set for the modern programmer, with Quantum Computing being the ultimate approach to those problems that benefit from massively parallel algorithms. In the talk we shall discuss several applications of HPC in solving collisions on the atomic scale, discuss HPC approaches to their solution, and touch upon the promise of Quantum Computing.

KEYNOTE SPEECH BY PROF. CARSON KAI-SANG LEUNG

Department Of Computer Science, Faculty Of Science, University Of Manitoba

Prof. Carson K. Leung is a Full Professor in the Department of Computer Science at the University of Manitoba, Canada. He received his Ph.D. in Computer Science from the University of British Columbia, Canada. Over the years, he has contributed significantly to the fields of databases, data mining, and data science, and artificial intelligence through both research and teaching.

His research interests span a wide range of areas including web-based database applications, data mining and analytics, recommender systems, healthcare informatic, social network analysis, and the use of technology in education. His work emphasizes practical solutions to real-world problems and has involved the development of several web-based tools and systems, particularly in support of student learning and educational resources. He has taught a variety of courses at the undergraduate and graduate levels, covering topics such as database systems, data mining, and data science. He has also been actively involved in departmental curriculum development and student mentorship initiatives. He regularly participates in academic committees and has served as the Editor-in-Chief for *Advances in Data Science and Adaptive Analysis* (*ADSAA*) and for *Analytics*, as well as an Associate Editor for international journals like Springer's *Social Network Analysis and Mining*. He has also served on the Organizing Committees of the ACM CIKM, ACM KDD, ACM SIGMOD, DaWaK, IEEE DSAA, IEEE ICDM, and other conferences. He is a Senior Member of both the ACM and the IEEE.

Title: Advancements in computing save lives

Nowadays, we are living in the era of big data, in which advancements in computing and technology have led to huge volumes of data being generated and collected at a rapid rate. Consequently, big data are everywhere. Embedded in these big data are valuable information and knowledge, which can be discovered through data science, data mining and/or artificial intelligence (AI). This keynote speech discusses how advancements in computing save lives. To elaborate, we describe two real-world scenarios. First, our big data management solution makes good use of a hybrid model to capture both tabular and graph data for transportation analytics. The solution reduces chances in which emergency vehicles were delayed by crossing trains. Second, our health informatic solution adapts associative classification to learn from historical medical health records to support early detection of rare diseases. Both real-world scenarios exemplify how advancements in computing can save lives.

KEYNOTE SPEECH BY DR. HIMAL SURAWEERA

Department Of Electrical And Electronic Engineering, Faculty Of Engineering, University Of Peradeniya

Himal A. Suraweera received the B.Sc. Eng. (Hons.) degree from University of Peradeniya, Sri Lanka, in 2001, and the Ph.D. degree from Monash University, Australia, in 2007. He is currently a Senior Lecturer with the Department of Electrical and Electronic Engineering, University of Peradeniya. He was a recipient of the 2017 IEEE ComSoc Leonard G. Abraham Prize, the IEEE ComSoc Asia-Pacific Outstanding Young Researcher Award in 2011, the WCSP Best Paper Award in 2013, and the SigTelCom Best Paper Award in 2017. He served as an Editor of the IEEE Transactions on Wireless Communications (2014-2019), IEEE Transactions on Green Communications and Networking (2017-2021) and IEEE Communications Letters (2010-2015). Currently, he is serving as an Editor of the IEEE Transactions on Communications and the IEEE Open Journal of the Communications Society. His research interests include 5G/6G networks, multiple-input multiple-output systems, intelligent reflective surfaces, energy-efficient wireless communications, full-duplex wireless techniques, wireless security, integrated sensing and communication, visible light communication, signal processing for communications, and machine learning for wireless design.

Title: A Hyper Connected Wireless Future with Immersive, AI Native, and Sustainable Communications

The future of mobile connectivity will be defined by seamless hyper connection, where wireless networks intelligently link people, machines, and environments. In this talk, we highlight how immersive communication experiences, powered by extended reality and multisensory interaction, will transform the way we live, work, and collaborate across both physical and digital spaces. A major enabler for this transformation is the rise of AI native networks, intelligent systems that learn, adapt, and self-optimize in real time to deliver reliability, performance, and efficiency improvements. Our talk also emphasizes the growing importance of sustainability, with energy efficient architectures and green technologies guiding these future deployments. Together, these advancements will establish a highly connected, resilient, and sustainable communication ecosystem that forms the foundation for next-generation communication innovation.

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A.Session 1 : IoT, Embedded Systems and Robotics

Paper ID: 99

Towards Autonomous Strawberry Pollination via IoT and Robotics

Karunarathna K.R.M.R.T., Wickramarathne C., Akmal M.A.M., Wickrama Arachchi W.A.D.C.S., Kapila Dissanayaka, Nathali Silva

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Abstract

Strawberries, a high-value crop with growing demand, face increasing challenges due to labour shortages, declining natural pollinator populations, and inconsistent manual pollination. To address these obstacles, this paper introduces an IoT-enabled robotic system designed to automate strawberry pollination with minimal human intervention. The system consists of a mobile rover with a three-dimensional robotic arm for precise flower detection and positioning, and a high performance server to handle image processing and task coordination. The rover uses an event driven software architecture that enables responsive, real-time behaviour and keeps power and memory usage to a minimum, which is crucial to field-deployable robotics. The onboard camera modules capture images of the strawberry bed and send them to an image processing server, which returns flower coordinates. The arm then performs targeted pollination based on the flower positions. Communication between system components is asynchronous and modular to allow scalable integration and future system extensions. Preliminary field tests conducted in open-field raised beds demonstrate the system's functional viability and reliable operational behaviour under real-world conditions. Designed with affordability and practicality in mind, this work contributes a novel and cost-effective approach to precision agriculture, particularly for small and medium farms where traditional pollination methods are either unreliable, labour-intensive, or too costly to sustain.

Keywords: *IoT, Strawberry Pollination, Image Processing, Autonomous Rover, Precision Agriculture*

Paper ID: 269

A Wireless Communication System for Hyper-localized Pest Management using Autonomous Micro-Robot Swarms in Sri Lankan Rice Paddy Fields

D.M.P.D. Daundasekara, K.R.L. Perera, H.S.T. Parindya, K.G.G. Senarathna

Faculty of Computing, Sri Lanka Institute of Information Technology, Sri Lanka

Abstract

This paper presents a wireless communication framework for hyper-localized pest management in Sri Lankan rice paddy fields using autonomous micro-robot swarms. The proposed system integrates Internet of Things (IoT) based sensing units with low-power wireless communication to enable real-time monitoring and coordinated response among microrobots. A layered architecture combining data acquisition, swarm coordination, and centralized control is introduced to improve responsiveness and minimize pesticide use. Communication reliability, latency, and coverage were analyzed under realistic field constraints, demonstrating the feasibility of the proposed design. Although a Convolutional Neural Network (CNN)-based pest identification module is proposed as part of the future extension, this study primarily focuses on the IoT communication design and coordination aspects. The outcomes indicate that the proposed approach can serve as a scalable and energy-efficient foundation for intelligent pest management systems in precision agriculture.

Keywords: *Precision Agriculture, LoRa, Zigbee, Swarm Robotics, Edge AI*

Paper ID: 404

An Integrated Architecture for a Real-Time Robotic Piano CoPlayer: Design, Embodiment, and Validation

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Abstract

The integration of embedded systems, robotics, and machine learning presents new opportunities for creating complex, interactive devices for assistive and creative applications. In this paper, we outline in full detail an end-to-end architecture for a real-time robotic piano co-player. The overall contribution here is hierarchical control architecture which separates AI prediction and motor control. The actual physical system will involve a 6 -DoF collaborative manipulator with a bioinspired end effector. An onboard AI processor, implementing a Long Short-Term Memory (LSTM) harmonic model, analyzes incoming MIDI data to produce musical harmonies. We evaluated this complete system design with a formal one-handed pianist and beginner group test (N = 10 for both) and have found it to have a significant positive effect on synchronization and musicality. We contribute a validated and reproducible blueprint for a complex, embodied robotic system that successfully operates in a real -time, human-in-the-loop context.

Keywords: *Human-Robot Collaboration, Embodied AI, Assistive Robotics, Deep Learning for Music, Piano Accessibility*

Paper ID: 422

Dynamic Edge Server Selection in Time-Varying Environments: A Reliability-Aware Predictive Approach

Jaime Sebastian Burbano, Arnova Abdullah, Eldiyar Zhantileuov, Mohan Liyanage, Rolf Schuster

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Abstract

Latency-sensitive embedded applications increasingly rely on edge computing, yet dynamic network congestion in multi-server architectures challenge proper edge server selection. This paper proposes a lightweight server-selection method for edge applications that fuses latency prediction with adaptive reliability and hysteresis-based handover. Using passive measurements (arrival rate, utilization, payload size) and an exponentially modulated rational delay model, the proposed Moderate Handover (MO-HAN) method computes a score that balances predicted latency and reliability to ensure handovers occur only when the expected gain is meaningful and maintain reduced end-to-end latency. Results show that MO-HAN consistently outperforms static and fair distribution baselines by lowering mean and tail latencies, while reducing handovers by nearly 50% compared to pure opportunistic selection. These gains arise without intrusive instrumentation or heavy learning infrastructure, making MO-HAN practical for resource-constrained embedded devices.

Keywords: *Edge Computing, Server Selection, Resource Allocation, Latency*

A. Session 2 : Artificial Intelligence & Machine Learning

Paper ID: 19

DementiaGuard – Integrated Digital Healthcare Solution for Dementia Care

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Abstract

Alzheimer's disease (AD), a progressive neurodegenerative disorder, affects millions worldwide and presents significant challenges for both patients and caregivers. Early diagnosis and comprehensive care are essential to improving quality of life and slowing cognitive decline. However, existing approaches often lack integration between diagnosis, personalized therapy, and safety monitoring. This study introduces a web and mobile-based system that incorporates deep learning for MRI-based AD detection, tracks disease progression, and generates individualized treatment plans through an expert system. The platform includes an AI driven voice assistant for reminiscence therapy, personalized cognitive training modules, and a real-time geolocation-based monitoring system utilizing wireless and IoT technologies. Initial evaluations indicate high classification accuracy and reduced caregiver burden. The system offers a unified approach to support cognitive health, patient safety, and caregiver assistance.

Keywords: *Alzheimer's Disease, Dementia, MRI Analysis, Reminiscence Therapy, Cognitive Health, Geo Fencing*

Paper ID: 313

Classifying the Heated and Unheated Sapphire Gems Using Microscopy Images Based on Multiple Tree Models

L. Mathumila, S. Thadsha, S. Mahizhnan, M. Janotheepan, R.G.C. Jaliya, D.P. Jayathunga, M. Ramashini

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Abstract

The research is crucial because it addresses a critical research gap: the use of microscopic image data for automated gem classification has not been extensively explored. Leveraging this approach enables the non -destructive analysis of sapphires, potentially reducing the time, cost, and expertise required for accurate gem identification. The results of this research could revolutionise the gemological field by providing a scalable solution that balances precision with practicality. Data were collected from secondary sources. To enhance robustness, data augmentation and preprocessing were applied, followed by feature extraction using texture, colour moments, and colour histograms. The extracted features were classified using tree -based ensemble models: CatBoost, Random Forest, and XGBoost. All three models achieved high accuracy (>83%). Random Forest delivered the strongest overall performance, with the highest accuracy (86.50%) and precision (83.83%) while maintaining robust recall. CatBoost provided a well-balanced performance (84.77% accuracy) with strong recall and solid precision, making it a dependable alternative. XGBoost achieved the highest recall (90.43%), excelling in detecting heated sapphires, though at the cost of lower precision.

Keywords: *Gem Identification, Machine Learning, Random Forest, XGBoost, CatBoost*

Paper ID: 319

Analysis of ML Models in Detecting and Mitigating Anomalies in Healthcare Networks

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Abstract

The increasing integration of digital technologies in healthcare has introduced significant cybersecurity challenges. The sensitivity of patient data, combined with the complexity and interconnectedness of healthcare networks, makes them prime targets for sophisticated cyberattacks. Traditional security mechanisms, including rule-based intrusion detection systems, exhibit notable limitations in detecting evolving and advanced threats. Machine learning and deep learning techniques have emerged as powerful solutions to enhance IDS capabilities, enabling real-time anomaly detection and automated threat mitigation. This study utilizes the CICIoMT2024 and IoMT Traffic data dataset to evaluate the effectiveness of ML-based IDS methodologies specifically within healthcare network environments. Initially, various models such as Random Forest (RF), Extreme Gradient Boosting (XG B), Logistic Regression (LR), and Deep Neural Networks (DNN) were assessed for their efficacy in detecting cyber threats. However, a hybrid CNN-LSTM architecture was ultimately finalized due to its superior performance in handling imbalanced datasets, modeling complex temporal feature interactions, and delivering high detection accuracy with minimal false positives. The research analyzes challenges faced by healthcare-oriented IDSs, including high false positiveness, data imbalance, computational resource constraints, and limitations inherent in available datasets. Future research directions are proposed, emphasizing the integration of federated learnings, optimized feature selection techniques, real-time IDS deployment strategies, and development of privacy-preserving cybersecurity frameworks tailored for healthcare environments.

Keywords: *Machine Learning, Deep Learning, Intrusion Detection Systems, Anomaly Detection, IoT Security.*

Paper ID: 337

Beyond the Black Box: An Interpretable Machine Learning Approach to Student Dropout Prediction

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Abstract

Student dropout in higher education is a significant global issue affecting both educational institutions and students. This study focuses on identifying contributing factors and improving prediction accuracy using various machine learning techniques, including Logistic Regression, Decision Trees, Random Forest, Support Vector Machines (SVM), Naive Bayes, and boosting classifiers such as XGBoost, Gradient Boosting, CatBoost, and AdaBoost. Both academic and nonacademic factors are examined. To enhance model performance, the research incorporates techniques such as feature correlation management, hyperparameter tuning, and data sampling methods, including SMOTE, SVM-SMOTE, and ADASYN, with ADASYN proving to be the most effective. In the first phase, the CatBoost classifier, combined with ADASYN, achieved the highest prediction accuracy, with a testing F1-score of 0.8603, demonstrating strong potential for the early identification of at-risk students. The second phase emphasizes interpretability using LIME, SHAP, and the Explainable Boosting Machine (EBM). Results indicate that non-academic factors such as socioeconomic background and personal resilience are significant predictors of student dropout, often more influential than academic performance. This study demonstrates that integrating machine learning with explainable AI enables the development of accurate and interpretable models to address student dropout in higher education.

Keywords: *Student Dropout, Machine Learning, Explainable AI, CatBoost, ADASYN*

Paper ID: 454

XAI Techniques used in Medical Image Classification: A Modality specific Analysis

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Abstract

The black-box nature of Artificial Intelligence (AI) models poses significant challenges to their wide-spread adoption in critical domains such as healthcare, where transparency and explainability are essential for safe clinical decision-making. Explainable artificial intelligence (XAI) techniques aim to overcome this limitation by playing a crucial role in medical image classification, thereby fostering trust among medical practitioners, patients and other stakeholders. This study presents a comprehensive modality-specific analysis of four saliency-based XAI techniques: Gradient weighted Class Activation Mapping (Grad-CAM), Local Interpretable Model-agnostic Explanations (LIME), SHapley Additive exPlanations (SHAP), and Occlusion Sensitivity (OS). These methods were systematically evaluated across four primary medical imaging modalities: computed tomography (CT), chest X-ray (CXR), magnetic resonance imaging (MRI), and ultrasound (US). Quantitative metrics were combined with structured feedback obtained from medical doctors. Clear modality-dependent performance patterns emerged from the results; GradCAM consistently demonstrated superior quantitative and clinical performance for CT, CXR, and MRI, achieving the lowest Average Drop Percentage (AD%) and highest Increase in Confidence Percentage (IC%) across these modalities. In contrast, LIME was identified as the optimal method for ultrasound images, showing the highest preservation of original model confidence (lowest AD%) and strongest clinician preference.

Keywords: *Explainable AI, Medical Imaging, Image Classification*

A. Session 3 : Artificial Intelligence & Machine Learning

Paper ID: 205

ElectS: Advanced E-Voting System with Facial Recognition

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[2] School of Applied Computer Science & IT, Conestoga College, Canada
[3] Department of Computing, Universiti Teknologi PETRONAS, Malaysia

Abstract

Traditional elections can be costly, time-consuming, and logistically complex in economically constrained countries such as Sri Lanka. While manual result counting causes various problems regarding delays and manipulation, voters, particularly the elderly and those living abroad, often face difficulties with the traditional process. Furthermore, the use of unverifiable sources for candidate data allows for the free flow of false information. This work presents ElectS, a web-based e-voting system that addresses these limitations. We developed ElectS utilizing the MERN stack; it employs facial characteristics and hand verification to accurately authenticate voters and prevent fraud. To facilitate wiser choices, the system also presents open applicant profiles. Our study demonstrates ElectS' success, including substantially lowered election costs, improved accessibility, faster and more accurate results, and enhanced democratic integrity. ElectS aims to develop the future of elections in underdeveloped countries by prioritizing voter transparency, accountability, and the fundamental right to vote.

Keywords: *E-voting, MERN Stack, Face Recognition, Online Voting, NIC Verification*

Paper ID: 356

A Comprehensive Review of Machine Learning Approaches for Handling Class Imbalance in Credit Card Fraud Detection

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Abstract

Detecting fraudulent transactions has become a major concern in the financial services industry. With the rise of credit card fraud in daily online banking activities, banking systems face a significant risk of financial losses. Traditional machine learning–based fraud detection systems often struggle to identify fraudulent activities efficiently due to the minority-class imbalance problem. As highlighted in many research studies, when online transaction datasets are highly imbalanced, the detection performance declines because the models tend to focus more on legitimate transactions. In this research, the Synthetic Minority Over-Sampling Technique (SMOTE) is applied to balance the dataset by increasing the number of fraudulent transaction samples relative to legitimate transactions. The experimental results show how the accuracy and F1-score values behave when training is conducted on both imbalanced and balanced datasets using SMOTE. This work serves as a foundation for further research focused on improving fraud detection performance in highly imbalanced datasets.

Keywords: *Credit Card Frauds, SMOTE, Logistic Regression, Random Forest, XGBoost*

Paper ID: 358

A Deep Learning Approach for Papaya Disease, Pest and Maturity Identification via Mobile Imaging

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Abstract

Papaya farming remains a vital agricultural activity but continues to face persistent challenges such as disease outbreaks, pest infestations and difficulties in accurately determining fruit maturity, all of which contribute to reduced yield and market quality. This study introduces a deep learning–based mobile solution that integrates multiple architectures, including EfficientNetV2B0, Vision Transformers (Vi Ts), Convolutional Neural Network (CNN), DenseNet121 and MobileNetV2, to address these challenges. The system demonstrated strong performance across different tasks, EfficientNetV2B0 achieved 99.34% accuracy in distinguishing healthy and diseased leaves while ViTs reached 95.7 7% accuracy in identifying specific leaf diseases. For fruit disease detection, the Custom CNN attained nearly 99% accuracy in classifying healthy fruits alongside those affected by Ringspot Virus and Powdery Mildew. DenseNet121 showed high potential in pest detection, achieving near-perfect training accuracy, though further validation was recommended to ensure generalization. In maturity classification, the models achieved close to 100% accuracy overall with particularly strong results for unripe and ripe categories. However, partially ripe and rotten fruits presented challenges due to overlapping features. These findings underscore the effectiveness of hybrid deep learning strategies in enabling early disease detection, pest monitoring, and reliable maturity grading. By supporting timely interventions and minimizing post-harvest losses, the proposed mobile solution offers a cost-effective, real-time tool to enhance papaya yield and fruit quality.

Keywords: *Deep Learning, Vision Transformers, Mobile System, Convolutional Neural Network, Papaya Disease*

Paper ID: 457

Generative AI-Based Chatbot for Customer IT Support Automation

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Abstract

Enterprises are facing increasing challenges in delivering efficient, adaptive, and secure IT support, as traditional ticketing systems suffer from latency, rigidity, and limited scalability. Existing chatbot solutions built on commercial large language models (LLMs) often introduce high operational costs, token inefficiency, and data privacy concerns, while current retrieval and multiagent systems lack personalization, multimodal understanding, and dynamic adaptability. This research presents a generative AI–based IT support assistant that integrates four core innovations: a multi-agent architecture enabling distributed and scalable task execution; a retrieval augmented knowledge base enhanced with knowledge graphs and episodic memory for more accurate and personalized responses; conversational form automation using Rasa and transformer based models to extract structured ticket information from natural queries; and an interactive 3D avatar interface with real-time speech-to-text, text-to-speech, and emotion-aware multimodal interaction to support more human-like communication. The system was evaluated using RAGAS metrics to measure accuracy, contextual recall, and response faithfulness. Results show improved domain-specific performance, reduced reliance on manual ticket handling, and lower computational overhead through caching and adaptive slot filling. This study proposes a privacy-preserving, scalable enterprise IT support framework, with future work targeting multilingual support and deeper ITSM integration.

Keywords: *Generative Ai, Agentic Ai, Virtual Assistant Avatar, Conversational Ai, Retrieval Augmented Generation*

Paper ID: 475

EEG-Based Motor Imagery Signal Processing and Building a Classifier

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Abstract

Brain Computer Interfaces (BCIs) enables direct communication between human imaginations and computers. Motor imagery-based electroencephalography (EEG) is the most dominant for developing BCIs. Interpersonal variability, extracting features specific to a person and building classifier with a high accuracy is still a difficult task when building Motor Imagery based BCIs. In this work, two machine learning approaches discussed building an EEG Classifier with good accuracy. First, Raw EEG data are first pre-processed through bandpass filtering and power spectral density (PSD) analysis to reduce noise and extract relevant frequency components. Feature extraction is performed using techniques such as covariance analysis and Common Spatial Patterns (CSP), followed by dimensionality reduction and classification using Linear Discriminant Analysis (LDA). The system is trained and evaluated on multi-trial EEG recordings, and classification performance is assessed using accuracy and confusion matrix metrics. The proposed results validate using BCI competition III dataset 1. In second approach, GRU–CNN hybrid model effectively combines temporal and spatial feature extraction to classify EEG motor imagery signals with high accuracy using BCICIV_2a dataset. Through a structured preprocessing pipeline, optimized learning rate scheduling, and deep recurrent–convolutional architecture, the model achieved a test accuracy of 94.17%, demonstrating excellent generalization across multiple motor tasks. Experimental results highlight potential for imagined motor actions could be used to decode and display imagination as a text output in real time. The proposed method would be used further for developing a Mind-to-text communication system that translates motor imagination into textual commands using electroencephalography (EEG) signals.

Keywords: *Brain Computer Interfaces, Motor Imagery, Electroencephalography, Neural Decoding, Deep Learning*

A. Session 4 : Artificial Intelligence & Machine Learning

Paper ID: 72

Adaptive Video Game Content Generation Through Player Centered Modeling

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Abstract

This research introduces a novel, integrated AI system for Adaptive Video Game Content Generation Through Player Centered Modeling, designed to overcome the limitations of conventional static game mechanics by dynamically modifying gameplay elements (levels, quests, music, and enemy behavior) in real-time based on player biometric and behavioral data. Key contributions include the Personalized Quest Generation System, where the CatBoost model performed well in predicting player engagement, and shifting to the YOLO11X-CLS classification model substantially reduced computational lag for real-time emotional adaptation. For Level Generation, the implementation of a bootstrapping methodology during DCGAN training enabled continued refinement, resulting in lower Symmetry Error and Block Diversity Error, while the Intelligent Enemy Agent, trained using Dueling DQN, demonstrated a clear upward trend in Mean Rewards, successfully generalizing learned pursuit strategies to a real-time environment. Despite these successes, limitations include potential mild overfitting in the emotion recognition model, evidenced by a slight increase in validation loss after 20 epochs, and the CNN used for dynamic music adjustment struggled with low-resolution webcam inputs, leading to occasional minor misclassifications and slight delays in music transitions when multiple biometric parameters changed simultaneously.

Keywords: *Adaptive Gaming, Procedural Content Generation, Dynamic Music Adaptation, Customized Quests, AI-Driven Gameplay*

Paper ID: 264

A General Classification Framework for Detecting AI-Generated Voices

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Abstract

The rapid advancement of deepfake voice synthesis technologies has led to increasing misuse cases, including impersonation, misinformation, and fraud. Although artificial intelligence (AI)-generated voices offer legitimate benefits, their misuse poses growing cybersecurity threats. This paper presents a general classification framework for detecting AI-generated voices across Sinhala, Tamil, and English languages. Publicly available datasets for multilingual deepfake voice detection, particularly in low-resource languages such as Sinhala and Tamil, remain limited, with most existing models focused primarily on English. To address this gap, an acoustic dataset covering Sinhala, Tamil, and English was created using real voice samples either recorded or sourced from public datasets and synthetic samples generated through Text-to-Speech (TTS) and Voice Conversion (VC) techniques, including tools such as Google Translate and Resemble AI. A hybrid CNN–LSTM model was developed to classify voices as real or synthetic. Mel-Frequency Cepstral Coefficients (MFCCs) were extracted and fed into separate CNN-LSTM models trained for each language. The proposed system achieved over 95% test accuracy across all three languages, demonstrating robust cross-linguistic performance. The findings offer a foundation for scalable, AI-driven deepfake voice detection frameworks adaptable to diverse linguistic and regional contexts.

Keywords: *Audio Deepfake Detection, AI-generated Voice Detection, Artificial Intelligence, CNN-LSTM, MFCC*

Paper ID: 305

FalconEye: Real-Time Bird Detection and Tracking System for Aviation Safety

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Abstract

Bird strikes present a significant threat to aviation safety, leading to potential loss of life, operational disruptions, and substantial economic costs. Traditional detection methods, which primarily rely on human observation, suffer from limited accuracy and responsiveness, particularly in varying environmental conditions. To overcome these limitations, we propose FalconEye, an AI-powered system for real-time bird strike detection and risk assessment. The system integrates a YOLOv8-based bird detection model (75.5% precision) with deep learning models for weather prediction and bird size estimation. A Random Forest-based risk analysis module dynamically fuses these inputs to assess threat levels. Implemented with a Python Flask backend and a responsive web interface (HTML, CSS, Bootstrap, JavaScript), FalconEye provides an intuitive and scalable solution for enhancing aviation safety. The research study advances AI-driven bird strike prevention, paving the way for future improvements, such as multi-sensor fusion and species-specific recognition, to further enhance detection accuracy and predictive performance.

Keywords: *Bird Strike Prevention, Yolov8, Object Detection, Convolutional Neural Networks, Image Enhancements*

Paper ID: 364

Intelligent Traffic Signal Optimization Using Sound-Based Ambulance Detection and GreenLight Extension

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Abstract

Urban traffic congestion significantly hinders ambulance mobility, particularly at intersections where static signals restrict timely passage. This study presents a sound-based intelligent traffic signal optimization framework that integrates siren detection with adaptive green-light extension. The system utilizes IoT audio sensors with Mel-Frequency Cepstral Coefficient (MFCC) feature extraction and a Support Vector Machine (SVM) classifier, achieving 98% detection accuracy in distinguishing ambulance sirens from urban noise. Direction identification reached 96.3% accuracy, while distance estimation maintained an average error of 5.8 m. A novel dynamic greenlight timer, incorporating speed, distance, and error-correction metrics, reduced unnecessary signal holding by over 50%, lowering cross-traffic disruption from 5% to 2%. Field tests demonstrated sub-second latency and effective convoy handling for multiple ambulances. These results establish the framework as a lightweight, scalable, and cost-effective solution for real-time ambulance prioritization in resource-constrained urban environments.

Keywords: *Ambulance Prioritization, Sound-Based Detection, SVM, Green-Light Extension, Intelligent Traffic Management*

Paper ID: 375

Machine Learning-Based Framework for Predicting Vehicle Arrival Times in Public Transport

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Abstract

This paper presents a machine learning–based framework for predicting vehicle arrival times when the origin and destination are not fixed. Several models were developed and evaluated, including Linear Regression, Artificial Neural Networks (ANN), Long Short-Term Memory (LSTM), Decision Trees, and Random Forests. The dataset was constructed using data collected from public transportation in Sri Lankan routes at fixed intervals. Model performance was assessed using Mean Absolute Error (MAE). Among the models, Linear Regression exhibited the highest error, while Random Forest achieved the lowest error. The results demonstrate that the effectiveness of the models was directly influenced by both the data collection methodology and the choice of features. With further improvements in dataset quality and model design, the proposed framework has strong potential for practical deployment in applications where accurate vehicle arrival time prediction is critical, such as public transportation management and taxi services.

Keywords: *Machine Learning, Intelligent Transportation Systems (ITS), Vehicle Arrival Time Prediction, Public Transportation*

A. Session 5 : Computer Vision & Image Processing

Paper ID: 361

Vision-Based Temporal Classification of Correct and Incorrect Weightlifting Exercises

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Abstract

Proper posture during weightlifting exercises is essential for maximizing muscular gains, improving metabolic performance, and reducing injury risks. However, many fitness enthusiasts, particularly home-based users, lack access to professional supervision or reliable feedback. Existing approaches often rely on sensor-based systems that are costly, invasive, and prone to placement errors, despite their precision. Vision-based methods have been explored, but they frequently focus on static frame analysis, overlooking temporal dynamics and joint-specific corrections. This research proposes a vision-based system that analyzes exercise videos to assess weightlifting techniques using temporal motion analysis with Long Short-Term Memory (LSTM) networks. The study focuses on barbell biceps curls and triceps kickbacks, with input videos processed using Google's MediaPipe to extract joint landmarks, with joint angles computed using a rigid three-point algorithm. The features comprising landmark coordinates and derived angles are normalized into standardized joint angles and orientations before being fed into an LSTM model to capture motion evolution and classify correct versus incorrect form across video frames. The proposed system achieves classification accuracies of 94% for biceps curls and 96% for triceps kickbacks. A lightweight web application provides frame-by-frame feedback, highlighting deviations in movement patterns. Overall, this study presents a lightweight and precise system for analyzing dynamic movements, advancing intelligent digital coaching for safer, more effective weightlifting.

Keywords: *Weightlifting, Posture Identification, LSTM, MediaPipe, Temporal Motion Analysis*

Paper ID: 366

Optimizing Data Annotation Strategies for Overlapping Objects in AI-Based Waste Sorting Systems

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Abstract

Annotation techniques and object detection methods play a huge role in AI -based waste management systems, enabling efficient identification and classification of recyclable materials. However, challenges arise when objects overlap within images, potentially impacting detection accuracy. This study investigates the effect of overlapping objects on detection performance using a high -density polyethylene (HDPE) waste dataset. We employed the YOLOv8 model along with RetinaNet and Faster R -CNN for detection tasks. Datasets were prepared with varying Intersection over Union (IoU) values, and bounding box performance was first evaluated. The results revealed a notable accuracy difference between overlapping and non -overlapping datasets, achieving a mean Average Precision at IoU 0.5 (mAP50) of 0.935 for the overlap model and 0.994 for the non -overlap model. Additionally, polygon mask segmentation using the YOLOv8 - seg model and observed lower accuracy compared to bounding box-based detection. These findings highlight the sensitivity of AI waste detection systems to object overlap and the potential benefits of optimizing annotation strategies for improved performance.

Keywords: *Overlapping Objects, Occlusion Handling, YOLOv8, Faster R-CNN, RetinaNet*

Paper ID: 369

Machine Vision-Enabled Driver Safety and Monitoring System with Arduino for Real-Time Detection of Drowsiness and Drunkenness

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Abstract

Drunk and sleepy driving-related traffic accidents continue to be a leading cause of death worldwide. This project introduces a smart driver monitoring and safety system that combines drowsiness recognition and alcohol detection technologies to reduce such incidents. The system interfaces with an alcohol sensor (MQ-3), a buzzer, a relay, a motor, an LCD display with I2C, a switch, and an Arduino Uno microcontroller. The system simulates vehicle shutdown by turning off power to a prototype motor via a relay, triggering a buzzer alarm, and displaying the driver's blood alcohol content on the LCD screen when it surpasses a predetermined threshold. Concurrently, the driver's facial features are continuously observed by a Python-based eye monitoring system that makes use of a camera and the OpenCV library running on a host computer. This system performs the computationally intensive machine vision tasks. The Arduino Uno, acting as the embedded controller, receives a simple serial signal from the host system if it notices closed eyes for an extended amount of time. The Arduino then executes the safety protocol by turning off the motor and activating the buzzer once more. This two-pronged safety system lowers the chance of accidents by ensuring that the driver is attentive and sober while operating a motor vehicle. The project offers a real time, reasonably priced safety solution that can be integrated into contemporary smart cars.

Keywords: *Eye Tracking, Embedded System, Python-Based Detection System, Machine Vision*

Paper ID: 374

Object Detection Approach for Pure and Cross Chicken Breed Identification

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Abstract

The proposed system aims to identify different types of purebred and crossbred chicken breeds across ten categories. Traditional methods such as visual inspection are often subjective and inaccurate, making breed identification challenging. To address this, image processing and deep learning techniques were employed, with the YOLOv5 object detection algorithm trained on a custom data set of 1,310 images. The model achieved strong results, with an overall precision of 83.5%, recall of 81.8%, and 0.5 of 89.3%. The Class wise evaluation showed particularly high performance for the Brahma and Leghorn breeds. Based on these outcomes, a mobile application was designed to provide farmers with a fast, reliable, and cost-effective tool for breed identification. In addition to classification, the application provides detailed information on breed characteristics and commercial value, helping small-scale farmers improve productivity, efficiency, and animal welfare.

Keywords: *Purebred Chicken Breeds, Crossbred Chicken Breeds, Object Detection, YOLOv5, Image Processing*

B. Session 1 : Cybersecurity & Privacy

Paper ID: 180

Mobile Integrated Continuous Authentication & Verification Ecosystem

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Abstract

Continuous authentication in mobile devices is crucial for safeguarding sensitive personal and corporate data against increasingly sophisticated cyber threats. Traditional one-time authentication methods, such as passwords or PINs, are no longer sufficient due to their susceptibility to being easily compromised through various means such as phishing, brute force attacks, or simple human error. The problem lies in the static nature of these traditional methods which, once bypassed, provide unrestricted access to the device and its data until the next authentication cycle. This security gap can lead to significant breaches, data theft, and unauthorized access, causing financial losses, reputational damage, and privacy violations. Continuous authentication addresses this issue by constantly verifying the user's identity through behavioral biometrics, contextual information, and usage patterns, ensuring that the user remains authenticated throughout their interaction with the device. This dynamic approach not only enhances security but also improves user experience by reducing the need for frequent manual re-authentication. As mobile devices continue to be integral to both personal and professional spheres, incorporating continuous authentication mechanisms is essential for maintaining robust security postures and protecting sensitive information in an increasingly digital world.

Keywords: *Continuous Authentication, Mobile Security, Biometric Authentication, Machine Learning*

Paper ID: 274

IDPS for Targeted Attacks in VR Headsets: Chaperone, Inception, Human Joystick Attacks

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Abstract

Virtual reality (VR) is no longer an exclusive technology but a strong form of medium with application in gaming, medical training, therapy, business and military ventures to create a dawn of a new computer age. The spread of VR in the fields of entertainment, healthcare, education, and defense creates security threats that are alarming. The paper outlines and protects four key groups of VR-specific attacks that threaten both users with an injury and psychological manipulation and are aimed at attacking the senses and spatial awareness of the users. This paper proposes CSN Shield, a behavior-driven Intrusion Detection and Prevention System (IDPS) engineered to secure consumer-grade VR headsets against immersive perception attacks. The system is based on a signature-based, non-AI framework that provides real-time immersive threat detection while maintaining system performance and user experience.

Keywords: *Virtual Reality (VR), Intrusion Detection Prevention System (IDPS), Human Joystick Attack, Chaperone Attack, Inception Attack*

Paper ID: 304

Dual-Architecture URL Phishing Detection System: A Comprehensive Approach Using Lightweight Browser Extensions and Deep Analysis Models

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Abstract

URL Phishing attacks continue to grow in complexity, making it harder for traditional detection methods increasingly ineffective against modern attack vectors such as HTTPS-enabled phishing sites, advanced typo squatting, and brand impersonation techniques. This research presents a novel dual-architecture machine learning system that addresses the fundamental trade-off between detection accuracy and computational efficiency by implementing two specialized Random Forest classifiers optimized for distinct operational contexts: a lightweight browser extension model for real-time threat assessment with sub-second response times, and an ultra-comprehensive deep analysis model providing thorough investigation capabilities. Through systematic algorithm evaluation, we demonstrate the superiority of Random Forest classifiers over Gradient Boosting and XGBoost variants, particularly in mitigating systematic HTTPS bias that causes dangerous misclassification of encrypted phishing sites. Our iterative dataset refinement methodology reveals that quality-focused curation significantly outperforms large-scale datasets containing outdated attack patterns. Real-world validation confirms the system's practical effectiveness, enabling organizations to deploy specialized detection strategies based on operational requirements without compromising security effectiveness.

Keywords: *URL Phishing Detection, Machine Learning, Browser Security, Random Forest*

Paper ID: 328

Federated Learning for Detecting Anomalies in IoT-Driven Smart Home Systems

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Abstract

The rapid proliferation of Internet of Things (IoT) devices in smart home environments has amplified significant cybersecurity challenges due to their outdated firmware, limited computational resources, and weak protection mechanisms. Traditional centralized anomaly detection approaches are ineffective in these environments owing to single points of failure, privacy risks, and limited scalability. To address these challenges, this study proposes a novel federated learning framework that integrates a lightweight hybrid architecture combining 1D Convolutional Neural Networks (1D-CNN) with shallow autoencoders to support both supervised and unsupervised anomaly detection. The supervised component enables robust binary classification of known attack patterns, while the unsupervised reconstruction mechanism enhances detection of previously unseen anomalies, thus balancing accuracy with adaptability. Distinct from prior approaches, the proposed framework employs dynamic quantization within the federated learning process, enabling substantial reductions in resource consumption without compromising detection performance. Experiments conducted on the TON-IoT dataset, with SMOTE-based class balancing and PCA-driven dimensionality reduction, under a realistic non-IID distribution across three federated clients, demonstrate that the proposed model achieves 97.39% test accuracy. This model is designed for deployment on resource-constrained devices, employing post-training dynamic range quantization that reduces the model size by 81.5% (42.60 KB to 7.87 KB) without compromising accuracy. The experiment performed using Raspberry Pi 4 confirmed sub-millisecond inference and real-time responsiveness, validating the practical viability of the framework for efficient anomaly detection in smart IoT systems.

Keywords: *1D-CNN, Anomaly Detection, Autoencoder, Federated Learning, IoT Security*

B. Session 2 : Computing for Education and Digital Learning

Paper ID: 103

Gamified Deep Learning-Based Strategies for Supporting Speech and Motor Skill Development in Children with Autism

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Abstract

Autism Spectrum Disorder (ASD) is a neurodevelopmental disorder that affects day-to-day behavior. ASD presents challenges in developing speech, language, and motor skills, which require early intervention. This study proposes deep learning-based gamified techniques to support children with ASD through interactive learning experiences. The system consists of two modules, speech and language assessment and motor skills assessment, addressing both gross and fine motor development. Speech and language capabilities are assessed through analysis of lip patterns and phoneme alignment, using a hybrid model that combines 3D Convolutional Neural Networks (3DCNN) with Bidirectional Gated Recurrent Units (Bi-GRU), achieving an accuracy of 95%. Fine motor skills are evaluated through the identification of color patterns using a You Only Look Once (YOLO) model combined with geometric methods, achieving a precision of 98%. Gross motor skills are assessed through gesture recognition using Long Short Term Memory (LSTM) networks and angle-based heuristic techniques, achieving 90% accuracy.

Keywords: *Autism, Deep Learning, Speech, Motor Skills, Neural Networks*

Paper ID: 280

Profiling Industry 5.0 Readiness: A Machine Learning Approach to Student Soft Skills

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Abstract

Industry 5.0 emphasizes human-centric values, promoting collaboration between humans and intelligent technologies such as AI and robotics. Unlike its predecessor, which prioritized automation, Industry 5.0 values soft skills, emotional intelligence, adaptability, critical thinking, communication, and ethical awareness, as essential competencies. However, traditional education systems often underrepresent these capabilities. This study aims to analyze patterns in student soft skill development relevant to Industry 5.0 using unsupervised machine learning techniques. A structured questionnaire with 31 items was administered to 236 undergraduate computing students across Sri Lankan universities. The responses covered six key domains: Emotional Intelligence, Adaptability & Resilience, Creativity & Innovation, Critical Thinking & Ethical Awareness, Teamwork & Collaboration, and Digital Literacy & Human-AI Interaction. K-Means clustering, guided by the Elbow Method and enhanced with PCA, identified three distinct student groups: Highly Ready, Moderately Ready, and Needs Improvement. Descriptive and predictive analyses validated the coherence of these clusters and revealed dominant traits in each group. The study found that while some students show strong readiness for Industry 5.0, others lack balanced development across critical soft skill domains. These insights inform targeted educational strategies, including mentorship, experiential learning, and adaptive curricula. Additionally, the model supports real-time classification of new students, facilitating scalable and personalized interventions. The research contributes a data driven framework for aligning student development with evolving workforce needs and underscores the necessity of embedding soft skills into academic environments. Future directions include longitudinal tracking and integration of explainable AI to enhance transparency in educational decision-making.

Keywords: *Industry 5.0, Soft skills, Unsupervised machine learning, K-means clustering, Student skill profiling*

Paper ID: 298

Deep Learning Based Approach to Enhanced Recognition of Emotions and Behavioral Patterns of Autistic Children

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Abstract

Autism Spectrum Disorder (ASD) significantly influences the communication abilities, learning processes, behavior, and social interactions of people. Although early intervention and customized educational strategies are critical to improving outcomes, there is a pivotal gap in understanding and addressing nuanced behavioral patterns and emotional identification in autistic children prior to skill development. This extended research delves into the foundational step of recognizing and mapping these patterns as a prerequisite to improving learning and soft skills. Using a longitudinal approach to monitor emotions and behaviors, this study aims to establish a baseline understanding of the unique needs and challenges faced by autistic students, particularly in the Information Technology domain where opportunities are markedly limited. Through a detailed analysis of behavioral trends over time, we propose a targeted framework for developing applications and technical aids designed to meet these identified needs. Our research underscores the importance of a sequential and evidence-based intervention approach that prioritizes a deep understanding of each child's behavioral and emotional landscape as the basis for effective skill development. By shifting the focus toward early identification of behavioral patterns, we aim to foster a more inclusive and supportive learning environment that can significantly improve the educational and developmental trajectory of children with ASD.

Keywords: *CNN Image Classification, Image Processing and Computer Vision, Object Detection, Transfer Learning.*

Paper ID: 385

Perceptions and Adoption of Generative AI Tools Among Undergraduate Students: An Integrated UTAUT and Social Cognitive Theory Perspective

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Abstract

The rapid emergence of tools like ChatGPT and other generative AI (GenAI) applications has transformed higher education by providing new avenues for learning, collaboration, and academic support. This study investigates the perceptions, self-efficacy, and adoption of generative AI tools among undergraduate students at the University of Kelaniya. An integrated theoretical framework combining the Unified Theory of Acceptance and Use of Technology (UTAUT) and Social Cognitive Theory (SCT) was employed to examine how performance expectancy, effort expectancy, social influence, self-efficacy, social reinforcement, and facilitating conditions shape students' behavioral intentions to adopt AI tools. The study population comprised 14,500 undergraduate students from the University of Kelaniya, with a sample of 374 respondents. Data was collected via a structured questionnaire using a 5-point Likert scale. The results indicate that performance expectancy, effort expectancy, social influence, self-efficacy, and social reinforcement significantly predict students' behavioral intentions to use GenAI tools, whereas facilitating conditions were not significant, suggesting that students currently lack adequate support, guidance, and resources to use AI tools effectively for academic work. These findings highlight the need for institutional guidelines, training programs, and support mechanisms to promote responsible and effective use of GenAI tools in higher education, while fostering essential skills such as critical thinking, creativity, and academic integrity.

Keywords: *Generative AI, Technology Adoption, Perception, Self-efficacy, Higher Education*

B. Session 3 : Artificial Intelligence & Machine Learning

Paper ID: 302

AI Powered Context Aware Emergency Sound Recognition System for Enhancing Situational Awareness in Hearing Impaired Individuals

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Abstract

Individuals with hearing impairments face significant safety challenges in detecting critical environmental sounds such as emergency sirens, vehicle accidents, and gunshots, which are essential for situational awareness and personal safety. This paper presents a novel Context-Aware Emergency Sound Recognition System that addresses existing limitations in assistive audio technology by integrating emergency sound classification with environmental context analysis. The proposed system employs two complementary deep learning models. First, an Emergency Sound Detection Model utilizing Convolutional Neural Networks trained on Mel Spectrograms to classify five emergency sound categories with 94% accuracy, and an Environment Identification Model leveraging YAMNet transfer learning to classify user environments with 89% accuracy. A risk assessment matrix integrates outputs from both models to provide context-aware risk level determination based on emergency sound type and environmental context. Unlike existing systems that provide generic alerts, the proposed framework delivers personalized feedback through text and American Sign Language video alerts, considering the severity of the detected emergency relative to the user's location. Experimental results demonstrate superior performance compared to traditional approaches. The system addresses critical gaps in current assistive technologies by providing differentiated emergency sound classification, environmental context integration, and risk-aware alerting, contributing to enhanced safety and independence for hearing-impaired individuals.

Keywords: *Emergency Sound Detection, Hearing Impairment, Assistive Technology, Convolutional Neural Networks, Situational Awareness*

Paper ID: 373

PharmaMap-LLM: Fine-Tuning Large Language Models for DrugDrug Interaction (DDI) Analysis

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Abstract

Adverse Drug-Drug Interactions (DDIs) pose a critical challenge under polypharmacy. Traditional methods (rules, classical ML) struggle with scale and novelty in free-text literature. The proposed framework PHARMAMAP–LLM a DDI extraction framework that instruction-tunes a biomedical LLM via QLoRA for memory-efficient domain adaptation on a single RTX 3090. The system uses an agentic flow: a Predictor (MedLLaMA-3-8B) with two Validators and a clinician-facing Risk agent so that predictions, confidence, and rationales are cross-checked for explainability. Training leverages the DDIExtraction 2013 corpus and an instruction dataset derived from DrugBank pairs ($\sim$20,000), with entity normalization (SciBERT tokenizer). The work reports hardware and training arguments (learning rate, LoRA ranks, batch/sequence sizes) to support reproducibility. On DDIExtraction 2013, PHARMAMAP–LLM attains F1 (0.87), Precision (0.89), and Recall (0.85), surpassing prior text-mining baselines. Human evaluation by a clinical pharmacologist (200 cases) rated 83% of responses as accurate or better (mean 4.2/5); an LLM-as-judge audit (GPT-4, 2,000 outputs) found 92.3% correctness. Against GPT-4o on 500 shared prompts, validity was similar; the difference was not significant by McNemar's$\chi 2$(continuity-corrected),$p \approx 0.40$. Brief error analysis highlights under-detection of pharmacodynamic patterns and missing dose/time qualifiers, which inform our mitigation strategy (PD-focused exemplars, retrieval of threshold cues, calibrated confidence). Overall, the proposed system achieves an explainable, reproducible, and deployment friendly DDI tool for clinical decision support.

Keywords: *Drug–drug Interaction, Large Language Model, QLoRA, Biomedical NLP, Explainable AI*

Paper ID: 421

AI Enabled IoT Architecture for Remote Cardiac Monitoring: Deep Learning Driven Arrhythmia Detection and Telemedicine Deployment in Rural Sri Lanka

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Abstract

Despite the fact that cardiac arrhythmias are the greatest cause of preventable morbidity, rural populations in Sri Lanka do not have access to timely diagnosis. In this study, an Internet of Things (IoT) and artificial intelligence framework is presented. This framework enables continuous remote cardiac monitoring and arrhythmia diagnosis through the utilization of wearable sensors, a mobile gateway, and cloud-based analytics. Heartbeats are classified by the suggested system, which makes use of lightweight deep learning models (recurrent and convolutional neural networks) that have been trained using electrocardiogram (ECG) data. This method also notifies clinicians of aberrant rhythms. Experiments conducted in the field have shown that a quantized Long Short-Term Memory (LSTM) recurrent neural network achieves an accuracy of 92.75%, which is very near to the accuracy of a deeper convolutional model (95.6%) while utilizing almost half of the memory. In this article, deployment factors such as intermittent connectivity, data protection, and user literacy are explored, and a plan for implementing telemedicine services across the rural regions of Sri Lanka is described.

Keywords: *Internet Of Things, Arrhythmia Detection, Deep Learning, Wearable Sensors, Rural Healthcare*

Paper ID: 468

Data-Driven Injury-Risk Prediction in Competitive Swimming using Convolutional Neural Networks

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Abstract

Recent advancements in computer vision and machine learning have improved real-time human motion analysis surpassing conventional biomechanical studies by focusing on sports accessibility and movement improvement. This paper presents SwimSight, a mobile application designed to identify injury-prone movements in swimming techniques and provide personalized prevention recommendations. The system consists of three primary stages, which are video processing and pose estimation, joint-angle analysis, and injury-risk prediction. The preprocessing stage enhances video quality through frame stabilization utilizing OpenCV based filters, conventional computer vision technique. Pose estimation is executed through a marker less pipeline built on modern 2D pose estimators, that extract stable 2D key-points to convert them into joint angles. An ensemble of 1D-CNN and 2D-CNN deep learning models is applied to predict identify risky shoulder and knee (the most common injury areas) movements with improved generalization. The system further integrates movement clustering to tailor recommendations. Through this pipeline, SwimSight delivers a robust and user-friendly solution that advances performance by injury prevention in aquatic sports.

Keywords: *Swimming Biomechanics, Deep Learning, Pose Estimation, Computer Vision, Injury Risk Prediction*

Paper ID: 485

Deep Ensemble Model for Fine-Grained Breast Tumor Classification Across Multi-Magnification Samples

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Abstract

Breast cancer is a type of malignant tumor that originates in the cells of the breast tissue. Breast cancer remains one of the leading causes of cancer-related mortality among women worldwide, and histopathological analysis plays a crucial role in its diagnosis and subtyping. Despite advancements in automated classification, the heterogeneity of tissue morphology across varying magnification levels remains a challenge to conventional deep learning approaches. In this study, we present a robust and interpretable multiclass classification framework for breast cancer tumor subtypes using the Breast Cancer Histopathological Image Classification (BreaKHis) dataset. To address the challenges of tissue heterogeneity, we introduce a novel ensemble architecture that integrates complementary features extracted from three state-of-the-art Convolutional Neural Networks (CNNs) (ResNet50, VGG16, and EfficientNet-B0) via an adaptive fusion strategy. The proposed model demonstrates superior generalization across all four magnification levels (40×, 100×, 200×, and 400×), achieving an average classification accuracy of 99.4%, a macro-averaged F1-score of 97.2% and low inter-fold variance, validated through stratified 5-fold cross-validation. This comprehensive pipeline not only outperforms several state-of-the art and baseline models but also advances explainable neural networks in histopathology, offering a transparent and reliable computational proof of concept for future decision-support tools in precision oncology.

Keywords: *Breast Cancer Classification, Ensemble Learning, Convolutional Neural Networks, Deep Learning*

B. Session 4 : Artificial Intelligence & Machine Learning

Paper ID: 368

Development of EEG Acquisition Device for Human Stress Level Monitoring and Analysis

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Abstract

Stress and depression pose significant mental health challenges, often misdiagnosed due to somatic symptoms masking psychological causes, leading to suboptimal treatment in outpatient settings. Traditional subjective assessments, such as self-reporting scales, lack precision for real-time monitoring. This paper presents a low-cost (~$50 USD) wearable EEG acquisition device for objective, real-time stress level monitoring and analysis, integrating custom PCB hardware with a pretrained EEG foundation model (EEGPT) for edge deployment in resource-limited contexts like Sri Lanka. Validated against clinical-grade EEG (Nihon Kohden), the device captures multichannel signals using dry electrodes and the 10-20 system. Data from 100 participants (50 high stress, 50 controls) in dual settings (hospital/university) were preprocessed via bandpass filtering and ICA, with PSD features classified using EEGPT (89.5% accuracy, F1=0.89, AU C=0.94). Preliminary schizophrenia exploration (n=100) achieved 68% cross-dataset accuracy postprocessing, highlighting generalizability challenges mitigated by standardized pipelines and transfer learning. The React-Node.js GUI enables live visualization and neurofeedback (<1s latency). This innovation outperforms baselines (75-78% accuracy) by 11-14% i n affordability and portability, reducing misdiagnosis potential by 30% in full pilots and advancing accessible mental health diagnostics.

Keywords: *EEG, Stress Detection, Wearable Technology, Machine Learning, Mental Health*

Paper ID: 453

Personalized AI System for Maternal Nutrition and Exercise

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Abstract

This work presents a personalized AI system for maternal wellness that generates two coordinated, daily outputs for pregnant users: culturally adapted meal plans and risk aware exercise prescriptions. In its nutrition module, the combination of a library of curated local dishes and trimester specific energy corridors with condition-aware rules (diabetes/gestational diabetes, anemia, hypertension, allergies) highlights iron, folate, protein, and calcium instead of full nutrient panels. The exercise module comprises a rules-first risk screen (Low/High) corroborated by a calibrated gradient-boosted classifier, followed by a template-based planner that renders day-level sessions with safety guardrails, trimester adaptations, and video guidance. Evaluation on de-identified datasets (2,000 meal profiles; 970 risk records; 1,934 exercise prescriptions) showed high nutritional adequacy and reliable safety enforcement: daily energy corridors were met on 94.7% of days and ≥ 3/4 essential nutrients on 91.3%, with 0 allergen violations. The risk classifier achieved AUROC 0.86, accuracy 0.82, sensitivity 0.79, and specificity 0.84. The exercise recommender successfully enforced trimester and risk-based guardrails, with all plans passing safety checks. These findings, from a study focused on Sri Lanka, suggest that an integrated, objective and culturally based method can provide personalized, safe guidance daily in resource-constrained environments, and serve as a basis for future clinical validation and predictive modeling.

Keywords: *Maternal Health, Pregnancy, Nutrition, Exercise Prescription, Personalization*

Paper ID: 462

Automated Mitosis Grading in Histopathology Images using YOLO with Customized Squeeze and Excitation and Spatial Attention

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Abstract

Mitosis detection in histopathological images is a critical task in automated cancer grading, as the density of mitotic figures strongly correlates with tumor proliferation and prognosis. Accurate mitotic counting plays a vital role in tumor grading, influencing clinical decision-making and treatment strategies. However, manual assessment is highly subjective, time-consuming, and prone to inter-rater variability, limiting its prognostic reliability. While deep learning methods have shown promise in aiding pathologists, their performance often degrades when applied across different clinical settings. This study presents an optimized YOLO-based framework for mitosis detection, emphasizing computational efficiency and potential robustness for real-world pathology workflows. Specifically, YOLOv8 detectors are fine-tuned on annotated histopathology images with extensive data augmentation and preprocessing to enhance accuracy and generalizability. We chose to implement the Squeeze-and-Excitation (SE) block combined with spatial attention (SA) dynamically in the YOLOv8 architecture rather than statically embedding it in the model design, allowing the network to adaptively recalibrate features across the backbone, neck, and head at multiple stages of representation. Evaluated on publicly available annotated histopathology datasets (Roboflow-V2), the proposed attention-enhanced YOLOv8-based approach achieved an F1-score of 90%, recall of 91%, precision of 100%, and mean average precision of 93% for the evaluated test set, surpassing existing deep learning benchmarks. By automating mitotic figure identification, this method reduces human error, alleviates the workload of pathologists, and enhances the consistency of tumor grading, making it a promising candidate for integration into routine pathology practice.

Keywords: *Breast Cancer Grading, Deep Learning, Histopathology Images, Mitosis Detection, SE+SA Block*

Paper ID: 469

Data-Privacy Based Federated Learning Framework for Industrial IOT

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Abstract

This paper explores the use of Federated Learning (FL) in the context of Industrial IoT (IIoT) with a focus on enhancing data privacy and cybersecurity. It presents a novel approach to secure communication, protocol enforcement in clients and the server, and attack detection and resilience, Scenario based protocols to ensure the global model quality. Techniques like Differential Privacy (DP), Homomorphic Encryption (HE), and Secure Aggregation are applied to protect data privacy and defend against attacks, including Model Poisoning and Byzantine Attacks. Furthermore, the paper investigates the integration of Edge Computing and Distributed Machine Learning to improve the resilience and efficiency of IIoT systems.

Keywords: *Federated Learning, Industrial Iot, Data Privacy, Threat Detection*

B. Session 5 : Computer Vision & Image Processing

Paper ID: 107

Ayur Prakrithi: A Deep Learning-Based Prakrurthi Diagnostic Tool for Ayurvedic Medicine Students and Practitioners

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Abstract

Ayurveda is one of the world's oldest holistic philosophies, focusing on physical, mental, and spiritual wellbeing. It is based on five fundamental elements: ether, fire, water, earth, and air. These elements combine to form three vital energies called doshas: Vata, Pitta, and Kapha. Every individual has a unique combination of these doshas, known as Prakurthi, which defines their physical, mental, and physiological characteristics. Understanding Prakurthi is essential in Ayurveda, as it guides personalized treatments and lifestyle choices to maintain balance and health. Traditionally, identifying Prakurthi involves visual inspection, pulse diagnosis, and interviews, it requires a long period of time for the analysis of the characteristics and expert skills. This research aims to classify the Prakurthi type of the human body based on the biomatrix image analysis by using a convolutional neural network. The proposed solution consists of a mobile application, and the classification is based on the different biometric characteristics, namely face, eye, hair, and nail. First, it classifies the Prakurthi type for each bio-matrix feature, and then, it provides the overall full-body Prakriti type of the human by analyzing all individual bio-matrix characteristics. Additionally, it includes Face mapping according to Traditional Chinese Medicine, Facial micro-expression analysis for emotion detection, and Blink rate to evaluate stress levels of the human body. Furthermore, it evaluates hair texture and hair loss patterns for Alopecia identification and measures Capillary refill time to assess circulatory health.

Keywords: *Ayurvedic Medicine, Prakurthi Analysis, Deep Learning, Convolution Neural Networks, Image Processing*

Paper ID: 136

Eye Health Monitoring and Eye Care System

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Abstract

This study presents a multi-modal AI-powered system designed for real-time eye health monitoring and early diagnosis. The proposed system integrates computer vision, machine learning, and image processing techniques to deliver non-invasive and accessible diagnostic solutions. The system comprises four key modules. The first one is a real-time eye exercise module that utilizes webcam-based eye tracking and adaptive machine learning to provide personalized routines for reducing digital eye fatigue. The second module is an AI-driven cataract detection module that analyzes retinal images to enable early diagnosis, particularly in resource-limited settings. The third module is a glaucoma detection system that tracks pupil dynamics, such as size and light reactivity, to identify early symptoms; and the fourth and final module is a color blindness and eye fatigue detection module that employs multi-modal AI techniques to assess color vision deficiencies and monitor signs of visual fatigue in real-time Collectively, these components form a comprehensive array of tools focused on improving eye health monitoring and treatment. Through the combination of advanced AI technologies with user-friendly interfaces, the proposed systems aim to democratize access to eye care, reduce the global burden of preventable vision loss, and enhance the quality of life for individuals everywhere.

Keywords: *Real-time Eye Exercises, Cataract Detection, Glaucoma Detection, Eye Fatigue Detection AI-driven Diagnostics*

Paper ID: 413

Computer-Vision-Based Multipurpose Artificial Intelligence Assistant for Smart Refrigerators

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Abstract

This study provides a detailed breakdown of the development stages involved in designing an Artificial Intelligence (AI) assistant for object detection in smart refrigerators, with capabilities for inventory management and calorie consumption tracking. A structured methodology consists of incremental and risk -driven development strategies, followed by two different approaches — accuracy and efficiency, which are evaluated based on detection outcomes and the tools and techniques used for each functionality of the application. In addition to the primary objectives, fundamental Artificial Intelligence tools and techniques were also tested with an advanced CNN model (VGG16) to evaluate the overall performance of the application. Decisions made using these approaches were supported by the findings of a comprehensive literature review conducted at the initial stage of this study. During the experiments, some attempts were made to address the identified gaps in existing works on this research field. The mean Average Precision (mAP) of the final candidate model was recorded as 97.19%.

Keywords: *Computer Vision, Object Detection, Sliding Window, Selective Search, Support Vector Machine (SVM)*

Paper ID: 434

MotionMetrics: A Hybrid Stereo Marker and Markerless System for Cost-Effective 3D Sports Biomechanics

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Abstract

Sports biomechanics analysis is essential for performance optimization, injury prevention, and rehabilitation, yet current motion capture systems face accessibility issues due to high costs, complex installation, and specialized expertise requirements. This paper introduces MotionMetrics, a cost-effective 3D sports biomechanics system employing stereo vision that combines markerless and marker-based motion capture using synchronized, calibrated cameras. The system allows flexible configuration to optimize accuracy and reduce cost based on application needs. Markerless detection leverages MediaPipe's pose estimation for 33 anatomical landmarks, while marker-based tracking uses green spherical markers on 14 major anatomical landmarks with MediaPipe fallback during occlusions. The technical pipeline incorporates automated human detection, Hue– Saturation–Value (HSV) -based marker recognition, stereo camera calibration, lens distortion correction, and 3D triangulation. A comprehensive biomechanics analyzer processes raw 3D coordinates through automated joint angle computation, bilateral symmetry assessment, and temporal kinematic profiling, generating standardized PDF reports with 3D visualizations, progression charts, and quantitative statistics. Comparative gait analysis demonstrates the system's ability to detect compensatory movement strategies through differential standard deviation patterns, providing objective clinical evidence. MotionMetrics bridges the gap between high-cost professional equipment and low-accuracy alternatives, offering a democratized solution for educational institutions, research facilities, community sports organizations, and rehabilitation clinics.

Keywords: *Biomechanics, Synchronization, Rehabilitation, Gait, Calibration*

C. Session 1 : Cloud , Quantum and Communication Technologies

Paper ID: 270

Evaluating Performance and User Perceptions of Multi-Cloud Database-as-a-Service Solutions: A Mixed-Methods Study

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Abstract

Multi-cloud adoption has accelerated the use of managed Database-as-a-Service (DBaaS) platforms, yet limited research provides provider-agnostic, empirical insight into how performance, scalability, and cost differ across vendors or how these objective outcomes align with practitioner perceptions. This paper presents a mixed-methods evaluation of three major cloud database platforms: Amazon RDS, Azure SQL Database, and Google Cloud SQL. Quantitative benchmarking experiments were conducted using identical workloads on the bench ANT framework to measure latency, throughput, and scalability, while a parallel survey collected perception data from academic lecturers, IT employees, and undergraduates. The study's novelty lies in triangulating benchmark results with user perceptions to reveal alignment gaps. Empirical findings show that AWS RDS and Google Cloud SQL deliver strong horizontal scalability, while Azure SQL favors vertical scaling but exhibits higher latency. A moderate correlation (r= 0.62) was found between perceived performance and measured throughput, but perceived reliability showed a weaker relationship to actual latency (r= 0.34), indicating notable perception divergences. Cost analysis further highlights trade-offs involving egress fees, storage tiers, and replica placement. The results provide actionable guidance for workload placement, elasticity planning, and multi-cloud governance, and demonstrate the value of a mixed methods approach for evaluating cloud database services.

Keywords: *Multi-Cloud, DBaaS, Benchmarking, Performance Evaluation, Mixed-Methods*

Paper ID: 460

From NISQ to Scalable Architectures: Challenges and Prospects for Practical Quantum Computing

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Abstract

Quantum computing has progressed from early demonstrations across superconducting, trapped ion, photonic, and spin-based platforms to increasingly integrated systems. However, transitioning from the noisy intermediate-scale quantum (NISQ) era to robust, fault tolerant implementations remain a central challenge. This paper presents a systematic review and synthesis of practical quantum computing, encompassing experimental advances, integrated photonics, error correction breakthroughs, software stack evolution, benchmarking practices, algorithmic readiness, and socio technical dimensions. We critically assess current limitations and highlight emerging directions, including integrated photonic modules with high fidelity interconnects, real time decoders for surface code logical qubits, and hardware aware compiler strategies. Our analysis is grounded in peer-reviewed experimental data and model-based evaluations. Key findings include demonstrated logical error suppression via increased code distance, scalable photonic module prototypes, and refined resource estimates for cryptanalytic and simulation tasks. This paper concludes with a structured research agenda for 2025 2030, proposing four priority thrusts such as hardware QEC co design, reproducible cross platform benchmarking, modular/distributed architectures, and quantum networking with governance frameworks. This evidence-based roadmap aims to align researchers and practitioners toward actionable milestones on the path to practical quantum computing.

Keywords: *Quantum Computing, Error Correction, Fault Tolerance, Benchmarking, Quantum Internet*

Paper ID: 481

Fidelity-Driven Physically Constrained Adaptive Code Distance for Surface Codes under Biased Circuit-Level Noise

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Abstract

Surface codes are leading candidates for fault tolerant quantum computing, but conventional implementations use fixed code distances that result in conservative resource allocation during varying noise conditions. We propose a physically constrained, fidelity-driven adaptive surface code framework that dynamically adjusts code distance at scheduled intervals to main tain target logical fidelity while minimizing resource overhead. Our approach introduces a syndrome-based logical error rate estimation algorithm using rolling-window statistics, a scheduled adaptation policy operating within pre-allocated qubit pools, and detailed modeling of adaptation latency and reconfiguration induced errors for superconducting qubit devices. Through large scale Monte Carlo simulations under realistic biased circuit-level noise, we demonstrate that hardware-constrained adaptive codes achieve 43-62% success rate improvements over fixed-distance strategies, reaching 72-82% success rates compared to ˜50% for fixed approaches. Oracle adaptive strategies with perfect error knowledge achieve 91-94% success rates, indicating substantial theoretical potential. Our results show that adaptive surface codes provide significant performance improvements even under realistic hardware constraints, with oracle strategies consuming only 37% of maximum resources while achieving 86% higher success rates for shorter circuits.

Keywords: *Quantum Error Correction, Surface Codes, Adaptive Code Distance, Fault-Tolerant Quantum Computing, Syndrome Decoding*

Paper ID: 466

Resilience-Aware Minimum Dominating Set Selection: A Novel Approach for Cost-Effective and Resilient Network Design

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Abstract

Networks are ubiquitous in the modern world and appear across a wide range of domains such as power grids, the internet, roads and subways. Ensuring their resilience is crucial, especially for critical infrastructure. This research addresses the gap in building a resilient network from the ground up by selecting a Minimum Dominating Set (MDS) of nodes to form a network backbone that maximizes structural resilience while minimizing resource usage. A novel metric, the Global Resilience Index (GRI), is introduced to measure this resilience. The methodology is validated across Watts-Strogatz, Erdos-Renyi, and Barabasi-Albert network models using a multi-metric analysis, including efficiency, algebraic connectivity, and giant component behavior. For large networks where finding an exact MDS is computationally infeasible, an efficient approximation method (Order-Based Randomized Local Search) is employed and shown to produce networks with high cost-resilience ratios. The results confirm that the proposed GRI and cost-resilience ratio are effective tools for designing resource-efficient and highly resilient network infrastructures.

Keywords: *Network Resilience, Minimum Dominating Set, Graph Theory, Global Resilience Index*

Paper ID: 401

Secrecy Rate Performance Evaluation for Next-Generation Wireless Networks

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Abstract

Secrecy rate optimization has emerged as a critical aspect of secure wireless communications to ensure confidential data exchange in the presence of eavesdroppers. However, increasing reliance on wireless technologies has also raised concerns about security and privacy. This paper demonstrates an analysis of secrecy performance through SNR and channel capacity, including the derivation of closed-form expressions and SOP under various channel conditions. The study assumes a uniform distribution for the location of the eavesdroppers, reflecting realistic interception scenarios. The calculated SOP serves as a crucial indicator of the likelihood that the secrecy rate drops below a secure threshold, thus highlighting potential vulnerabilities. To validate the analytical results, extensive simulations are conducted that demonstrate the accuracy and effectiveness of the derived expressions in different wireless environments. The findings underscore the importance of secrecy rate analysis in the design of secure wireless systems, providing valuable insights for optimizing information transmission while protecting against eavesdropping threats.

Keywords: *Secrecy Rate Optimization, Outage Probability, Secure Wireless Communications, SNR, Eavesdropper*

C. Session 2 : Software Engineering & DevOps

Paper ID: 4125

A Scalable Microkernel Inspired Architecture for Transparent and Adaptive Supply Chain Management

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Abstract

Supply Chain Management (SCM) in industries such as coconut peat production increasingly demands systems that are not only efficient but also transparent and adaptable to rapid changes. Traditional monolithic architectures often fail to scale effectively and struggle to integrate emerging technologies such as IoT and blockchain, limiting their usefulness in dynamic environments. To address these limitations, this research proposes a microkernel-inspired architecture tailored for SCM. The architecture separates core system functions from domainspecific processes through the use of dynamically loadable plugins, allowing for modularity, fault isolation, and real-time adaptability. The impact of this study lies in its integration of multiple technologies to enhance transparency and operational flexibility. The system incorporates IoT sensors for real-time data acquisition, blockchain for immutable traceability, gRPC for high-performance communication, and K3S for lightweight container orchestration. A workflow customization tool allows non-technical users to define or modify supply chain processes without altering core logic. We employed the Architectural Trade-off Analysis Method (ATAM) and Cost-Benefit Analysis Method (CBAM) to evaluate architectural decisions and conducted runtime performance testing using simulated workloads. Results showed improved scalability, flexibility, and fault tolerance, with moderate latency introduced by inter-process communication and CGo overhead. Despite some limitations in performance variability, the architecture maintained high availability and was able to recover from plugin failures seamlessly. These findings suggest that the proposed model provides a viable foundation for next-generation SCM systems. The contributions include a modular, resilient framework that effectively integrates advanced technologies to support adaptable and transparent supply chain operations across various industries.

Keywords: *Microkernel Architecture, Supply Chain Management (SCM), Blockchain, IoT, Modular Systems*

Paper ID: 132

Agile User Story Builder: Transforming Real-Time User Requirement Conversations into Structured Agile User Stories

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Abstract

Agile software development methodologies rely heavily on well-structured user stories to bridge technical and business requirements. However, the traditional manual process of converting stakeholder conversations into structured user stories presents significant challenges including transcription errors, communication ambiguity, and inefficient processing. This research presents an automated Agile User Story Builder system that transforms requirement conversations into well-structured user stories. The system integrates cloud speech recognition, Natural Language Processing (NLP), machine learning, and Retrieval-Augmented Generation (RAG) for automated requirement processing within a microservices architecture. The system was developed using synthesized audio from 1,247 SRS documents (achieving 78% transcription accuracy) and validated on 75 real stakeholder conversations. Real-world validation demonstrates 68% speech to-text accuracy (95% CI: 64–72%), 82% task classification precision, 73% reduction in manual documentation effort, and 86% format compliance in generated stories. The system achieves 20% timeline and 62% budget prediction improvement while providing measurable benefits including enhanced collaboration and streamlined Agile workflow efficiency.

Keywords: *Agile Project Management, Automation, Machine Learning, Requirements Engineering, User Story Generation*

Paper ID: 171

Optimizing Gas Efficiency in Ethereum Smart Contracts using Design Pattern Refinement and Complexity Reduction

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Abstract

Smart contracts on the Ethereum blockchain enable automation and transparency in decentralized applications; however, their scalability is often constrained by high gas costs resulting from inefficient code design. This research investigates the relationship between cyclomatic code complexity and gas consumption, proposing a design pattern-based approach to optimize gas efficiency in Ethereum smart contracts. Three common Solidity patterns Factory, Registry, and State Machine were optimized using both existing and novel techniques, including variable packing, the use of fixed-size data types (uint256, bytes32), immutable variables, and mapping simplification. These optimizations were implemented and tested within a real-world coco peat supply chain management system to measure their impact on gas usage. Experimental results showed that deployment gas costs decreased by approximately 19% and runtime execution gas by around 14%, confirming that design-level optimization can significantly reduce costs without affecting functionality. The findings demonstrate that structured refinement of contract design can enhance scalability, making blockchain-based enterprise solutions more efficient and economically sustainable.

Keywords: *Blockchain, Solidity Design Patterns, Ethereum Smart Contracts, SCM, Gas Fee Optimization*

Paper ID: 354

Context-Aware Incremental Learning Pipeline Triggers

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Abstract

Modern Continuous Integration/Continuous Delivery pipelines require intelligent and adaptive learning mechanisms to enhance software deployment stability and efficiency. While previous studies have introduced Pull Request prioritization techniques and predictive models for build failures, they do not offer real-time recommendations based on Pull Request criticality and build stability. This research presents a GitHub app based on reinforcement learning for intelligent Pull Request prioritization and deployment advisory in Continuous Integration/Continuous Delivery workflows. The system combines natural language processing with contextual features to dynamically determine whether a Pull Request should be prioritized for early deployment or flagged for urgent review based on its priority level and associated build failure risk. Due to limited labeled feedback data, the study employs a hybrid approach using supervised learning for initial classification, enhanced by reinforcement learning for continuous adaptation. Using a dataset of 682148 Pull Requests from 28835 repositories, experimental results demonstrate significant improvements in deployment efficiency, achieving 92.01% accuracy in Pull Request classification with strong developer alignment. This research presents a comprehensive solution for optimizing Continuous Integration/Continuous Delivery pipelines through intelligent Pull Request prioritization with deployment advisory.

Keywords: *Continuous Integration/Continuous Delivery, Pull Request Prioritization, Build Failures, Deployment Schedules, Reinforcement Learning*

Paper ID: 474

Adapting Microlearning for Personalized Study Journeys: CLT-BLM Guided Video Shorts with AI-Driven Re-Authoring

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Abstract

Modern learners favor short-form media, traditional long-form lectures result in low retention rates and reduced motivation. Popularity of platforms such as YouTube Shorts, Instagram Reels, and TikTok demonstrates a shift toward bite-sized content, positioning microlearning as timely and relevant. This research introduces an Intelligent Microlearning Web Application that enhances learning through three components: (i) an adaptive diagnostic that estimates learner level and topic preferences, (ii) a recommender that identifies YouTube resources using transcript-level analysis, and (iii) a Micro Video Component that automatically composes 2–6 minute cognitively structured shorts. Grounded in Cognitive Load Theory (CLT) and implemented through the CLT-Based Lecture Model (CLT-BLM), each micro-video follows a four-phase cycle (Prepare, Initiate, Deliver, End), ensuring reduced extraneous load, improved retention, and pedagogical coherence. Evaluation with 60 undergraduates showed learners using microlearning shorts achieved 15% higher immediate retention, 25% higher delayed recall, and 87% engagement versus 52% for traditional videos, with system usability scoring 82.1. This work contributes: (1) a scalable pipeline transforming open-web videos into personalized, Bloom-aligned microlearning shorts, (2) a methodology integrating cognitive science with AI-driven automation, and (3) empirical evidence that shorts significantly enhance retention and engagement while complementing long form study.

Keywords: *Microlearning, Cognitive Load Theory, CLT-BLM, Bloom's Taxonomy, Personalized Learning*

C. Session 3 : Cybersecurity & Privacy

Paper ID: 124

An Approach to Detect Advanced Persistent Threats using Machine Learning Techniques

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Abstract

Advanced Persistent Threats (APTs) pose significant risks to organizations due to their stealthy, prolonged nature and their ability to evade traditional detection mechanisms. Conventional solutions often analyze isolated data elements, such as network traffic or endpoint activity, which limits their effectiveness against sophisticated APT campaigns. This research, however, proposes a holistic, machine learning-driven approach to detect APTs by integrating three critical data dimensions: user behavior anomalies, endpoint activity monitoring, and network traffic analysis. The system further incorporates Tactics, Techniques, and Procedures (TTP) analysis using the MITRE ATT&CK framework to generate actionable intelligence. As the final output, a real-time dashboard is developed to visualize detection results, TTP mappings, and corresponding mitigation strategies, enabling cybersecurity teams to respond proactively. This integration of multiple ML models that are trained on both synthetic and publicly available datasets enhances detection accuracy while bridging the gap between threat identification and contextual understanding. The results demonstrate the system's capability to detect APT indicators across diverse attack vectors and effectively prioritize high-risk TTPs.

Keywords: *APT, ML, TTP, Machine Learning, Supervised Learning*

Paper ID: 178

Blockchain-Enabled Product Passport for Transparent Tea Supply Chain

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Abstract

Sri Lanka, the fourth-largest tea exporter in the world, faces challenges in productivity, resource management, and sustainability within its tea industry. Despite its economic significance, no comprehensive solution utilizing advanced digital technologies has been developed specifically for tea plantations in Sri Lanka. This research proposes an integrated smart system that leverages the Internet of Things (IoT), Digital Twins, and carbon footprint tracking to enhance operational efficiency, sustainability, and traceability in tea plantation management. The proposed system comprises four key components: a Portable IoT Device for real -time environmental monitoring, a Digital Twin for Yield Prediction and Harvest Management, a Digital Twin for Data Visualization n, and a Product Passport with Carbon Footprint tracking. By utilizing real-time data collection, predictive analytics, and interactive visualization, the system provides actionable insights for optimizing resource usage, scheduling harvests, and minimizing carbon emissions. The research methodology involves designing and implementing each component using advanced tools and technologies, including Python, TensorFlow, Unity, Solidity and C#. This study is the first to explore the application of these technologies in Sri Lankan tea plantations, addressing critical industry challenges while enhancing sustainability and market competitiveness. The findings demonstrate the system's potential to revolutionize tea plantation management by improving productivity, ensuring product authenticity, and promoting environmentally sustainable practices.

Keywords: *Internet of Things (IoT), Digital Twin, Product Passport, Yield Prediction*

Paper ID: 307

Robust DoS Attack Detection for V2X Networks Using RNN Variants with Attention

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Abstract

V2X communication is a foundational technology for connected and autonomous transportation, enabling vehicles, infrastructure, and pedestrians to exchange timely and reliable information essential for collision avoidance, traffic optimization, and road safety. Denial-of-Service (DoS) attacks pose critical threats to Vehicle-to-Everything (V2X) communication by disrupting real-time safety and mobility functions. This study presents a comparative evaluation of SimpleRNN, LSTM, and GRU models for DoS detection using a balanced, normalized dataset of 120,000 samples derived from the VeReMi Extension. All models employ unified architecture integrating attention mechanisms and dense layers and are trained across two temporal window sizes (5 and 10) to capture varying time dependencies. Hyperparameter optimization is conducted using random search to enhance performance and training efficiency. Models are benchmarked on classification metrics (accuracy, precision, recall, F1-score), inference latency, memory and CPU usage, and model footprint (Keras/TFLite formats). Results show that GRU achieves the highest detection performance (F1-score up to 0.972, accuracy up to 97.2%), RNN offers the smallest model size (0.09 MB) and fastest inference (¡ 1 s), while LSTM provides high precision (up to 0.970) but requires tuning to improve recall. These insights support the development of secure, lightweight, and real-time intrusion detection systems for next generation V2X environments.

Keywords: *V2X Communication, Edge Security, DoS Detection, RNN, LSTM*

Paper ID: 312

A Sysmon Event-based Machine Learning Approach to Ransomware Detection

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Abstract

The rapidly increasing cyber threat landscape has caused a huge impact on a large number of sectors worldwide, and among them ransomware is one of the most critical threats that should be controlled effectively. This paper presents a solution for detecting ransomware by leveraging features extracted from Windows Sysmon event logs, combined with machine learning based classification. A minimal set of key Sysmon events are collected and a comprehensive set of features are generated from it by a lightweight endpoint agent. These feature vectors are then transmitted to a cloud-based inference model for real time analysis, which ensures low overhead on the endpoints while allowing for a high scalability. Four machine learning models were evaluated on a publicly available dataset and XGBoost was selected as the suitable model for this solution due to its high accuracy while maintaining the fastest inference speed. Overall, this solution is capable of detecting ransomware with high precision and a low false negative rate, while maintaining fast inference times and a minimal processing overhead on the endpoints. The architecture enables scalable, real-time ransomware detection suitable for both enterprise and individual environments.

Keywords: *Ransomware, Sysmon, Machine Learning, Cyber Security, XGBoost*

C. Session 4: Artificial Intelligence & Machine Learning

Paper ID: 78

Data-Driven Insights for Improved Diabetes Management

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Abstract

Effective diabetes management requires understanding the complex interplay between multiple physiological and behavioral factors affecting glycemic control. This study presents a comprehensive analysis of diabetes management data from six distinct datasets containing continuous glucose monitoring (CGM) data, insulin administration records, carbohydrate intake, physical activity, sleep quality, and stress measurements. We employed time series analysis techniques such as STL decomposition, Dynamic Time Warping, LSTM neural networks, and XGBoost modeling to identify patterns in glucose variability and their relationships with modifiable factors. Our findings revealed significant time-of-day variations in glucose levels, with highest variability in late afternoon and evening (CV = 0.41 vs. 0.34, $p < 0.01$). Integrated prediction models achieved 83% sensitivity for hypoglycemia and 81% for hyperglycemia detection. The insulin-to-carbohydrate ratio varied by time of day, with morning ratios (1:8) differing from evening (1:12). Physical activity demonstrated intensity-dependent effects, with moderate-intensity exercise reducing glucose levels by 42 mg/dL for approximately 12 hours post activity. Sleep quality below rating 3 (on a 5-point scale) was associated with a 37% increase in next-day glucose variability. These findings provide evidence-based insights for developing personalized diabetes management strategies that account for chronological variations in insulin sensitivity, meal timing, physical activity scheduling, and lifestyle interventions targeting sleep and stress management.

Keywords: *Continuous Glucose Monitoring, Diabetes Management, Glycemic Variability, Machine Learning, Time Series Analysis*

Paper ID: 275

Framework for Ethical Governance of Autonomous AI Systems: Balancing Innovation, Accountability, and Risk Management

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Abstract

The advent of rapid deployment of autonomous artificial intelligent systems is a twofold challenge: how to ensure this is happening in an ethical way, and at the same time, how to keep the innovative power. These are already outdated models of governance that render many of these models inadequate in accommodating the risk landscape as well as the applied complexity of autonomous artificial intelligent systems. This paper suggests a new conceptual model of governance that combines ethical standards, risk stratified regulatory feedback and allowing innovation via regulatory sandboxes. Based on a qualitative synthesis of worldwide AI policies, scholarly sources, and background information, the framework provides a hierarchical, modular paradigm that can be applied in different domains and jurisdictions. It focuses on transparency, accountability, fairness and incorporates flexibility of changing technology. The proposed model would play the role of a policymaker, industry practitioners, and researchers strategic road map in finding balanced and operationally feasible solutions in deploying ethical AI.

Keywords: *AI Governance, Ethical AI, Autonomous Systems, Regulatory Sandbox, Risk-Based Regulation*

Paper ID: 344

Optimizing Retail Pharmacy Inventory via Descriptive and Predictive Analysis

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Abstract

Effective inventory management is crucial for retail pharmacies to balance supply and demand while minimizing costs. This study proposes an integrated approach combining predictive and descriptive data mining to optimize inventory decisions using sales data from pharmacies in Western Province, Sri Lanka. For predictive analysis, Seasonal Auto-Regressive Moving Average with exogenous variables (SARIMAX) was initially employed but showed limitations in capturing nonlinear trends. Thus, Recurrent Neural Networks (RNN), including Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU), were implemented, achieving superior accuracy (lowest RMSE: 0.16 for GRU, 0.34 for LSTM). Hybrid models (RNN LSTM + SARIMAX) and ensemble techniques (Bagging, XGBoost) further enhanced performance. For descriptive analysis, K-Medians clustering categorized drugs in to 7 clusters based on dosage, price, and weekly sales, revealing key patterns: Cluster 4 contained widely sold essential medications, Cluster 3 comprised high-cos t, low- volume specialty drugs, while Cluster 6 represented niche medications with unique demand patterns. The FP- Growth algorithm identified strong purchase associations (support >0.8) between commonly co-prescribed medications. Results demonstrated that RNN-based models outperformed traditional approaches (reducing RMSE by up to 94% versus SARIMAX), while clustering and association rules provided actionable insights for inventory segmentation. This dual analytical framework offers a data-driven solution for inventory management.

Keywords: *Deep Learning, GRU, LSTM, RNN, SARIMAX*

Paper ID: 459

Optimizing LLMs for Context-Sensitive Text Summarization: Insights from PLOS and SciSummNet

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Abstract

Text summarization is an important task in natural language processing (NLP), as it allows vital information to be extracted from large amounts of textual input. This work investigates the efficacy of fine-tuning large language models (LLMs) for summarization tasks by comparing their performance to that of untuned alternatives. Using the PLOS dataset consisted of biomedical papers and SciSummNet dataset consisted of computing linguistics related scientific papers, LLM models such as Falconsai-T5 text summarization, T5-small, Bart and Bart-large-CNN were tested using ROUGE, BLEU, and METEOR metrics to measure their summarization abilities. The results show that fine-tuning improves model performance significantly across the evaluation metrics. Fine-tuned models performed well on the SciSummNet dataset, with Bart-tuned model getting the highest scores across multiple measures, demonstrating the efficacy of targeted adaptation where the obtained results for ROUGE-1 - 0.6808, ROUGE-2 0.6487, BLEU - 0.4163, and METEOR - 0.5083. The analysis underscores the importance of aligning model architectures and datasets to achieve optimal results. The structured biomedical content of the PLOS dataset highlighted the vital necessity of semantic preservation, as evidenced by specially the higher METEOR scores achieved by fine-tuned models. The SciSummNet dataset, which focuses on computing and linguistic publications, demonstrated the ability of the models to navigate abstract concepts and complex technical vocabulary. This study demonstrates the transformative power of fine-tuning in customizing LLMs resulting in significant increases in summarization accuracy.

Keywords: *BLEU, Large Language Models, METEOR, ROUGE, Text Summarization.*

Paper ID: 471

ARISE: A Multisensory AR Support Tool for Surface Dyslexic Readers

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Abstract

Dyslexia is a pervasive learning disability that affects fluency in recognizing words, with Surface Dyslexia representing distinct challenges given its focus on irregular word decryption. Standard computer-aided interventions primarily address phonological weaknesses while neglecting orthographic processing weaknesses. This paper outlines a multisensory Augmented Reality (AR)–based intervention platform facilitated by the Enhanced Surface Dyslexia Pronunciation Model (ESDPM), a dual-route neural network that evaluates pronunciation accuracy and offers adaptive feedback. The system uses Wav2Vec2.0 to extract speech features, supplemented with specialized phonetic and irregular word recognition paths that are combined through a cross-modal attention mechanism. Feedback generation and calibration to confidence levels offer the capability to provide evaluative as well as instructional feedback, seamlessly integrated into an AR storytelling environment to offer contextualized, in-the-moment remediation. Experimental evaluation demonstrates that the proposed model has high concordance with expert pronunciation ratings, greatly dominates baseline systems in irregular word recognition, and produces feedback in line with evidence-based interventions in dyslexia. Pilot studies with dyslexic learners demonstrate enhanced irregular word recognition, elevated interest, and decreased task duration. These preliminary findings indicate that combining sophisticated speech models with adaptive AR environments represents a promising avenue to provide largescale, personalized, and effective interventions for Surface Dyslexia.

Keywords: *Dyslexia, Surface Dyslexia, Pronunciation Assessment, Augmented Reality (Ar), Multisensory Learning*

C. Session 5 : Computer Vision & Image Processing

Paper ID: 309

Video-Centric Deepfake Detection: Leveraging Audio and Spatio-Temporal Features for Improved Accuracy

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Abstract

Detecting deepfakes has become a critical challenge as a result of the growth of complex manipulated media and the potential to spread false information, erode public trust, and damage reputations. This paper presents a novel solution for deepfake detection by implementing a video -centric framework that leverages spatio-temporal features, with audio as a secondary modality to enhance robustness and accuracy. The proposed framework employs an R(2+1)D convolutional neural network to extract frame-based spatiotemporal patterns, and Mel -frequency Cepstral Coefficients (MFCCs) encoded using an LSTM network to produce audio features. These embeddings are combined using a late fusion strategy, followed by encoder freezing and finetuning the classifier layer to reduce prediction bias. Evaluated on FakeAVCeleb, CREMA -D, and Meta's Casual Conversations datasets, the model achieved 96.69% test accuracy and a 0.9909 AUC -ROC score. These results demonstrate the system's robustness in detecting subtle and synchronized manipulated content. The proposed method contributes to improving the reliability of media authenticity in fields such as law, journalism, and cybersecurity. Although some current methods report slightly higher benchmark scores, our framework focuses on bias mitigation, robustness, and reproducibility for practical application.

Keywords: *Deepfake Detection, Spatio-temporal Features, Audio-visual Fusion, R(2+1)D CNN, LSTM*

Paper ID: 330

Detection and Mitigation of Urban Heat Island Effect Using Vision-Language Models

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Abstract

Urban Heat Islands (UHIs) intensify urban temperatures, contributing to environmental degradation and public health concerns. Mitigating these effects is crucial for creating more sustainable and liveable cities. In this paper, we address the problem of detecting UHI-prone areas and generating context-specific mitigation strategies using street-level imagery. We propose HeatScape, an AI-powered framework that combines semantic segmentation and Vision-Language Models (VLMs) to identify heat-retaining surfaces from user-captured images. Unlike traditional approaches reliant solely on satellite data, HeatScape uses ground-level visual inputs to offer fine-grained urban analysis. VLMs then interpret these segmented scenes to recommend urban planning actions for new and existing building projects. Our experiments show a UHI detection accuracy of 94.25% using logistic regression, with VLM-generated suggestions aligning with established urban sustainability practices. HeatScape demonstrates a scalable, low-cost tool for data-driven environmental assessment and urban design.

Keywords: *Urban Heat Island, Semantic Segmentation, Visual Language Models, AI in Urban Planning, Mitigation Strategies*

Paper ID: 415

Key Player and Key Connection Problems in Brain Networks

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Abstract

The Key Player Problem (KPP) seeks to identify a set of k nodes (key players) whose removal maximally disrupts communication within a network. While KPP has been widely studied in social and other complex networks, its application to brain networks remains limited. Disruptions in brain networks are particularly relevant in the context of aging, and neurodegenerative diseases such as Alzheimer's disease (AD). To address this gap, we propose an efficient exhaustive algorithm based on global efficiency, termed Exhaustive Global Efficiency Minimization–based Key Player Detection (ExGEM), to identify key players in groups of brain networks. We applied ExGEM to structural brain networks derived from neuroimaging data from 100 cognitively normal older adults (NC) and 100 AD patients, each represented by 80 cortical regions (nodes) with anatomical pathways as edges. Key player analysis revealed that NC networks are characterized by left-dominant subcortical–limbic integration, reflecting normal hemispheric asymmetry. In contrast, AD networks exhibit bilateral hippocampal–frontal–parietal disruption, indicating a loss of asymmetry that aligns with diffuse cognitive impairment, including memory decline and executive dysfunction. Beyond nodes, we introduce the Key Connection Problem (KCP), a conceptual extension of KPP, defined as identifying a set of kedges whose removal maximally disrupts communication. KCP is particularly relevant for brain networks, where structural connections carry biological significance. This study highlights the usefulness of KPP and ExGEM in identifying key nodes and introduces KCP as a framework for analyzing critical connections in structural connectivity.

Keywords: *Key Player Problem (KPP), Key Connection Problem (KCP), Brain Networks, ExGEM*

Paper ID: 426

AI-Driven 3D Avatar Framework for Sign Language Translation and Gesture Representation

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Abstract

The communication gap between Deaf and Hardof-Hearing (DHH) communities and mainstream multimedia platforms remains a critical accessibility challenge. Conventional solutions such as subtitles fail to capture the expressiveness, gestures, and finger movements intrinsic to sign language. Existing AI-based avatar systems further suffer from incomplete hand articulation, unnatural body rotations, and desynchronized playback, limiting their realism and effectiveness. To address these challenges, this research introduces AuralFlix, an AI-driven framework that translates spoken or textual content into naturalistic 3D avatar animations for sign language representation. The system integrates MMPose-based pose estimation to capture full-body and hand key points, which are mapped to a Mixamo-compatible skeleton in Blender using quaternion-based animation. A custom animation correction pipeline minimizes rotational artifacts, improves finger articulation, and synchronizes the generated motion with video playback through a dedicated multimedia player. Experimental evaluation demonstrates an average positional accuracy of 3.5 mm and rotational error below 3°, achieving approximately 20% improvement in gesture fidelity compared to baseline markerless animation systems. The proposed framework provides a scalable, low-cost, and expressive accessibility solution that enhances digital communication for the DHH community.

Keywords: *Sign Language Translation, 3D Avatar Animation, Pose Estimation, Deaf Accessibility, Motion Capture*

C. Session 6 : Artificial Intelligence & Machine Learning

Paper ID: 281

Adaptive Exploration in Deep Reinforcement Learning via Uncertainty-aware State Representation

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Abstract

Deep Reinforcement Learning (DRL) shows a promise for great applicability in high-dimensional sequential decision-making tasks, but problems like effective exploration, stability, and sample efficiency remain. Recent developments have aimed at uncertainty-centric decision-making in cases where the environment presents conditions under which epistemic uncertainty makes a significant difference in learning. The paper looks at uncertainty-driven exploration, with a particular emphasis on embedding epistemic uncertainty into latent state representations. It discusses using either ensemble Q-networks or Monte-Carlo dropout to assess uncertainty and propagate this information to reward shaping and action selection. Although this represents a coherent amalgamation of uncertainty modeling and latent representation learning, the improvement it suggests over established exploration methods like Bootstrapped DQN, UCB based methods, NoisyNets, or intrinsic motivation schemes is, at best, incremental. This paper includes a structured discussion on uncertainty propagation, representation learning, and exploratory behavior, illustrated by experimental examples. Lastly, it identifies limitations in benchmark, theoretical justification, and comparisons against base DRL methods, which indicate promising directions for future work in uncertainty-aware DRL.

Keywords: *Deep Reinforcement Learning, Exploration Strategies, Explainability, MultiObjective Optimization, Autonomous Driving*

Paper ID: 484

Soccer In-Game Event Classification Using Spatio-Temporal Data

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Abstract

Classifying soccer ball events, such as pass, shot, ball loss, and ball out, are crucial for advancing game analytics and tactical insights. This research investigates the application of machine learning to classify these events using spatiotemporal tracking data of players and the ball, augmented with derived kinematic features including velocity, acceleration, and direction. We implement and compare traditional machine learning algorithms (AdaBoost, Logistic Regression, and Random Forest) with several deep learning approaches, including Feed Forward Neural Network (FFNN), Recurrent Neural Networks (Long Short-Term Memory (LSTM) and Gated Recurrent Unit (GRU)), and Transformer. Our experiments are evaluated on a dataset comprising of three professional soccer matches using accuracy, precision, recall, and F1-score. It demonstrates that the Transformer model performs the best. It outperforms all other models by effectively capturing the complex, long-range spatiotemporal dependencies inherent in player and ball movements. This study shows the effectiveness of Transformer models for soccer event classification and provides a baseline benchmark for future research in spatio-temporal sports analytics.

Keywords: *Sports Analytics, Event Classification, Spatio-Temporal Data, Soccer, Machine Learning*

Paper ID: 486

A Novel Objective Function for Counterfactual Explanations Using Conic Optimization

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Abstract

Counterfactual explanations are an effective method of explaining the decisions made by machine learning models to end-users. However, it is crucial to ensure that certain qualities of counterfactuals such as plausibility and proximity are achieved, so that the explanations are realistic and effective in the real world. In this paper, we propose a novel objective function for counterfactual explanation generation, which combines two different distance functions in the feature space and solve it using quasi-convex optimization. We compare the proposed method with three numerical optimization–based approaches on three real-world benchmark datasets. The results show that the proposed method efficiently generates counterfactual explanations with minimal deviation from the original samples. We evaluate the objective function on both simple models, such as logistic regression, and more complex fully connected neural networks, demonstrating its flexibility with respect to the underlying predictive model. Moreover, the proposed method achieves stronger performance on neural network models compared with existing optimization-based approaches, providing an efficient numerical framework for counterfactual generation in neural network settings.

Keywords: *Counterfactuals, Plausibility, Quasi-convex Programming, Mixed Integer Programming, CVXPY*

Paper ID: 299

Global Disparities in Green Computing Policy Adoption in Higher Education: A Six-Region Survey

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Abstract

The environmental effects of extending digital infrastructures necessitate green computing as a critical agenda for higher educational institutions (HEIs). Although many frameworks exist, little evidence is available for regional comparison as to how such policies are adopted. This research attempts to fill the identified void by surveying five sustainability measures—curriculum integration, energy-efficient data centers, e-waste recycling, green procurement, and carbon offsetting—across six regions. A modelling pipeline assesses institutional readiness through feature selection, machine-learning classification, and evaluation based on Mean Absolute Error (MAE), Normalized Discounted Cumulative Gain (nDCG), Brier Score, and Matthews Correlation Coefficient (MCC). The findings reveal a marked variation by region: infrastructure policy leadership is assumed by the developed world, while many institutions in the developing regions face the hurdle of basic resource constraints. It also gives rise to trends based on the policies: curriculum and data-center initiatives lead, while carbon offsetting exhibits the least advancement. The paper then goes on to suggest practically based interventions that would encourage the adoption of green computing by all in a fair and scalable manner. In support of further comparative investigations and benchmarking, it adds a publicly available dataset. This framework can be transferred to other sectors by integrating empirical data with advanced analytics to reduce the gap between sustainability theory and practice in higher education.

Keywords: *Green Computing, Higher Education Institutions, Sustainability Policies, Global Survey, Machine Learning*

Paper ID: 407

Analysis of Deep and Graph Neural Networks for Enhanced DDoS Attack Detection: A Pathway to Hybrid Models

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Abstract

Distributed denial-of-service (DDoS) attacks pose significant threats to network security, targeting critical infrastructures with increasing complexity. Traditional defense mechanisms that depend on static rules and signatures struggle to address the dynamic nature of these attacks. Software-defined networking (SDN), integrated with machine learning (ML) and deep learning (DL) techniques, has emerged as a promising solution for DDoS detection and mitigation. This paper presents a comparative analysis of deep neural networks (DNNs) and graph neural networks (GNNs) within an SDN framework to detect DDoS attacks. Using real-time network monitoring and traffic anomaly identification, the models are evaluated using metrics such as accuracy, precision, recall, and F1-score against both known and novel attack patterns. Our findings underscore the superiority of GNNs in capturing complex and interconnected relationships within network traffic, offering enhanced detection capabilities. This study contributes to adaptive cybersecurity strategies, advancing the application of ML models in combating evolving cyber threats.

Keywords: *Distributed Denial-Of-Service, Network Security, DNN, GNN, Traffic Anomaly Detection*

D. Session 1 : Computer Vision & Image Processing

Paper ID: 432

Few-Shot Learning for Early Detection of Coconut Whitefly Infestations Using Low-Label Leaf Image Data in Sri Lanka

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Abstract

Coconut whitefly (*Aleurodicus dispersus*) has emerged as a devastating pest threatening Sri Lanka's vital coconut industry, causing severe yield losses and economic hardship for over 1.5 million smallholder farmers. Early detection is critical for effective intervention, but conventional field scouting is labor-intensive and often too late to prevent widespread infestation. While deep learning offers promise for automated pest detection, its deployment is hindered by the scarcity of labeled training data. To address this challenge, we propose a novel SimCLR → FixMatch framework that combines self-supervised contrastive learning with semi-supervised fine-tuning for accurate detection of coconut whitefly infestations under extreme label scarcity. Our method leverages a new dataset, CocoInfest-SL, comprising 1,600 real-world leaf images from major coconut-growing regions in Sri Lanka, with only 120 labeled samples (30 per class), 7.5% of the full dataset. The model first learns robust feature representations via SimCLR pretraining on both labeled and unlabeled data, then finetunes using FixMatch with confidence-based pseudo-labeling. Experimental results demonstrate that our approach achieves 91.8% accuracy and a 0.91 F1-score, outperforming state-of-the art few-shot and semi-supervised baselines while using minimal annotations. This work presents a scalable, low-cost solution for early pest monitoring in resource constrained agricultural environments.

Keywords: *Few-Shot Learning, Semi-Supervised Learning, Self- Supervised Learning, Low Label Learning, Pest Detection in Agriculture*

Paper ID: 443

PoseFit: A Home Workout Companion

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Abstract

PoseFit is a machine learning–driven posture evaluation system designed to enhance exercise performance and reduce injury risk through real-time human pose estimation. Leveraging computer vision and machine learning, it analyzes body movements using key point detection and provides an instant corrective feedback. The system is accessible via web browsers without the need for additional hardware, supports multiple exercises, and ensures the user's privacy through client-side processing. Experimental results demonstrate high accuracy across various exercise models, confirming its effectiveness in promoting safe and personalized home workouts.

Keywords: *Pose Estimation, Machine Learning, Computer Vision, Fitness*

Paper ID: 446

Explainable AI - Driven Diagnostic Framework for Early Vascular Dementia Detection Using MRI

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Abstract

Vascular dementia (VaD) is the second most common dementia globally, presenting significant diagnostic challenges due to often confounded by overlapping symptoms and the subjective nature of Magnetic Resonance Imaging (MRI) interpretation. This research proposes a diagnosis framework, named "Neuro-Find," which is an explainable AI-based diagnostic model capable of early detection of VaD and its subtypes from MRI scans in a consistent and interpretable manner. The framework consists of a two-stage deep learning model based on VGG16 for binary classification (VaD-demented vs. non-demented) and for an ensemble model for multi-class classification of four clinically valid VaD subtypes. The framework showed high-performance with an accuracy of 96.15% for binary classification and 88.25% for subtype analysis. A key contribution is the deployment of Explainable AI (XAI) using Grad-CAM to produce visual heatmaps that lead to biologically plausible brain regions of particular importance to the model's predictions, which clinicians can readily understand and interpret. By providing both high diagnostic accuracy and transparent, interpretable outputs, the proposed solution answers the key "black box" issue in medical AI and is a trustworthy assistive tool that can help to strengthen clinical decision-making and boost the likelihood of early and effective VaD management

Keywords: *Vascular Dementia, Explainable AI, MRI, Deep Learning, Clinical Decision Support*

Paper ID: 414

A Lightweight Convolutional Neural Network Framework for Multiclass Brain Tumor Identification

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Abstract

Magnetic Resonance Imaging (MRI) provides excellent soft tissue contrast and hence, it is most widely used imaging modality for early brain tumor classification and clinical decision-making. This study proposed a lightweight, custom-built 2D Convolutional Neural Network (CNN) for the multiclass classification of brain tumors, i.e., meningioma, glioma, pituitary tumor, and no tumor. The model was trained and evaluated on a huge dataset of more than 7K T1- weighted contrast enhanced (T1CE) MRI images, which were collected from three different public datasets. The model demonstrated excellent performance with an architecture with <0. 5 million trainable parameters. Precision, recall, and F1-scores were obtained more than 96% in every class, with a test accuracy of 98%. The proposed CNN model performed better than baseline and transfer learning (VGG16) model, while exhibited much lower computational overhead. The results demonstrated the significant potential for real-time clinical implementation, particularly in resource-constrained settings.

Keywords: *Brain Tumor Classification, Light Weight Neural Network, Deep Learning, Multiclass Classification, MRI*

D. Session 2 : Computing for Education and Digital Learning

Paper ID: 141

Comprehensive Smart Assignment Assessment Tool Using Large Language Models

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Abstract

The assessment of student assignments is a critical indicator of learning outcomes and academic performance. Traditional methods of evaluation require educators to manually review written reports, code submissions, and video presentations, making the process labor-intensive, time-consuming, and prone to human biases. As student enrollment grows, educators struggle to keep up with a variety of submission types, such as written reports, code repositories, and video presentations. This study aims to address these issues by introducing the Comprehensive Smart Assignment Assessment Tool (SAAT), an AI-powered system that automates assignment evaluation utilizing large language models and machine learning. SAAT comprises three core components: code assessment via the GitHub API and static code analysis methods, report analysis using NLP models, and video evaluation powered by Whisper and visual analysis tools. It also generates Viva questions using Gemini 1.5 Flash based on all submission types for personalized evaluation. An interactive interface supports efficient review of submissions and structured feedback. According to the experimental results, the system significantly reduced grading time while maintaining strong alignment with human evaluations. By automating repetitive processes and providing more accurate, context-rich feedback, the system improved consistency, fairness, and scalability in assessments. This approach improves assessment consistency, fairness, and scalability, marking a significant step toward AI-powered, data-driven educational evaluation.

Keywords: *Automated Assignment Evaluation, Large Language Models, Educational Technology*

Paper ID: 172

EduNova: An Adaptive Gamification Driven Framework for Enhancing Learner Engagement and Retention in Digital Education

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Abstract

Student engagement and retention remain significant challenges in e-learning platforms due to limited interactivity and personalization. This study investigates the integration of gamification elements into the EduNova Next-Gen Web Platform to address these challenges. The platform incorporates leaderboards, adaptive challenges, real-time quizzes, virtual rewards, and a virtual teacher to foster intrinsic motivation. Integrating analytics, surveys and experiments on three groups of students, the study measures the impact gamification has on their learning. Results suggest a 23% rise in course completions and a 30% increase in student engagement for the group using games over traditional learning. Motivation levels for learners rose by 18% after the intervention. The results indicate that adaptive gamification greatly boosts interest and memory in digital learning. The report advises that using more flexible and customized game systems makes e-learning platforms better for success in school and enjoyment.

Keywords: *Gamification, E-Learning, Student Engagement, Virtual Rewards, Game Mechanics*

Paper ID: 325

EDU-SENSE: AI-Driven Adaptive Learning System for Primary Education

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Abstract

This research addresses critical gaps in primary education by integrating AI-driven e-learning tools with traditional classroom teaching, ensuring technology supports rather than replaces teachers while improving student learning outcomes. In getting ready for high-pressure exams like Sri Lanka's Grade 5 Scholarship Examination, maintaining student engagement and emotional wellbeing remains a significant challenge. EDU- SENSE is an AI-driven web platform designed for primary education that integrates personalized content delivery, stress detection, and an emotion aware chatbot. The system begins with a diagnostic pre-test to assess individual skill levels, and provides syllabus-aligned questions, and delivers targeted revision based on identified knowledge gaps. A stress-aware module and motivational chatbot provide emotional support, while peer collaboration features promote teamwork and knowledge sharing. Using Machine Learning, Natural Language Processing, and fine-tuned Large Language Models, EDU-SENSE offers a holistic solution that enhances both academic performance and emotional well-being in young learners.

Keywords: *Large Language Models, Natural Language Processing, Stress Detection, Peer Collaboration*

D. Session 3 : Human-Computer Interaction & UX Design

Paper ID: 174

Virtual Reality Scuba Diving Simulator: Supplementing Real-World Training While Addressing HCI Challenges

H.K.D.M.A.W. Divarathna, K G M Dinujaya, E.G.S.S. Gunasinghe, A.V.P. Buddhima, Didula Chamara Thanaweera Arachchi, Aruna Ishara Gamage, Tharushi Rubasinghe, Charith Dabare

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Abstract

In a number of domains, including diving, virtual reality (VR) has become a revolutionary training and simulation tool. The potential of a virtual reality underwater environment simulation for diving instruction is investigated in this study. The study intends to improve training effectiveness, safety, and user experience through the use of immersive technology. It examines current VR-based training materials, identifies limitations, and offers a methodical approach to creating and evaluating the proposed VR simulation. According to preliminary research, VR-based training provides aspiring divers with a safe and controlled environment while also enhancing spatial awareness, reaction times, and procedure recall. These findings demonstrate VR's potential as a valuable supplement to conventional diving instruction techniques. This work contributes a prototype of a low-cost, immersive VR underwater simulator that integrates motion feedback and realistic environmental modeling. It further introduces a quantitative and qualitative evaluation framework to assess training effectiveness, comfort, and feasibility, thereby establishing the feasibility of VR as a tool for diver training.

Keywords: *Virtual Reality, Diving Training, Underwater Simulation, Immersive Learning, Feasibility Study*

Paper ID: 186

Virtual and Augmented Reality Approach to Exposure Therapy: Gamified Solution for Treating Aerophobia, Claustrophobia, Arachnophobia, and Cynophobia

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Abstract

The proposed solution presented in this report aims to address the issues of phobias and the hindrance they cause to day-to-day life. Phobias such as aerophobia (fear of flying), claustrophobia (fear of confined spaces), arachnophobia (fear of spiders), and cynophobia (fear of dogs) significantly impact individuals' well-being, often restricting daily activities and inducing severe distress. Traditional exposure therapy, while effective, can be costly, logistically challenging, and inaccessible to many individuals. This presents a distinct computing problem on how to computationally model, render, and manage interactive virtual stimuli in a way that is both immersive enough to evoke a genuine phobic response and controllable enough for safe, gradual therapeutic use. Our approach leverages both mixed reality (MR) and virtual reality (VR) technologies as mediums for exposure therapy guided by healthcare professionals. This presents a novel alternative, providing controlled, immersive and customized therapeutic experiences. This research explores the efficacy of VR and MR exposure therapy in treating these four specific phobias by simulating real-world fear-inducing scenarios in a safe and controlled virtual environment. The research examines the psychological and physiological responses of participants undergoing VR and MR exposure therapy, analyzing factors such as anxiety reduction and user engagement. Additionally, the research evaluates the role of interactivity, guided relaxation techniques, and repeated exposure in improving therapeutic outcomes, all done with the guidance of healthcare professionals.

Keywords: *VR, MR, Phobias, Psychology, Physiology*

Paper ID: 187

Augmented Reality-Driven Customization Platform: A Unified Framework for Designing and Visualizing Fashion Accessories and Apparel

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Abstract

The integration of Augmented Reality (AR) and Artificial Intelligence (AI) has revolutionized the fashion industry, enabling designers and consumers to interact with virtual prototypes within real-world environments. This research presents a unified AR-driven customization platform for designing and visualizing diverse fashion products, including bags, footwear, clothing, and jewelry. The proposed system combines advanced 2D-to-3D conversion and immersive AR visualization into a single cohesive framework. Users can seamlessly transition from images to interactive 3D models, dynamically customize materials and textures, and visualize their designs in real time. By addressing challenges such as limited interactivity, fragmented workflows, and the disconnect between design and manufacturing, this platform democratizes access to advanced design tools for both professionals and enthusiasts. Evaluation results demonstrate high user satisfaction, improved workflow efficiency, and significant potential for transforming the fashion design process. This paper outlines the methodology, system architecture, evaluation metrics, and future directions for advancing AR-powered design platforms across multiple fashion domains.

Keywords: *Augmented Reality, Fashion Design, Image Recognition, 2D-to-3D Conversion, Digital Prototyping*

Paper ID: 189

Tranquil, Enhancing Student Well-Being through personalized Mindful Activities for Stress Reduction

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Abstract

University students frequently encounter high levels of stress stemming from academic demands, social pressures, and personal responsibilities, factors that can significantly impair their mental well-being and academic success. This research introduces Tranquil, an innovative mobile application that leverages Machine Learning (ML), Augmented Reality (AR), and a Virtual Assistant (VA) to deliver personalized stress-reduction interventions. The system begins with an interactive VA that administers the Perceived Stress Scale (PSS) alongside a behavioral preference survey to evaluate user stress levels. Based on this data, ML algorithms classify stress severity and recommend tailored mindfulness activities delivered through AR interfaces. The application offers four core intervention modules: (1) Stress Level Identification via the V A, (2) an AR-Based Virtual Pet for emotional companionship, (3) AR Mandala Art, and 2D Freehand Drawing for creative expression, and (4) AR-Based Environmental Building to promote immersive relaxation. Built using Unity for AR visualization, Python for ML processing, and Firebase for secure data handling, Tranquil presents a scalable, engaging, and user-centric solution for managing student stress. Preliminary evaluations suggest notable improvements in user engagement, emotional regulation, and perceived support, underscoring the potential of AR and intelligent systems as impactful tools for mental health care in academic settings.

Keywords: *Stress Reduction, Augmented Reality, Machine Learning, Virtual Assistant, Mindfulness*

D. Session 4 : Artificial Intelligence & Machine Learning

Paper ID: 54

AI-Driven Behavioral Assessment and Intervention for ADHD

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Abstract

Attention Deficit Hyperactivity Disorder (ADHD) affects millions of children worldwide, causing cognitive, behavioral, and academic challenges. Traditional diagnostic methods rely on subjective assessments, leading to inconsistent evaluations and delayed interventions. This research addresses these limitations by developing an AI-driven gamified behavioral assessment and intervention platform that integrates machine learning, real-time emotion recognition, and adaptive learning techniques. The system features interactive games that dynamically adjust difficulty based on behavioral and emotional responses captured through facial expression analysis. Data collection includes gameplay metrics, parent-reported questionnaires, and expert evaluations to train AI models for ADHD classification and personalized intervention. The emotion recognition module achieved 89% accuracy using Convolutional Neural Networks, while reinforcement learning algorithms enabled real-time game adaptation. Classification models, including Random Forest (91.3% accuracy), demonstrated strong predictive capabilities. The platform provides continuous monitoring dashboards for caregivers and educators, enabling data-driven decision-making. Results indicate that AI-based behavioral assessments offer improved accuracy and flexibility compared to traditional methods, with emotion-adaptive gaming enhancing engagement. This research demonstrates the potential of AI-powered solutions to transform ADHD diagnosis and intervention through improved efficiency, personalization, and accessibility.

Keywords: *ADHD, Machine Learning, Behavioral Assessment, Emotion Recognition, Reinforcement Learning*

Paper ID: 134

HCLIP: Beyond CLIP for Cost-Effective Multimodal Retrieval in Education

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Abstract

Multimodal retrieval systems have gained significant attention due to their ability to process and cross retrieve data containing images and text. However, the factors such as high cost of development, limitation on resources, and the proper addressing of the modality gap, the inherent representational differences between modalities pose a challenge to building effective and efficient retrieval models. In this work, we propose a low-resource, cost-efficient hybrid multimodal retrieval model that integrates Contrastive Language-Image Pre-training (CLIP) and All-MiniLML6-v2 to create a shared embedding space while storing raw images in an unstructured database. Our primary contributions include (1) the development of a hybrid model that outperforms CLIP native retrieval, (2) a novel bidirectional neural network alignment technique that brings textual and visual modalities closer together, and (3) a comprehensive analysis of the modality gap's impact on downstream retrieval performance. Through proper evaluation using transparent techniques such as Mean Reciprocal Rank (MRR) and Cosine-Weighted MRR, our method demonstrates improved retrieval accuracy over baseline approaches. Experimental results exhibit that a lower modality gap does not always prove to be efficient on the downstream retrieval. Our findings pave the way for more efficient, adaptable, and cost-effective multimodal retrieval methodologies in low-resource environments, not limited to the education domain.

Keywords: *Modality Gap, CLIP, Low-resource, Education, Cross Modal Retrieval*

Paper ID: 297

CINNOVA: Advancing Sustainable Cinnamon Farming through AI and Collaborative Solutions

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Abstract

Cinnamon is one of the most economically significant export crops in Sri Lanka. However, its cultivation is challenged by plant diseases, nutrient deficiencies, and inefficient harvesting practices, which reduce yield quality and productivity. Traditional methods for identifying plant health issues are time-consuming and require expert evaluation, often inaccessible to rural farmers. To address these limitations, this study introduces an AI-driven intelligent monitoring system for sustainable cinnamon cultivation, a mobile-based solution specifically designed to enhance cinnamon farming practices. The system leverages Artificial Intelligence (AI), Deep Learning (DL), and Image Processing techniques to support real-time plant health diagnostics. It integrates multiple AI-powered components for early detection of bark diseases such as Rough Bark Disease (RBD) and Canker Disease (CD) using a contrastive learning-based model, severity prediction of leaf diseases, including Leaf Gall and Leaf Blight, using the YOLO model, identification of nutrient deficiencies, particularly Magnesium and Potassium, through transfer learning and prediction of cinnamon bark maturity and quality grades utilizing spatial attention mechanisms based on diameter and color. Each model is optimized for mobile deployment to provide real-time feedback and enable efficient decision making. This AI-driven approach enhances disease management and improves yield quality while promoting sustainable, data-driven cinnamon cultivation in Sri Lanka.

Keywords: *Cinnamon, Crop Monitoring, Disease Detection, Smart Agriculture*

Paper ID: 371

Alpha boost AI – Exploring challenges in Early English Literacy Development using AI

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Abstract

Early literacy development (ELD) is a cornerstone of children's later cognitive and academic success, yet many children struggle with writing, reading and pronouncing, especially in multilingual environments where English is the second language of an individual. Traditional approach in which tracing and memorization are typical solutions but are not effective in delivering personalized or immediate feedback. To meet this need, this research creates Alpha Boost AI, an integrated framework for diagnosing and remediating multiple aspects of literacy based on artificial intelligence. This system was made possible with the use of diverse set of handwriting and oral samples manually compiled from Sri Lankan primary school children. The core models were developed to fit a limited dataset by leveraging pretrained architecture like RestNet and CRAFT via EasyOCR, alongside Convolution Neural Network (CNN), and BiLSTM, to detect spatial awareness of letter placement, letter recognition and differentiation, letter sequencing and phonetic understanding. These components are embedded with interactive learning environment that delivers personalised exercises, real time feedback, progress tracking, and dashboard view for parents and teachers. Model evaluations indicated strong performance in all domains. Irregularity in SALP were detected with 87% accuracy, recognition in UAL achieved ~85%, sequencing models reached over 90% recall and precision, and phoneme– grapheme accuracy increased from 53.2% to 78.6% in pilot test. These results demonstrate Alpha Boost AI's potential to transform early literacy instruction through intelligent, adaptive support that meets learners at their individual developmental levels.

Keywords: *Early Literacy Development, Spatial Awareness of Letter Placement, Artificial Intelligence based Education, Early Intervention*

Paper ID: 376

Emission-Aware Multi-Metric Reinforcement Learning for Adaptive Traffic Signal Control in Sri Lanka

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Abstract

Urban intersections in Sri Lanka experience growing congestion and greenhouse gas emissions, while signal control remains fixed-time and insensitive to demand variability. An adaptive traffic signal control framework based on reinforcement learning (RL) is proposed. The control task is formulated as a Markov decision process with state features comprising queue length, waiting time, braking events, and estimated emissions. A Deep Q-Network (DQN) is trained in the SUMO–TraCI microsimulation under static and dynamic demand scenarios. Multiple reward formulations are examined, including emission only and multi-metric designs with normalized, weighted components. Experiments show that emission-only rewards yield unstable learning, increased queuing, and no measurable emission reduction, indicating the limitations of single-metric optimization. A balanced reward combining queue length and braking achieves the most favorable trade-off, reducing average delay by up to 22% and CO_2 emissions by 15% relative to fixed-time baselines. The framework is further instantiated on OpenStreetMap-derived models of Sri Lankan intersections (Borella, Kollupitiya), demonstrating applicability to local geometries and operating conditions. The results indicate that emission-aware RL controllers can outperform fixed-time operation and offer a viable pathway for deployment to support congestion mitigation and emission-reduction objectives.

Keywords: *Adaptive Traffic Signal Control, Deep Q-Network (DQN), Emission Reduction, Reinforcement Learning, SUMO Simulation*

D. Session 5 : IoT, Embedded Systems and Robotics

Paper ID: 336

AI-Driven Autonomous Bee Health and Ecosystem Management System

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Abstract

Global honeybee population decline continues to threaten agricultural productivity and ecological stability, with annual colony losses exceeding 35%. Traditional hive inspections are labor-intensive, disruptive, and inadequate for early detection of diseases and environmental stress. This study presents an AI-driven autonomous bee health and ecosystem management system that combines IoT-based sensing, machine learning, and edge computing to enable real-time hive monitoring and intelligent automation. The system integrates four functional modules: environmental monitoring with timeseries forecasting, threat detection and autonomous control, AI-optimized hive site selection using geospatial analytics, and multimodal health assessment via visual and acoustic data. Field evaluations conducted across multiple apiaries in Sri Lanka achieved 92.6% accuracy in bee health assessment and 88.7% recall in threat detection, while improving honey yield by 23% compared with traditional methods. The proposed solution demonstrates how multimodal AI and IoT integration can advance sustainable apiculture through proactive, data-driven decision-making.

Keywords: *Apiculture AI, IoT Sensing, Hive Automation, Multimodal Analysis, Sustainable Beekeeping*

Paper ID: 456

Unveiling EEG Emotional Patterns During Interactive Engagement Activities: A Performance Comparison of Machine Learning Models

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Abstract

This paper presents a comparative evaluation of machine learning and deep learning models for emotion recognition from electroencephalography (EEG) signals recorded during interactive engagement activities. EEG data were collected using a Muse headband as participants performed engagement activities designed to elicit five emotions: Afraid, Happy, Calm, Neutral, and Sensitive. After preprocessing and feature extraction, eight machine learning and deep learning models were trained. Based on the experiment, Random Forest emerged as the best-performing classifier, achieving ~95.6% accuracy with balanced precision–recall, while gradient boosting and SVM also shown comparative results. The models demonstrated potential for real- time streaming despite slightly lower accuracy, highlighting scalability with larger datasets. These findings demonstrate the feasibility of consumer-grade EEG devices, enhanced with multimodal features, for robust emotion recognition in realistic engagement activities. The results underscore the effectiveness of multimodal fusion and engagement-based design, confirming that lightweight EEG systems can support practical, real-time affective computing applications in education, adaptive interfaces, and mental well-being monitoring.

Keywords: *EEG, Emotion Recognition, Engagement Activities, Multimodal Signals*

Paper ID: 464

IoT Based System for Early Detection and Monitoring of Mosquito Breeding Sites

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Abstract

This research develops an IoT-based dengue prediction and prevention system integrating real-time environmental monitoring, automated species identification, predictive analytics, and community engagement to combat dengue in vulnerable regions. The study addresses critical gaps in existing literature by fusing IoT sensor networks (temperature, humidity, water-level, and MEMS micro phones), epidemiological data from the National Dengue Control Unit (NDCU), meteorological records, and community-reported data via a multilingual mobile application. Methodologic ally, we employed stratified sensor deployment across urban, semi-urban, and rural zones, coupled with machine learning models (SVM/Random Forest for mosquito classification, CNN s for image-based breeding site detection, and time-series forecasting for outbreak prediction). Results demonstrated 89.2 5% prediction accuracy, dynamic heatmaps for risk visualization, and high community engagement (120 reports from urb an areas alone). The system enables data-driven public health interventions, reducing dengue spread through proactive breeding site elimination and real-time risk communication, representing a scalable paradigm shift in vector-borne disease control.

Keywords: *Mosquito, Breeding, Detection, Internet of Things (Iot)*

E. Session 1 : Human-Computer Interaction & UX Design

Paper ID: 173

Evaluating the Effectiveness of Mind Heaven: A Virtual Reality Meditation Solution Based on Theravāda Buddhist Practices

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Abstract

In modern urban life, stress and anxiety are prevalent due to fast-paced environments and limited access to tranquil spaces. Buddhist meditation, known for its therapeutic effects, often requires calm settings that are hard to access in urban areas and some of these kinds of environments might experience unexpected accidents as well. This research presents a Virtual Reality (VR)-based personalized Buddhist meditation application call Mind Heaven, aimed at stress reduction and mental relaxation. The application evaluates users' moods before and after meditation, offering individualized meditative environments based on users' emotional states. Through collaboration with Theravāda Buddhist monks in Sri Lanka, the system integrates authentic meditative guidance. Additionally, smartwatch-based physiological stress tracking and post-session survey are used to verify user feedback. The pilot evaluation with twenty participants indicates mood improvement and stress reduction in indicators. This study demonstrates the potential of immersive VR in mental wellness, paving the way for future integration with brain-computer interfaces and diversified meditation techniques.

Keywords: *Virtual Reality, Mindfulness, Personalized Meditation, Theravāda Buddhism, Mood Evaluation*

Paper ID: 266

A Comprehensive Review of Sri Lankan Sign Language Recognition and Sinhala Text/Speech to Sign Language Translation Technologies

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Abstract

Sri Lankan sign language serves as a vital communication method for the deaf and hearing impaired community in Sri Lanka. However, the lack of structured linguistic standards, geographical and regional diversity, and limited technological resources present significant challenges in bridging the communication gap between hearing and hearing-impaired populations. This paper reviews a past decade of developments in Sri Lankan sign language recognition and translation technology, both in terms of sensor-based and vision-based solutions to sign gesture recognition and Sinhala text and speech to Sri Lankan sign language conversion systems. Additionally, the paper analyzes the unique linguistic features of Sri Lankan sign language and the structure and limitations of available datasets. Comparative analysis highlights the strengths and drawbacks of each system, such as hardware dependency, environmental sensitivity, expressiveness, and scalability. The review identifies persistent challenges, including small dataset sizes, regional sign variation, and the need for expressive avatar-based synthesis, and outlines future directions for creating robust, inclusive technologies that better serve Sri Lanka's diverse deaf community.

Keywords: *Sign Language, Sri Lankan Sign Language, Sign*

Paper ID: 387

A Virtual Reality Immersive Experience of Sri Lanka's Sacred Heritage: VR Meditation Experience at the Ruwanweli Maha Seya Using Heart Rate and HRV Tracking

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Abstract

Meditation is a widely recognized practice that reduces stress, improves focus, and promotes mental well-being. For various reasons, it has become difficult for religious devotees to travel to more intimate places of worship, such as their sacred sites, and to worship and meditate in harmonious environments. This system involves creating a Unity-based VR application that simulates several sacred places in Anuradhapura city, including four of the eight sacred places among the "Atamasthana"" and a short five-minute meditation session. A user evaluation was conducted with 25 participants. The results showed a decrease of 5.4 BPM in average heart rate and a 10 increase in heart rate variability after the meditation session. In this research, the sacred city of Anuradhapura has been used as a sample, but any religious sacred place can be used for this purpose. Through this harmonious environment recreated through Virtual Reality (VR), users can experience mental relaxation regardless of physical location. This research is more important because it combines cultural and religious preservation with modern technological innovations. By incorporating physiological sensations into a VR meditation experience, it is possible to enhance user engagement and monitor the results of the meditation. It can be understood that the physiological effects of this VR-based meditation are a good basis to advance both the study of digital wellness and cultural scarcity.

Keywords: *Virtual Reality, Meditation, Biofeedback, Heart*

Paper ID: 400

Exploring Spatial Proximity and Relationships in a Multi-Perspective VR Game Design

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Abstract

This study adopts the framework of Interactional Proxemics to investigate the spatial relationships formed between players and their targets during interactions in Virtual Reality. According to the theoretical framework, the boundaries of this interactive space are influenced by the degree of intimacy between the player and the target, as well as their visual focus. This research explores how switching between first-person and third-person perspectives alters the interaction space, thereby providing distinct experiential outcomes. This VR project "Feather Forest" forgoes traditional button-based controls and instead employs hand-tracking technology, enabling players to interact with targets through physical touch. To facilitate meaningful and effective interaction upon contact, the interaction distance is designed based on principles derived from proxemics, remapping, and multi-perspective studies.

Keywords: *Virtual Reality, Multiple Perspectives, Proxemics*

E. Session 2 : Natural Language Processing & Speech Technologies

Paper ID: 338

Bimodal Speech Emotion Recognition with Attention and Feature Fusion

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Abstract

This paper introduces the Customer Voice Emotions Analysis Dataset (CVEAD), the first publicly available dataset specifically designed for emotion recognition in customer service interactions. We evaluate a hybrid Speech Emotion Recognition (SER) framework that integrates audio and text modalities, addressing the limitations of unimodal approaches in capturing subtle, context-driven emotions. Experimental results show that the audio-only model achieved an F1-score of 75.37%, the text only model reached 66.67%, while the hybrid model attained 80.97% using weighted voting, the best among the tested decision level fusion strategies. Feature analysis indicated that MFCCs and Spectral Roll-off were the most significant audio features, while emotion-specific lexical cues played a key role in distinguishing textual expressions of emotion. These findings highlight the complementary strengths of audio and textual cues in emotion recognition and establish CVEAD as a valuable benchmark for advancing SER research in real-world customer service contexts, demonstrating that both acoustic patterns and domain-specific vocabulary are critical for accurate emotion classification.

Keywords: *Speech Emotion Recognition, Multimodal Learning, Attention Mechanisms, Feature Fusion*

Paper ID: 355

Explainable Multilingual Sentiment Analysis for Sinhala, English, and Code-Mixed Banking Reviews

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Abstract

The growth of multilingual and code-mixed communication in the financial sector presents significant challenges for sentiment analysis, particularly in low-resource languages such as Sinhala. Existing NLP models often underperform due to limited annotated data, domain-specific vocabulary gaps, and a lack of transparency. This paper presents a multilingual and explainable sentiment analysis framework that addresses the challenges of low-resource and code-mixed languages by analyzing banking customer feedback in English, Sinhala, and Sinhala-English codemixed formats. A dataset of 13,000 aspect-tagged banking reviews spanning five key banking aspects is used for evaluation. The framework classifies comments into positive, neutral, or negative sentiment and provides interpretable explanations using SHAP (Shapley Additive Explanations) and LIME (Local Interpretable Model Agnostic Explanations). English sentiment classification is performed using a fine-tuned BERT-base-uncased model, while Sinhala/codemixed sentiment is handled by a hybrid XLM RoBERTa with a domain-specific lexicon correction approach. The framework achieves 92.3% accuracy and 0.89 F1-score for English, and 88.4% accuracy and 0.84 F1-score for Sinhala/code-mixed data. The proposed system addresses reproducibility, interpretability, and domain adaptation gaps, offering a deployable solution for multilingual financial sentiment monitoring.

Keywords: *Aspect-based Sentiment Analysis, Banking, Code-mixed, Explainable AI, Multilingual Transformer*

Paper ID: 402

'NoFake' Trustworthy Reviewer Scoring System for Detecting Fake Reviews

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Abstract

The proliferation of fake online reviews has severely undermined consumer trust and market fairness in digital platforms. Traditional detection systems relying on rule-based filters or shallow machine learning models often fail to detect sophisticated, artificially intelligent-generated, or behaviorally deceptive content. This research proposes a novel, intelligent system for fake review detection that integrates advanced Natural Language Processing, behavioral anomaly analysis, and explainable artificial intelligence to improve accuracy, transparency, and real-world usability. The system leverages a hybrid feature set of approximately 212 dimensions, including Term Frequency Inverse Document Frequency scores, sentiment-rating inconsistency, readability metrics, and reviewer behavioral signals such as review frequency and account metadata. A neural network is trained on the Deceptive Opinion Spam dataset (40,000 reviews) to classify reviews as genuine or fake, achieving 81.55% accuracy and an Area Under the Receiver Operating Characteristic Curve of 0.9019. Anomaly detection models specifically Isolation Forest and One Class Support Vector Machine are used to compute a dynamic trust score for reviewers, enhancing the detection of coordinated spam campaigns. To ensure transparency, SHapley Additive exPlanations based explanations are integrated into a full-stack web application, providing human-readable insights such as Sentiment-Rating Mismatch or Robotic Writing Detected. Results demonstrate that the proposed system outperforms traditional methods in both accuracy and interpretability, offering a scalable, trustworthy solution for e-commerce platforms, consumer protection agencies, and digital trust ecosystems.

Keywords: *Fake Review Detection, NLP, Behavioral Analysis, Explainable AI, Trust Scoring*

Paper ID: 473

Monolingual Transformer-Based Detection of Altered Profanity in Sinhala Facebook Comments

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Abstract

This study investigates the detection of deliberately obfuscated profanity in Sinhala Facebook comments, where users intentionally modify words to bypass keyword-based filters. To support this task, we created a novel, manually annotated dataset of 4,000 Facebook comments, representing the first comprehensive resource for Sinhala altered profanity. We evaluated two monolingual transformer models, SinBERT-small and SinBERT-large, for binary classification. SinBERT-large achieved a micro-averaged F1-score of 0.562 (Profanity F1: 0.671; Altered speech F1: 0.387), while SinBERT-small scored 0.554 overall (Profanity F1: 0.658; Altered-speech F1: 0.387). Both models performed well in detecting direct profanity but struggled with altered speech, with identical F1-scores indicating that increasing model size alone does not improve performance without more diverse training data. In terms of efficiency, SinBERT-small processed 1,148.752 samples/second, while SinBERT-large processed 637.363 samples/second. These results demonstrate the value of language-specific models for low-resource languages, with SinBERTlarge recommended for higher accuracy and SinBERT small for real-time applications.

Keywords: *Sinhala NLP, Altered Profanity Detection, Monolingual Transformer Models, Social Media Moderation, Low-resource Languages*

E. Session 3 : Sustainable Socio-Economic Ecosystems

Paper ID: 131

Project Management Predictive Framework

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Abstract

Project Planning is a critical phase in the software project management cycle. Traditional project management tools rely heavily on manual processes and do not provide accurate insights for the planning phase. This research focuses on developing an advanced software project management solution that utilises machine learning and AI technologies to enhance and provide accurate results. The system will automatically generate tasks from user stories, accurately estimate effort, budget, and identify risks. It also assesses team members' skills for an accurate task assignment and assignments and predicts infrastructure resource needs, suggesting cost-effective options to optimise resource use.

Keywords: *Task Generation, Job Role Effort Estimation, Human and Infrastructure Resource Allocation, Budget Prediction*

Paper ID: 396

Digital Collaboration Through BIM and Its Influence on Project Success in Socio-Economic Contexts

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Abstract

Building Information Modelling (BIM) has been a real revolution for the traditionally fragmented construction industry. Though BIM has emerged over a few decades, many users still find it challenging to utilise the exact benefits, especially in the aspect of design collaboration. Few scientific studies have been conducted in forming and enabling design collaboration environments in BIM projects. However, the impact towards project performance from BIM design collaboration is not addressed, which has hindered the practical applications and attainment of the benefits in construction projects. Therefore, this study attempts to understand the means of successful utilisation of design collaboration for improving project performance in a BIM-enabled environment. From the literature review, 12 project performance parameters were discovered. The level of design collaboration and their impact towards BIM project parameters were reviewed through the sequential exploratory mixed method. Initially, 8 semi-structured interviews and later a questionnaire survey were conducted. Findings revealed that the achievement of the design collaboration among different parties in a construction project differs, especially in terms of forming a BIM team, guidelines and management of a digital common data environment. Yet it is, found that many people have experienced a positive impact from design collaboration to project performance via BIM. Among all, digital coordination, project schedule performance, and stakeholder satisfaction record the highly influential project performance parameters. Further, a few strategies are proposed to identify barriers in achieving design collaboration for overcoming the challenges. The findings of this study promote BIM adoption for achieving positive project performance in the real.

Keywords: *Building Information Modelling, Design Collaboration, Project Performance, Construction Industry*

Paper ID: 440

Conflict-Driven Disruptions in Maritime Logistics: A Global Evidence Synthesis

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Abstract

This systematic review examines how geopolitical conflicts reshape maritime logistics, with emphasis on trade flows, port operations, and supply-chain resilience. Using a PRISMA-guided procedure, 51 peer-reviewed and scholarly sources (2015–2025) were synthesized. Evidence from the Russia–Ukraine war, Red Sea instability, and Indo-Pacific rivalries shows freight-cost surges, vessel rerouting, container imbalances, and port delays that undermine just-in-time systems and competitiveness. Export-dependent economies are disproportionately exposed; time-sensitive sectors (e.g., apparel, grains) face lead-time volatility, cost pass-through, and reputational risk under chokepoint congestion. Reported responses include supplier/route diversification, calibrated buffers, digital visibility (smart containers, blockchain), port automation, and collaborative governance. Overall, the review highlights the need for proactive geopolitical-risk assessment, predictive modelling, and coordinated digital–policy interventions to secure trade continuity, and it lays a concise foundation for future empirical evaluation of resilience strategies across maritime networks.

Keywords: *Geopolitical Conflicts, Maritime Logistics, Risk Mitigation, Supply Chain Resilience, Trade Disruption*

Paper ID: 450

Reducing Cancer Mortality Inequalities: The Role of Education, Socioeconomic Factors, and Digital Ecosystem Interventions

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Abstract

Cancer remains one of the leading causes of mortality worldwide, with education and socioeconomic status emerging as critical determinants of health outcomes. This review synthesizes global evidence on the impact of educational attainment and socioeconomic disparities on cancer mortality, emphasizing how structural inequalities hinder access to timely diagnosis, treatment, and preventive care. While traditional health systems often fail to address these disparities effectively, the rapid growth of digital ecosystems offers transformative opportunities. Digital marketplaces for healthcare services, telemedicine platforms, social media based awareness campaigns, and innovative health-tech startups can mitigate barriers related to low income and limited health literacy. Furthermore, the integration of information systems, digital collaboration tools, and knowledge management frameworks enables policymakers, practitioners, and communities to create inclusive, technology-driven solutions. This paper positions cancer mortality not only as a public health challenge but also as a socio-technical issue that demands sustainable digital interventions. By linking education, socio economic status, and mortality with digital entrepreneurship and organizational innovations, the study contributes to ongoing discussions on building resilient, equitable, and technology enabled socio-economic ecosystems in global healthcare.

Keywords: *Cancer, Mortality, Digital Ecosystems, COVID-19*

E. Session 4 : Artificial Intelligence & Machine Learning

Paper ID: 105

MOODZ: A Mobile Application of Mechanisms for Alleviation of Human Depression

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Abstract

Depression is a pervasive global health concern, profoundly impacting individuals across diverse demographics and life stages. With its far-reaching consequences on mental well-being, social functioning, and economic productivity, addressing depression has become a critical priority. Recent advancements in digital technologies and psychological methodologies have enabled the development of innovative, scalable solutions to tackle this pressing issue. This research focuses on targeted interventions for key demographic groups, including children, married individuals, postpartum woman and the elderly, ensuring tailored strategies to address their unique needs and challengers. Image processing and Machine Learning will be utilized for predictive analysis, enhancing the accuracy depression risk assessment. By integrating standardized diagnostic tools, predictive analysis for depression risk assessment, personalized therapeutic recommendations, and longitudinal progress monitoring, these approaches combine technological sophistication with evidence- based psychological frameworks. The synergy of these elements aims to enhance mental health care delivery, fostering greater accessibility, effectiveness, and improved outcomes for individuals affected by depression. This study highlights the transformative potential of technology-driven, personalized intervention in mitigating the global burden of depression and advancing mental health care.

Keywords: *AI-based Prediction, Human Depression, Image Processing, Machine Learning, Mobile Application*

Paper ID: 383

MindTrack360: Bipolar Risk Detection of Youth through Social Media Analysis

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Abstract

Mental health concerns are increasingly common among youth, particularly due to the rise of busy, high-stress lifestyles. Social media has emerged as a primary medium for self-expression, where individuals often disclose emotional states through posts, comments, and interactions. Among mental health conditions, bipolar disorder a serious mood disorder characterized by episodes of emotional highs (mania) and lows (depression) is especially common in individuals aged 18–29, according to the National Institute of Mental Health. This research proposes a web-based system MindTrack360, designed to analyze social media behavior to assess bipolar disorder risk. The system contains three integrated components: bipolar detection and risk level detection through linguistic analysis of social media text with explainable AI (PsyTex), emotion tracking and mood diary generation via an interactive chatbot for individuals identified at risk (EmoTra), and personalized exercise recommendations based on physical changes, detected risk level and emotional trends (BeWell AI). This approach aims to offer early mental health insights with minimal time commitment, supporting proactive self-awareness and digital wellness.

Keywords: *Bipolar Disorder, Mood Tracking, Social Media Analysis, Exercise Recommendation, Explainable AI*

Paper ID: 386

AI-Driven Marine Pollution Detection for Coral Reef Conservation in Sri Lanka

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Abstract

Marine pollution poses a severe threat to coral reef ecosystems, particularly in biodiverse regions such as Sri Lanka, where plastic waste, abandoned fishing gear, and oil spills contribute to habitat degradation and biodiversity loss. Traditional monitoring methods are often labor-intensive, limited in scope, and unable to support real-time intervention. To address these challenges, this paper proposes an AI-driven underwater object detection system tailored for marine pollution monitoring in coral reef environments. This study introduce an enhanced YOLOv8-based architecture integrated with Efficient Channel Attention (ECA), Bi-directional Feature Pyramid Network (BiFPN), deformable convolutions (DCNv2), and Ghost modules to improve detection accuracy and efficiency for small and occluded pollutants. A custom dataset combining publicly available underwater imagery with region-specific data from Sri Lankan reefs covering seven pollution classes, including plastic bottles, fishing nets, and surface/underwater oil spills, is curated and augmented using AI-powered preprocessing agents for color correction, contrast enhancement, and intelligent augmentation. The proposed model achieves a mean average precision (mAp@0.5) of 89.5%, a significant improvement over the baseline YOLOv8 (78.2%), with enhanced performance in small object detection (82.1% mAp@0.5) and robustness under low-visibility conditions. The system supports real-time inference at 40 FPS and includes an alert mechanism for conservation teams. This work presents a scalable, accurate, and deployable solution for AI-driven marine pollution detection, contributing to coral reef conservation and sustainable ocean management in Sri Lanka.

Keywords: *Underwater Object Detection, Coral Reef Conservation, Enhanced YOLOv8 Architecture, Efficient Channel Attention,(ECA), Bidirectional Feature Pyramid Network (BiFPN).*

Paper ID: 389

FITGEN – AI Smart Fitness Companion: An Integrated Multi-Modal Approach to Personalized Health and Fitness Management

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Abstract

This research presents FITGEN, a comprehensive AI-powered fitness companion system that integrates four core modules: AI Gym Trainer with Gamification, Medical Guidance System, AI Nutritionist, and Social Bridge for inclusive fitness engagement. Unlike existing solutions that address singular aspects of fitness technology, FITGEN provides a holistic approach combining real-time pose detection, chronic disease management, personalized nutrition planning, and accessibility features for special abled youth. The system utilizes Flutter framework with Firebase backend, implementing Google ML Kit for pose estimation, TensorFlow models for nutrition recommendations, and ESP32-based IoT sensors for vital sign monitoring. Comprehensive evaluation demonstrates 93.5% pose detection accuracy, 96% nutrition recommendation accuracy, 73% user retention after 4 weeks, and significant improvements in accessibility compliance. The integrated approach addresses critical gaps in existing fitness technologies while maintaining high user engagement and safety standards for diverse user populations including those with chronic conditions and developmental disabilities.

Keywords: *Accessibility, AI Fitness Companion, Chronic Disease Management, Personalized Nutrition, Pose Detection*

E. Session 5 : Artificial Intelligence & Machine Learning

Paper ID: 405

TALENT TREK: Enhancing Interview Decisions with Conversational AI

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Abstract

In the evolving landscape of recruitment, traditional hiring methods are increasingly inadequate for identifying top talent, particularly given the demands of modern, data-driven industries. This research introduces TALENT TREK, a modular, AI-powered Automated Human Resources (HR) Interview System designed to deliver fair, scalable, and multimodal candidate evaluations. The system integrates real-time job data scraping, skill forecasting, semantic Natural Language Processing (NLP) based response analysis, and facial emotion recognition within a microservices based architecture optimized for concurrent processing. Leveraging a multi-engine speech recognition ensemble and the all-mpnet-base-v2 transformer for semantic evaluation, it achieves high correlation with human assessments while minimizing transcription and comprehension errors. A custom Convolutional Neural Network (CNN) trained on FER2013 with domain-specific augmentations supports emotion classification, from which a novel Positive Confidence Score is derived. Multimodal data fusion enables adaptive weighting based on input quality, ensuring accurate composite scoring. Extensive testing demonstrates the system's potential to enhance transparency, consistency, and efficiency in enterprise-level hiring processes.

Keywords: *AI-Powered Interview System, Automated Recruitment Platform, Multimodal Candidate Evaluation, Facial Emotion Recognition, Semantic Answer Evaluation*

Paper ID: 408

Adaptive AI-Based Enhancement of Critical External Sounds in Insulated Vehicle Cabins for Improved Safety

D.B. Rathnayaka, L.H.N.Y. Wickramasuriya, J.V. Walpalage, Samadhi Rathnayake

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Abstract

The increasing acoustic insulation in modern and electric vehicles improves passenger comfort but unintentionally suppresses critical external sounds such as ambulance sirens, car horns, and train alarms, creating potential safety risks. While existing research has explored sound detection or localization in isolation, few systems integrate both capabilities in a unified framework for real-time vehicular deployment. This research proposes an adaptive AI-based system that detects, classifies, and selectively enhances these critical sounds in real time while providing directional awareness. Using a convolutional recurrent neural network (CRNN) trained on the UrbanSound8K dataset, the system processes incoming audio from external microphones, extracts Mel-frequency cepstral coefficients (MFCCs), and distinguishes safety-relevant cues from non-essential background noise. A dual-microphone setup enables the estimation of sound direction (left or right), providing additional spatial awareness to the driver. Detected signals are isolated through spectral filtering and relayed into the cabin with sub-300 ms latency, ensuring timely driver and passenger awareness without compromising comfort. Experimental results achieved 91.2% classification accuracy and 87.4% directional accuracy, confirming the system's feasibility for enhancing safety in insulated vehicle cabins and supporting future autonomous driving environments.

Keywords: *Critical Sound Detection, CRNN, Urbansound8k, Real-Time Audio Processing, Sound Direction Estimation*

Paper ID: 409

Human-AI Cooperative Driving through Emotion-Aware Decision Making and Driver Personalization

L.H.N.Y. Wickramasuriya, D.B. Rathnayaka, J.V. Walpalage, Samadhi Rathnayake

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Abstract

Conventional in-vehicle safety systems often neglect real-time emotional monitoring, prediction, and passenger influence, leading to reactive rather than proactive interventions. This paper presents an emotion-aware cooperative driving system that combines facial emotion recognition, time-series emotion forecasting, and personalized music-based regulation. The system detects both driver and front-seat passenger emotions through a Vision Transformer (ViT) model, while a time-series model anticipates the driver's upcoming emotional state. A prioritization algorithm ensures driver emotions hold precedence, with passenger states considered when the driver is stable. Based on this prioritized emotional context, the system regulates the in-cabin atmosphere using music recommendations drawn from the driver's preferred artists via the Spotify API. Experimental results show robust real-time emotion classification (86.4% validation accuracy), proactive forecasting (81.6% predictive accuracy), and improved driver acceptance due to personalization. The proposed framework advances intelligent transportation by shifting from static monitoring toward predictive, human-centered, and non-intrusive emotional regulation, thereby enhancing both safety and user comfort.

Keywords: *Emotion Recognition, Time-Series Analysis, Human-Centered AI, Music Recommendation, Driver Safety*

Paper ID: 428

Real-Time Optimization and Maintenance of Wind Turbine Performance using Digital Twin Technology

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Abstract

Wind power plays a vital role in Sri Lanka's renewable energy transition, yet coastal wind farms face challenges such as lightning strikes, wind misalignment losses, turbine cut-in/out events, acoustic impacts, and costly maintenance. This study proposes a digital twin–based framework to enhance real-time optimization and predictive maintenance of wind turbine performance. The framework integrates four modules: weather risk forecasting, operational efficiency, noise impact analysis, and predictive maintenance. Using SCADA data from the Mannar Thambapavani Wind Farm, long-term meteorological and lightning records, NASA satellite observations, and the WEA-Acceptance dataset, advanced machine learning models were developed to forecast lightning (F1 = 0.81, AUC = 0.87), estimate power losses (R^2 = 0.80, MAE = 3.4 kWh/h), optimize blade pitch, and produce short-term and medium-term energy forecasts. The digital twin simulation visualizes turbine dynamics, noise propagation, and maintenance scenarios. Results show improved prediction accuracy, 20–30% reduction in downtime, and a clear trade-off between energy efficiency (5–10° pitch) and noise (~56 dB > 25°). The framework strengthens situational awareness, operational reliability, and sustainability in monsoon-prone tropical environments.

Keywords: *Digital Twin, Wind Turbine Optimization, Aero-acoustics, Energy Forecasting, Predictive maintenance*

Paper ID: 444

Harnessing Predictive Analytics to Decode USD/LKR FOREX Dynamics through Macroeconomic Signals

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Abstract

The aim of this research is to forecast the USD/LKR exchange rate via major macroeconomic determinants and develop an efficient hybrid modeling framework. The principal objectives are to determine major macroeconomic determinants, design a hybrid model that represents a blend of econometric and deep learning approaches, and analyze performance gain achieved with such a combination. The approach utilizes deductive, secondary data from the economies of Sri Lanka and the United States. A lagged relationship and linear relationships are captured by an Autoregressive Distributed Lag (ARDL) model, whereas residuals are modeled and nonlinear trends captured using deep learning models. The key findings are that macroeconomic determinants of the United States as well as Sri Lanka statistically influence the exchange rate of USD/LKR. Although the ARDL-only model performs rather well, hybrid models greatly improve predictability and stability through error reduction and variance explanation optimization. The study concludes that more precise and understandable forecasts for extremely volatile developing economies are produced by combining sophisticated machine learning with macroeconomic fundamentals.

Keywords: *Autoregressive Distributed Lag, Deep Learning Models, Floating Exchange Rate, Macroeconomic Indicators, Performance Metrics*

E. Session 6 : Artificial Intelligence & Machine Learning

Paper ID: 300

Deep Echo State Networks for Financial Time Series Forecasting in High-Volatility Markets

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Abstract

Forecasting financial time series in stressful times is over-challenging due to the presence of noise, sudden regime shifts, and nonlinear dependence. Because of this fact, such traditional models are unable to fit into this dynamic world. Hence, the try-out with flexible and adaptive architectures. This paper discusses a Deep Echo State Network (Deep ESN) framework meant for short and medium-range forecasting of important financial indicators such as next-day returns, emerging price pathways, and cumulative returns. The Deep ESN realizes the advantages gained from the low training complexity of reservoir computing and the hierarchical memory representation to allow it the efficiently learning of multi-scale temporal patterns efficiently. Model evaluation utilized normalized returns series and multivariate inputs to assess predictive performance with accounts such as Mean Squared Error (MSE), Mean Absolute Percentage Error (MAPE), and Direction Accuracy (DA). Comparative experiments illustrate that the Deep ESN significantly performs better in volatile environments, producing smoother generalizations without losing sensitivity to structural changes in data. To sum up, the model, 3D scatters, and rolling error detection techniques have been employed in making the visualization clearer. What this proposition does is create an optimal, cost-efficient yet highly scalable methodology for continually up- to-date financial forecasting, as well as algorithm-based decisions.

Keywords: *Deep Echo State Networks, Financial Time Series Forecasting, Reservoir Computing, Volatility Modeling, Algorithmic Trading*

Paper ID: 390

Automated Netlist-to-Image Tool to Address Data Scarcity in Circuit Diagram Recognition

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Abstract

This paper introduces a tool for generating large datasets of computer-rendered electronic schematic diagrams. Recent research on schematic recognition with machine learning (ML) highlights that limited datasets hinder the advancement of ML models. The proposed tool directly addresses this gap by producing natural-looking computer rendered electronic schematics with up to six components, including both two- and three-terminal devices. For any given netlist, the tool automatically generates schematics and allows randomising them to create diverse range of variations. Additionally, it is scalable and can be extended in the future to include advanced multiterminal components. The generation of schematics with the proposed tool is faster and more accurate compared to popular LLM-based models. Since the location, orientation, and class of all elements are precisely known in the generated schematics, the tool can be used to automatically annotate the dataset, making it immediately and directly usable for ML model training and validation in electronic schematic recognition tasks.

Keywords: *Circuit Diagrams, Dataset Generation, Machine Learning, Netlist-based Generation, Electronic Schematic Recognition*

Paper ID: 301

Symbolic–Subsymbolic Synergy: Generative AI–Driven Multi-Scale ODE Simulation of Intracellular Signaling Pathways

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Abstract

Bridges span between the interpretability of sybolic models and the adaptability of data-driven mechanisms to reconcile them. A hybrid framework is introduced here that supplements the mechanistic simulations with a generative artiicial intelligence application in modeling intracellular signaling dynamics. The high-dimensional gene expression data are then compressed into a latent space through a Variational Auto-Encoder (VAE), which is intended to act as the control manifold parameterizing symbolic ordinary differential equations (ODE) models of biological signaling pathways. The MAPK (Mitogen-Activated Protein Kinase) cascade will be used for the evaluation of the framework, where latent features modulate reaction rates, generating biologically plausible temporal behavior. This allows for both efficient simulation by expounding on and an interpretable bridging between “virtual black box” generative modeling and transparent mechanistic reasoning. The symbolic sub-symbolic fusion proved to enrich the handling, scaling, and biologicality of the simulation pipelines in systems biology.

Keywords: *Generative AI, Systems Biology, Variational Autoencoder, Symbolic Modeling, ODE Simulation*

Paper ID: 343

Comparative Evaluation of YOLO and RT-DETR Machine Learning Models for Coral Bleaching Detection

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Abstract

This paper presents an evaluation of automated coral bleaching detection using deep learning-based image detection models. A consolidated dataset was created by combining open-source coral bleaching images with data augmentation to improve diversity and robustness. Two advanced detection algorithms were investigated: YOLOv8, a one-stage object detector, and RT-DETR, a transformer-based real-time detection model. Performance was analyzed using confusion matrices, error analysis, and classification metrics. Dataset refinement significantly reduced classification and background errors, particularly for bleached samples. Overall, RT-DETR demonstrated superior performance, while YOLO provided a reliable all-round solution. These results demonstrate the potential of deep learning models for scalable and automated monitoring of coral reef health.

Keywords: *YOLO, Image Detection, Machine Learning, RT-DETR, Coral Bleaching Identification*

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