AMITY UNIVERSITY
MADHYA PRADESH

Department of Electronics and Communication Engineering,
Amity School of Engineering & Technology
Amity University Madhya Pradesh

CONFERENCE SOUVENIR

International Conference
on
Advances in Intelligent Computing and Communication Technologies
[AICCT 2025]

📅 13th November 2025

EDITORS

Prof. (Dr.) Raghavendra Sharma | Prof. (Dr.) Kuldeep Singh | Dr. Rinkoo Bhatia
Dr. Narendra Kumar Garg | Dr. Devendra Rawat | Dr. Shally Goyal | Dr. Ajay Dadoria

INTERNATIONAL CONFERENCE SOUVENIR

Advances in Intelligent Computing and Communication Technologies (AICCT 2025)

Editors
Prof. (Dr.) Raghavendra Sharma
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Dr. Ajay Dadoria

FOUNDER PRESIDENT'S MESSAGE

It is matter of immense pride that Department of Electronics & Communication Engineering (ECE), Amity School of Engineering and Technology (ASET), Amity University Madhya Pradesh (AUMP), Gwalior is organizing the **International Conference on Advances in Intelligent Computing and Communication Technologies (AICCT 2025)** on Thursday, 13th November 2025.

In the present era of rapid technological transformation, Intelligent Computing, Electronics, and Communication Technologies form the backbone of innovation and sustainable progress. As the world moves towards emerging paradigms such as Artificial Intelligence, Internet of Things, Smart Devices, Next-Generation Communication Networks, and Sustainable Engineering Solutions, it is evident that these domains will play a pivotal role in shaping a knowledge-driven economy, fostering digital empowerment, and contributing to inclusive societal growth. In this context, I am confident that AICCT 2025 will provide an excellent platform for knowledge exchange, enabling participants to share pioneering research, innovative practices, and transformative ideas.

I heartly welcome all distinguished academicians, eminent scientists and subject experts from prestigious universities and institutions from India and overseas whose scientific deliberations and meaningful interactions will prove to be highly enriching for brilliant students, research scholars, Ph.D scholars, faculty members and other worthy participants and lead to strengthening academic and industrial collaborations at both national and international levels.

My appreciation to Prof. (Dr.) Vikas Thada, Director, ASET, AUMP and Prof. (Dr.) Raghavendra Sharma, Convener of the conference & Head ECE, ASET, AUMP as well as all the dedicated members of the Organizing Committee including co-conveners Dr. Rinkoo Bhatia and Dr. Devendra Rawat, Ph.D. scholars, and students for their tireless efforts under the guidance of Lt. Gen. V.K. Sharma AVSM (Retd.), Pro-Chancellor, AUMP and with unwavering support from Prof. (Dr.) R. S. Tomar, Vice Chancellor, AUMP. I also appreciate the continued encouragement and cooperation extended by Prof. (Dr.) M.P. Kaushik, Pro Vice Chancellor, AUMP.

The most strategic and unparalleled leadership of Dr. Aseem Chauhan Ji, Resp. Chancellor & Chairman, AUMP & Addl. President, Ritnand Balved Education Foundation (RBEF), would lead to outcome based and result oriented success of the seminar.

I warmly welcome all participants and hope they have a memorable and enriching experience that not only contributes to the goals of the conference but also leaves a profound impact on the fellow participants. I extend my best wishes for the grand success of AICCT 2025.

Ritnand Balved Education Foundation (RBEF)
(The Foundation of Amity Universities,
Institutions & Amity International Schools)

Message from Patron

Dr. Aseem Chauhan
Hon'ble Chancellor & Chairman
Amity University Madhya Pradesh

It gives me immense pleasure to extend warm greetings and best wishes to all the delegates, researchers, academicians, and industry professionals participating in the International Conference on Advances in Intelligent Computing and Communication Technologies, organised by the Amity School of Engineering and Technology (AUMP) on 13 Nov 25.

The theme of this conference reflects on one of the most dynamic and transformative areas of contemporary research. The convergence of intelligent computing and next-generation communication systems is reshaping the world around us, driving innovation across diverse sectors, including healthcare, manufacturing, transportation, education, and governance.

Intelligent computing when integrated with emerging communication technologies, enable real-time, data-driven decision-making on an unprecedented scale. The synergy between these fields promises smarter cities, more efficient industries, and enhanced quality of life for society at large. As a nation, it is imperative that we continue to innovate in these cutting-edge areas to maintain a strong global competitive advantage.

In this journey, our universities play a defining role, where ideas are transformed into innovations. By fostering interdisciplinary research, encouraging creativity, and nurturing a culture of curiosity, universities provide actionable solutions to the challenges being faced by the industry globally. This education technique enables our students to become inventors, entrepreneurs, and ethical leaders and shape the intelligent systems of tomorrow. This collaborative effort aligns seamlessly with the visionary ideals of our Hon'ble Founder President Dr Ashok K Chauhan, who has always envisioned Amity University as a global knowledge hub committed to inclusivity and sustainable development.

I am certain that AICCT 2025 will attract a distinguished gathering of researchers, academicians, and industry professionals from across the globe, creating a vibrant forum for meaningful discussions and knowledge sharing. I am confident that the deliberations and outcomes of this conference will greatly enrich the global dialogue on intelligent computing and communication technologies and inspire continued excellence in research and education.

I commend the organizers for providing a global platform that fosters the exchange of knowledge, ideas, and collaborative research among scholars and practitioners. I am confident that the deliberations and outcomes of this conference will inspire novel perspectives and contribute meaningfully to the advancement of intelligent and sustainable technologies.

I would like to take this opportunity to extend my heartfelt congratulations and appreciation to the organizing committee of AUMP (ASET) for organizing the International Conference on such a topical theme and wish them success in all future endeavors.
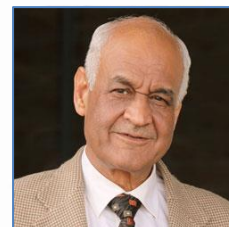
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Established vide Government of Madhya Pradesh Act. No. 27 of 2010

Lt Gen VK Sharma, AVSM (Retd.)
Pro Chancellor
Senior Vice President, RBEF

Message from Co-Patron

It gives me immense pleasure to extend my warm greetings to all participants of the *International Conference on Advances in Intelligent Computing and Communication Technologies (AICCT 2025)* organized by the Department of Electronics and Communication Engineering (ECE), Amity School of Engineering and Technology, Amity University Madhya Pradesh on 13 November 2025.

In the era of rapid technological transformation, innovations in computing and communication systems are driving unprecedented progress across industries and societies. This conference provides an excellent platform for academicians, researchers, and industry professionals to exchange ideas, share their latest research findings, and explore collaborative opportunities that can lead to meaningful technological advancements.

I am confident that this conference will generate valuable and thought-provoking insights for all participants. By highlighting cutting-edge advancements and addressing real-world challenges, the discussions and deliberations will prove immensely beneficial for professionals and experts from diverse fields around the world. The conference promises to be a fertile ground for the exchange of knowledge, innovation, and collaboration.

Amity University Madhya Pradesh has always emphasized academic excellence, research innovation, and holistic development. I am confident that AICCT 2025 will inspire participants to pursue impactful research and contribute to the creation of sustainable, intelligent solutions for the future.

A conference of this magnitude requires unwavering dedication, meticulous planning, and collaborative teamwork. I congratulate the organizers, participants, and contributors for their efforts in making this conference a grand success and wish them fruitful discussions and enriching experiences. I wholeheartedly congratulate the department of ECE, Amity School of Engineering and Technology for spearheading this prestigious event and extend my best wishes for the grand success of AICCT 2025.

Lt Gen VK Sharma, AVSM (Retd)
Pro Chancellor, Amity University Madhya Pradesh
Senior Vice President, Ritnand Balved Education Foundation
Former Commandant, Military College of Telecommunications Engineering
Former Colonel Commandant, Corps of Signals, Indian Army

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AMITY UNIVERSITY
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(Established vide Government of Madhya Pradesh Act. No. 27 of 2010)

Prof. (Dr.) R. S. Tomar
Vice-Chancellor

<u>Message from the Chairperson</u>

It is my privilege to welcome you all to the International Conference on *"Advances in Intelligent Computing and Communication Technologies"* **(AICCT-2025)** being organised on 13 November 2025 by the Department of Electronics and Communication Engineering, Amity School of Engineering and Technology, Amity University Madhya Pradesh.

As we gather here, we recognize the pivotal role that intelligent computing and advanced communication systems play in shaping our modern world. This conference is a platform for cross-disciplinary collaboration, fostering innovation and creativity that will drive humanity towards a smarter and more sustainable future.

At Amity University Madhya Pradesh, we are committed to nurturing talent, creativity, and research excellence. I believe that the discussions and outcomes of this conference will inspire new ideas, encourage young researchers, and strengthen the bond between academia and industry.

I appreciate the organizing committee for their tireless efforts and dedication to making this event a success. I invite you to participate in the vibrant academic discussions and experience the rich cultural heritage of Gwalior, our pleasant weather, and the warm hospitality of our university.

I extend my warmest wishes for engaging deliberations, profoundly fruitful interactions, and a memorable experience at AICCT-2025. May this conference be a transformative journey for all participants, filled with innovative idea, and lasting connections.

I wish the conference a grand success! May it be a landmark event that sparks meaningful connections and leaves a lasting impression on all attendees!

Prof. (Dr.) R. S. Tomar

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Message from Co-Chairperson

Prof. (Dr.) M. P. Kaushik
Pro Vice Chancellor (R)
Amity University Madhya Pradesh

I am delighted to know that the Department of Electronics and Communication Engineering, Amity School of Engineering and Technology is hosting the ***International Conference on Advances in Intelligent Computing and Communication Technologies (AICCT 2025)*** on 13 November 2025.

The world today stands at the threshold of a new technological era, where intelligent computing, communication networks, and automation are redefining the boundaries of human capability. AICCT 2025 embodies this spirit of innovation by providing a global forum for researchers and practitioners to exchange transformative ideas and foster solutions that address real-world challenges.

Amity University Madhya Pradesh remains committed to advancing research excellence and fostering an ecosystem that encourages innovation, creativity, and collaboration. I am confident that this conference will not only enhance academic discourse but also inspire participants to contribute meaningfully to sustainable technological progress.

AICCT 2025 will provide a vibrant platform for students, academicians, researchers, and industry professionals to exchange ideas, share insights, and inspire future innovations. It is a commendable initiative that fosters interdisciplinary dialogue and enhances the academia industry collaboration for sustainable technological development.

I extend a warm and heartfelt welcome to all invited speakers and participants who have joined us from across the globe. Your presence, research contributions, and thought leadership are invaluable to the success of this event. I am confident that the discussions and exchange of thoughts during the conference will spark new ideas, encourage collaborative research, and contribute significantly to innovations and intelligent computing and communication.

I congratulate the organizers for their tireless efforts and extend my best wishes for the grand success of AICCT 2025.

Message from Conference Chair

Prof. (Dr.) Vikas Thada
Director (Offg.)
Amity School of Engineering & Technology
Amity University Madhya Pradesh

It gives me immense pleasure to welcome all participants to **the *International Conference on Advances in Intelligent Computing and Communication Technologies (AICCT 2025)*,** organized by the Department of Electronics and Communication Engineering, Amity School of Engineering and Technology, Amity University Madhya Pradesh.

This conference is a confluence of innovation, intellect, and inspiration bringing together global researchers, academicians, and industry leaders to explore the frontiers of intelligent systems and communication technologies. In an age where artificial intelligence, IoT, and data-driven solutions are transforming the way we live and work, such academic gatherings play a pivotal role in shaping the future of technology and human advancement.

At ASET, we are deeply committed to promoting a culture of research, innovation, and interdisciplinary collaboration. *AICCT 2025* stands as a testament to this vision, offering a platform where new ideas can evolve into impactful innovations that serve society and industry alike.

I extend my sincere appreciation to the organizing team for their dedication and to all participants for contributing to this global dialogue. May this conference spark collaborations and discoveries that define the next era of intelligent technology. Let us embark together on this inspiring journey of discovery, dialogue, and innovation charting new frontiers in engineering. Wishing you a highly enriching and successful experience at AICCT 2025.

Message from Convener

Prof. (Dr.) Raghavendra Sharma
Head of the Department (ECE)
Amity School of Engineering & Technology
Amity University Madhya Pradesh

It is my great honour to welcome you all to the ***International Conference on Advances in Intelligent Computing and Communication Technologies (AICCT 2025).*** This event marks another milestone in our endeavour to foster academic excellence, interdisciplinary research, and global collaboration in emerging domains of technology.

The rapid growth of intelligent systems, machine learning, IoT, and communication technologies is reshaping the future of industry and education. *AICCT 2025* provides an excellent opportunity for researchers, scholars, and professionals to present their innovative work, share insights, and explore the transformative power of these technologies for sustainable and inclusive growth. This conference is an opportunity to foster innovations and highlight the recent technological advancements and achievements in Intelligent computing and communications.

At Amity University Madhya Pradesh, we believe in nurturing innovation that benefits society. This conference embodies our commitment to bridging the gap between theory and practice, between academia and industry, and between imagination and realization.

I extend my heartfelt gratitude to our patrons, distinguished speakers, organizing committee members, and all contributors who have worked tirelessly to make *AICCT 2025* a success. I wish all delegates an intellectually enriching and inspiring experience.

Advances in Intelligent Computing and Communication Technologies
(AICCT 2025)

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Track 1: Intelligent Computing & Control

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Track 1
Intelligent Computing & Control

AICCT2k25104

Removing EEG Artifacts with a Neural Filter Based on Classifier

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ABSTRACT

Signals from electroencephalography (EEG) are subject to a variety of motion artifacts throughout the acquisition process. Thus, eliminating these artifacts at the outset of human illness investigation is crucial. Numerous artifact removal techniques based on unsupervised learning have been developed and published in the literature. However, the high peaks of eye blink artifacts cannot be eliminated by the majority of current techniques. The objective is to develop a filter that simultaneously suppresses every motion artifact. To eliminate motion artifacts, this study proposes to construct an effective adaptive neural filter based on supervised learning. The classifier is employed to improve the signal's quality.

In order to categorize the data using wavelet classifiers, the research suggested first removing the artifacts. The classification performance of several combinations of EEG artifact reduction techniques for EEG data classification is compared and shown. All things considered, the suggested optimal reduced order filter can more effectively classify the EEG data. A multichannel database of genuine EEG signals is used to assess the filter's performance. Peak signal to noise ratio (PSNR) and root mean square error (RMSE) are used to provide parametric stability.

Keywords: EEG Signal Processing, Motion Artifact Removal, Adaptive Neural Filter, Supervised Learning, Wavelet Classification, Signal Quality Metrics

Innovative Generative Adversarial Networks: Architectures, Applications, and Future Directions

Sandeep Kumar Agrawal[1]   **Narendra Kumar Garg**[2]   **Jagdish Makhijani**[3]

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ABSTRACT

Generative Adversarial Networks (GANs) have emerged as one of the most transformative deep learning frameworks, enabling machines to generate highly realistic synthetic data across images, audio, video, and text domains. Despite their remarkable success, traditional GANs face critical challenges including mode collapse, unstable training, and limited controllability. This research paper explores innovative GAN architectures and techniques that address these limitations, such as Wasserstein GANs, Conditional GANs, StyleGAN, CycleGAN, and Diffusion-GAN hybrids. Furthermore, the paper reviews novel applications of GANs in medical imaging, cybersecurity, creative industries, and scientific simulations. Finally, it highlights open challenges and proposes future research directions for achieving more stable, interpretable, and ethically responsible GANs.

Keywords: Generative Adversarial Networks, mode collapse, IGAN, training

Detection and Classification of heart arrhythmia using deep learning

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ABSTRACT

The aim of this paper is to develop an effective deep learning–based approach for detecting abnormal electrocardiogram (ECG) signals. The proposed methodology focuses on differentiating arrhythmic ECG signals from normal ones, thereby contributing to early heart disease diagnosis. To enhance signal quality, preprocessing techniques are applied to the raw ECG data for noise detection and removal. The cleaned signals are then used to train a customized Convolutional Neural Network (CNN), which classifies them into normal or arrhythmic categories. Furthermore, arrhythmic signals are subdivided into different types of arrhythmia for more detailed analysis. The effectiveness of the proposed method is evaluated using the MIT-BIH Arrhythmia database, with performance measured in terms of sensitivity, specificity, and accuracy. Experimental results demonstrate that the method achieves high classification accuracy, indicating its reliability for automated ECG signal analysis and potential for clinical application.

Keywords: ECG, Filter, Arrhythmia, CNN, Dataset

BA-Text: Boundary Aware Text Framework for Text Detection in the Wild

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ABSTRACT

Text detection in natural scene images is popularly known as Wild Text Detection in the field of computer vision. It has developed as an important domain due to its utility and applicability in numerous areas such as autonomous driving, augmented reality, scene understanding and assistive technologies. Wild text is marked by high variations in text orientation, scale, shape, colour, layout, background colour and illumination conditions. Due to its various irregularities, it becomes challenging in text detection. Even existing text detection methods faces difficulty in text detection due to complex geometric shapes of texts. This paper attempts to introduce Boundary Aware Text (BA-Text), a new text detection framework designed to generate tight boundaries for text in natural scene images.

The proposed BA-Text framework implements an architecture that initiates with resizing, normalizing and pre-processing of images, then extract features using residual network backbone with feature pyramid network to generate multi-scale features. Features are fused to assist text instances representation. Differing from existing methods, BA-Text brings together a kernel shrinking factor and mid-line prediction strategy so as to capture the geometric attributes of text smoothly especially curved or irregularly shaped instances. Setting kernel shrinking factor to eliminate threshold noise while mid-line prediction provides structural guidance to align text contours. Thus, BA-Text approach enhances reliability and validity to detect text.

The objective function is formulated with a combination of classification and regression losses, optimized through a smoothed loss function to enhance stability during training. Experiments are conducted on benchmark datasets Total-Text and CTW1500 where BA-Text outdoes existing state-of-the-art methods such as PSENet, TextSnake, CRAFT, and DBNet by getting results having precision of 90.1%, recall of 83.1%, and F-measure of 86.5% on Total-Text, while obtaining precision of 87.7%, recall of 85.3%, and F-measure of 86.5% on CTW1500. BA-Text proposes generalize and effective resolution for detecting arbitrary-shaped-text in natural images in practical applications where accurate scene text detection is critical.

Keywords: Scene Text Detection, Wild Text, Boundary Aware Text, Kernel Shrinking, Feature Pyramid Network, Computer Vision

AICCT2k25136

A Comprehensive Study on Security Challenges and Defense Mechanisms in IoT Systems

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ABSTRACT

The Internet of Things (IoT) has transformed traditional computing by interconnecting billions of smart devices across industries such as healthcare, transportation, manufacturing, and smart homes. While this hyper-connectivity enhances efficiency and automation, it also introduces complex security and privacy challenges. IoT systems often operate with limited computational resources, heterogeneous protocols, and distributed architectures, making them vulnerable to cyber threats such as data breaches, device hijacking, and denial-of-service attacks. Ensuring end-to-end security within IoT environments requires the integration of lightweight cryptography, secure authentication, intrusion detection, and anomaly-based monitoring mechanisms. This study explores the key security concerns in IoT networks, analyzes existing protection frameworks, and discusses emerging solutions leveraging machine learning, blockchain, and edge computing for proactive threat mitigation. The objective is to establish a comprehensive understanding of IoT security risks and propose adaptive defense strategies that enhance the reliability, confidentiality, and resilience of connected systems.

Keywords: Internet of Things (IoT), Cybersecurity, Data Privacy, Intrusion Detection, Lightweight Cryptography.

AICCT2k25139

AI-Driven Decision Support System for Heart Disease Risk Prediction Using GdHO-Fused BiLSTM and HRV Features

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ABSTRACT

Heart disease remains one of the most critical global health challenges, emphasizing the urgent need for early, accurate, and intelligent diagnostic systems to enable timely clinical intervention and effective risk management. Conventional diagnostic approaches often depend on static datasets and lack real-time analytical capabilities, limiting their ability to capture dynamic physiological variations and contributing to reduced sensitivity and specificity.

To overcome these limitations, this research introduces an AI-driven Intelligent Decision Support System (IDSS) for heart disease risk prediction, integrating a Fused Layered Bidirectional Long Short-Term Memory (BiLSTM) architecture enhanced through Guarddog Hunt Optimization (GdHO). The proposed GdHO-Fused BiLSTM framework leverages the rich information contained in Heart Rate Variability (HRV) features, which serve as critical indicators of autonomic nervous system activity and overall cardiovascular health. By combining deep learning's sequential modeling capability with GdHO's powerful optimization mechanism, the system effectively captures complex temporal dependencies and enhances predictive reliability.

Overall, the proposed AI-based IDSS represents a dynamic and intelligent framework that supports clinicians with actionable insights, paving the way for next-generation predictive healthcare systems in cardiovascular disease management.

***Keywords*:** Artificial Intelligence, Intelligent Decision Support System, Heart Disease Riskm Prediction, Guarddog Hunt Optimization, Bidirectional Long Short-Term Memory, Heart Rate Variability.

New Approaches in Software Development Using Software Regression Techniques

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ABSTRACT

The tasks in Software Regression Testing are based on verifying the previous functionalities each time any modifications take place, and some new characteristics are added to the software. The present software development processes are iterative-incremental. Herein new software functionalities may be added in short development cycles. This creates every possibility that new defects may be added. The area of Regression testing is to uncover faults and fix problems every time an integration occurs.

Also, when changes occur in software size the need for software regression testing becomes more important to ensure control over software cost. It is performed by executing all test cases or only a subset of test suite. This research paper focuses on proposing selected test cases in software regression testing. This could be achieved with the help of Machine learning techniques in software regression testing. The proposed idea combines minimization and prioritization of regression technique. It includes list of changes made in software code. Thereafter a subset of test suite may be identified to ascertain the changed behavior in software. Of late with automation of software development these techniques are run along the development to reduce cost and effectiveness.

Keywords: Software Regression Testing, Minimization, Prioritization, Selection, Modification.

Dermatological Image Analysis: A Comparative Study of Deep Learning and Traditional Methods for Acne and Scar Prediction

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ABSTRACT

This paper presents a comprehensive analysis of models and algorithms for predicting skin conditions such as acne and scars from images. Various approaches-including Vision Transformers (ViT), YOLOv8, Convolutional Neural Networks (CNN), Principal Component Analysis (PCA), Eigenvectors, and Support Vector Machines (SVM)-are evaluated for their efficacy in dermatological image analysis. Using a standardized dataset, we assess accuracy, computational efficiency, and robustness of these methods. Techniques such as PCA with eigenfaces and K-Nearest Neighbors (KNN) with Histogram of Oriented Gradients (HOG) features are explored for enhancing prediction capabilities. The study highlights the potential of these methods and discusses future directions emphasizing the importance of large datasets and advanced computational resources for improved dermatological diagnosis and treatment.

***Keywords*:** Acne, CNN, Eigenfaces, Eigenvectors, Image Classification, KNN, Prediction, Scar, SVM, ViT Model, YOLOv8

A Comprehensive Review on Federated and Explainable Multimodal Hybrid Ensemble Learning for Early Brain Tumor Detection

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ABSTRACT

Detecting brain tumors at an early stage is vital for effective treatment and better patient outcomes. With the growth of artificial intelligence, hybrid ensemble learning models have shown great potential in improving diagnostic accuracy. Many existing methods still depend on single-modality data and lack transparency and privacy protection. In this review, we examine recent studies on multimodal hybrid ensemble learning for early brain tumor detection, emphasizing the use of federated learning for secure and decentralized data training, and Explainable AI for making model decisions more interpretable. The review highlights different model architectures, data fusion techniques, and explainability frameworks used in current research. From our analysis, we find that integrating multimodal data with federated and explainable ensemble models can significantly enhance diagnostic accuracy, reliability, and clinical trust, paving the way for safer and more transparent AI applications in healthcare.

Keywords: Multimodal Data, Hybrid Ensemble Learning, Brain Tumor Detection, Federated Learning, Explainable AI.

Enhancing Data Confidentiality and Integrity in Cloud Computing: A Survey

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ABSTRACT

The rapid adoption of cloud computing has revolutionized the information-technology landscape by delivering unprecedented scalability, flexibility, and cost efficiency. However, outsourcing sensitive information to third-party cloud service providers (CSPs) introduces critical security and privacy challenges. This study presents a comprehensive survey of state-of-the-art techniques that ensure data confidentiality and integrity in cloud environments. It evaluates existing encryption algorithms, access-control frameworks, and authentication mechanisms, emphasizing hybrid cryptographic approaches such as Attribute-Based Encryption (ABE) and One-Time Password (OTP) authentication. Findings reveal that although substantial progress has been achieved, persistent vulnerabilities—particularly in scalability, key management, and insider threats—remain unresolved [10]. The paper concludes that a multi-layered, defence-in-depth strategy integrating hybrid encryption, dynamic access control, and intelligent anomaly detection is vital for maintaining trust and resilience in modern cloud ecosystems.

Keywords: Cloud computing, Data Security, Data Privacy, Cryptology, Encryption of data, and Access control.

PCA-Driven Feature Engineering and Optimized Preprocessing for Enhanced Retinal Disease Recognition

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ABSTRACT

Accurate recognition of Diabetic Retinopathy (DR) remains a crucial objective in medical image analysis, supporting early diagnosis and timely treatment intervention. However, retinal fundus images often exhibit high dimensionality, illumination variability, and redundant visual information, which can hinder model performance and increase computational demands. This study introduces an efficient preprocessing and PCA-informed deep feature engineering framework to improve the accuracy and generalization of DR detection systems. The proposed approach employs advanced image preprocessing techniques—such as illumination normalization, noise reduction, and adaptive contrast enhancement—to refine image quality and emphasize pathological regions. Principal Component Analysis (PCA) is subsequently integrated with deep convolutional feature representations to extract compact and discriminative components, effectively reducing dimensionality while preserving salient visual cues. These PCA-enhanced deep features are used to train and fine-tune multiple deep learning classifiers for DR stage classification. Experimental evaluation demonstrates that the hybrid integration of robust preprocessing, PCA-based dimensionality reduction, and deep learning significantly enhances diagnostic accuracy, reduces overfitting, and accelerates convergence compared to conventional image-based training pipelines. This framework provides a computationally efficient and scalable solution for automated DR recognition, advancing computer-aided ophthalmic diagnostics and precision healthcare.

Keywords: Diabetic Retinopathy (DR); Retinal Fundus Images; Deep Learning; Principal Component Analysis (PCA); Feature Engineering; Image Preprocessing; Dimensionality Reduction; Convolutional Neural Networks (CNN); Computer-Aided Diagnosis; Ophthalmic Image Analysis; Medical Image Classification.

A Mathematical Model for Optimized Energy-Efficient Data Transmission in Intelligent IoT Networks Using Deep Learning and Game Theory

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ABSTRACT

The rapid growth of Internet of Things (IoT) ecosystems demands energy-efficient data transmission strategies to sustain intelligent network operations. This paper presents a hybrid mathematical model integrating deep learning and non-cooperative game theory to optimize energy consumption while maintaining high transmission reliability. The proposed model formulates the energy–throughput optimization as a multi-objective problem expressed as

$$\min_{P_i} \ J = \sum_{i=1}^{N} \left(\alpha_i E_i(P_i) - \beta_i R_i(P_i) \right),$$

subject to $0 \leq P_i \leq P_{max}$ where $E_i(P_i)$ and $R_i(P_i)$ denote the energy expenditure and data rate of the ith node, respectively, while α_i and β_i are adaptive weighting factors learned through a deep neural network. A Nash equilibrium is derived to ensure stable and fair resource allocation among IoT nodes, guaranteeing network-wide energy optimization. Simulation results demonstrate that the proposed framework achieves up to 35% reduction in energy consumption and 25% improvement in throughput compared to traditional transmission schemes. The synergy of deep learning and game-theoretic modelling enables adaptive and intelligent energy management, making the model highly suitable for next-generation IoT and edge computing environments.

Keywords: Energy Efficiency, IoT Networks, Deep Learning, Game Theory, Nash Equilibrium, Optimization, Intelligent Communication, Edge Computing

Optimization of Composite Material Processing Parameters Using Response Surface Methodology (RSM): A Statistical Approach

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ABSTRACT

The performance of composite materials depends significantly on the optimization of their processing parameters, which influence their microstructure and mechanical behaviour. This study employs Response Surface Methodology (RSM) as an effective statistical tool to model and optimize the key process variables during composite fabrication. Using Design of Experiments (DOE) techniques such as Central Composite Design (CCD) and Box–Behnken Design (BBD), the effects of parameters like reinforcement percentage, stirring speed, and processing temperature on responses such as hardness, tensile strength, and wear resistance were analyzed. A quadratic regression model was developed, and Analysis of Variance (ANOVA) confirmed its adequacy and significance. The generated response surfaces and contour plots identified the optimal conditions for enhanced performance. The results demonstrate that RSM is a reliable and efficient approach for minimising experiments, predicting process behaviour, and improving composite material properties for advanced engineering applications.

Keywords: RSM, Composite Materials, DOE, ANOVA, Mechanical Properties.

Comprehensive Review of Deep Learning Approaches for Medical Image Processing and its Applications

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ABSTRACT

Medical image processing is a multidisciplinary field crucial to modern medicine, encompassing various techniques to extract, enhance, and interpret information from medical images. In current scenario, the Artificial Intelligence (AI) is helpful in interpretation of medical imaging modalities, such as MRI, CT, X-ray, and Ultrasound, generates vast amounts of data essential for clinical decision-making. This emphasizes the importance of image preprocessing techniques to enhance image quality by mitigating artifacts, intensity inhomogeneities, and noise that may arise during data acquisition. This study outlines a systematic approach to medical image analysis, encompassing stages from image acquisition to diagnosis, highlighting the critical role of segmentation and feature extraction. Advanced machine learning and deep learning methodologies, including quantum-based morphological pattern analysis (QMPA), quantum-feature-based segmentation networks (QFS-Net), and U-net variants, were evaluated for their efficacy in medical image segmentation and classification. This study also discusses traditional machine learning classifiers, such as support vector machines and random forests, alongside deep learning models, such as Convolutional Neural Networks (CNNs) and their quantum-enhanced versions.

Keywords: Medical Image Processing, Artificial Intelligence, Deep Learning, Quantum-Based Image Analysis, Segmentation and Classification, Clinical Decision Support.

Towards Human-Like Cognition: A Framework for Emotionally Intelligent Artificial Agents

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ABSTRACT

AI has made stupendous advances in perception and reasoning, but it cannot be called emotional in the sense in which human cognition can be regarded. In this paper, an Emotionally Intelligent Artificial Agents (EIAAs) framework is proposed, a cognitive reasoning and affective computing framework that employs the human-like interpretation and reaction. The suggested system uses deep learning to identify emotions and reinforcement learning to adaptive behavior, which allows agents to make contextual and sympathetic decisions. In contrast to traditional AI models which just follow the rules, this one will enable agents to read emotional signals, respond to changes in time, and improve the quality of human-AI interaction. The results of the experiment indicate an increase in the accuracy of emotional recognition and level of user engagement. The framework is a move towards Cognitive AI that combines rational intelligence with emotional sensitivity as a way of achieving more natural and trustworthy artificial agents.

Keywords: Emotionally Intelligent Artificial Agents, Affective Computing, Deep Learning, Reinforcement Learning, Human-AI Interaction, Cognitive AI Framework.

AICCT2k25170

Quantum Cryptography- Reliable Encryption: A Review

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ABSTRACT

In Quantum there are many areas where research and development take place in the world of science and technology. One of the fields is Quantum Computing and Communication. Quantum computing may be a new technology with the potential of exponentially powerful computation. The facility of quantum computing comes from the flexibility to store large info in a very single bit. This paper gives a concise review on what's going on in quantum computing and cryptography both. This paper attempts to give the whole idea about cryptography, polarization, quantum entanglement and also use in communication via quantum.

*Keywords***:** Quantum Computing, Quantum Cryptography, Quantum Key Distribution, Quantum Entanglement, Post-Quantum Algorithms, Quantum Communication.

Track 2

Frontiers in Communication Technologies

MIMO Configured Microstrip Patch Antenna for 5G mm-Wave Applications

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ABSTRACT

The fifth-generation wireless technology which will operate at millimeter-wave frequency band also called 5G high band is supposed to overwhelm the shortcoming of the existing wireless communication technology. At present, the digital society suffers from low data rates, high latency, weak connectivity, and many other similar issues which prevent the users from fully leveraging the technology. 5G emphasizes long-distance communication having larger bandwidth to accommodate more users along with the reduced latency as well as compact devices. To procure such characteristics, antennas should be versatile to cover most of the aspects of the fifth generation. By incorporating multiple transmissions as well as the antennas and by decreasing multipath fading effects, the data rate can be increased in MIMO antennas. One of the keys to increasing the channel capacity of MIMO systems is to design multiple antennas for independent channels. In addition, the antennas should be small and low-profile that can easily fit into hand-held devices. Furthermore, a low mutual coupling MIMO antenna is required for a 5G mobile communication system.

Keywords: 5G mmWave, MIMO Antenna Design, Ultra-Low Latency, High Data Rate, Compact Antennas, Wireless Communication Innovation.

AICCT2k25102

Graphene-Integrated THz MIMO Antenna with AI-Driven Bandwidth Optimization for Future 6G Networks

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ABSTRACT

This research presents the results of a study that combined simulation, an RLC equivalent circuit, and machine learning (ML) to enhance indoor wireless communication for future 6G applications. The proposed antenna is fabricated on a polyimide substrate. It is remarkably compact, measuring only 95.52 x 227.24 μm^2, and features impressive performance metrics. These include a wide 4.331 THz bandwidth (operating from 0.631 THz to 4.962 THz), a high peak gain of 13.3 dB, and 95% efficiency. The antenna also demonstrates strong isolation, with an isolation value of 27 dB. The envelope correlation coefficient (ECC) falls below 0.0002, while the diversity gain (DG) exceeds 9.99.

An RLC equivalent circuit model of the proposed MIMO antenna was created using the Advanced Design System (ADS) to validate the return loss data obtained from the Computer Simulation Technology (CST) simulation. Following extensive data collection from the CST Microwave Studio (MWS) simulation, a supervised regression ML technique was applied to predict the antenna's performance. The Gaussian Process Regression model proved to be the most accurate, achieving nearly 99% accuracy, which was confirmed by high R-squared and variance scores. This model also exhibited the lowest error (less than one) in predicting the antenna's bandwidth. The combined results from the CST simulations and the machine learning predictions indicate that the proposed antenna is a strong candidate for future 6G terahertz band applications.

*Keywords***:** 6G Wireless Communication; Terahertz MIMO Antenna; RLC Equivalent Circuit; Machine Learning (ML); Gaussian Process Regression; CST Simulation; ADS Validation; Polyimide Substrate.

Design of AI based fractal rectenna for wireless power transmission and radio frequency energy harvesting for Electric Vehicles

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ABSTRACT

This manuscript proposes a unique fractal rectenna design for transmission of wireless power transmission and radiofrequency (RF) energy simultaneously on the same channel. Rectenna is a combination of rectifier+ antenna which is optimized for efficiency improvement using AI tools like ANN, Neuro-fuzzy, Genetic Algorithm, Particle Swarm Optimization, Ant Colony Optimization techniques. The goal of this research is to find a way to charge electronic devices wirelessly using radio frequency (RF) electromagnetic (EM) waves (Rectenna using energy detection-based spectrum sensing).

Keywords: Artificial Intelligence, Wireless Power Transfer, Electric Vehicles, Genetic Algorithm, Particle Swarm Optimization, Ant Colony Optimization, Rectenna, Fractal Antenna

Development of Wideband Antenna Arrays for Millimeter-Wave 5G Applications

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ABSTRACT

With the recent push toward 5G millimeter-wave (mmWave) technology, a variety of compact antenna array designs have emerged for mobile and handheld devices [1]. These designs commonly employ methods such as dipole, quasi-Yagi, Vivaldi, slot, multilayer low-temperature co-fired ceramic (LTCC), and microstrip patch antennas. Dipole antennas are simple to implement, requiring two quarter-wavelength monopoles [2], and their operating bandwidth can be enhanced by adding more branches [3] or modifying the structure [4]. For improved end-fire radiation, high directivity, and wide fan-beams, quasi-Yagi [5]–[7] and Vivaldi [8]–[11] arrays have been explored, with one notable Vivaldi design in [11] integrating a heatsink with minimal effect on its wide impedance bandwidth of 28.8% (21.63–28.83 GHz). To accommodate metal-casing smartphones, slot array designs have been integrated into the device edges [12] or top section [13]. A modified tilted slot array [13] was adapted into an H-shaped design for dual-band operation at 28 and 38 GHz [14]. Additionally, LTCC technology offers a low-profile and compact solution for antenna-in-package (AiP) applications, enabling designs like a 1×4 array for 39 GHz operation [15], [16] or a 1×7 array with good pattern agility at 28 GHz [17]. However, LTCC technology requires precise fabrication and has higher production costs than printed antennas. This letter proposes a planar 1×4 antenna array with a broad 28% bandwidth, covering the 5G FR2 NR bands n257/n258/n261 (24.25–29.5 GHz). The proposed array has a compact size of 26 × 5 mm and a low profile of 1.524 mm (0.142λ0 at 28 GHz). The design's performance, including gain, efficiency, radiation pattern, and beam scanning angles, was experimentally validated using soldered SMPM connectors

Keywords: 5G mmWave Antenna; Planar Antenna Array; Microstrip Patch Antenna; Quasi-Yagi Array; LTCC Technology; Wideband Design; FR2 NR Bands; High-Gain Compact Antenna.

AICCT2k25108

Review of Performance Analysis of Intelligent Reflecting Surface Assisted NOMA Networks using k-μ Fading channel

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ABSTRACT

The integration of Intelligent Reflecting Surfaces (IRS) with Non-Orthogonal Multiple Access (NOMA) has emerged as a promising approach to enhance spectrum efficiency and support massive connectivity in next-generation wireless networks. This work presents a comprehensive performance analysis of IRS-assisted NOMA systems under the generalized k-μ fading channel model, which effectively characterizes a wide range of wireless propagation environments. By employing analytical modeling and simulations, we evaluate key performance metrics such as outage probability, ergodic capacity, and system throughput. The results highlight the significant role of IRS in mitigating fading effects and improving signal quality for multiple users sharing the same spectrum resources. Moreover, the study demonstrates how varying the k and μ parameters influence system reliability and user fairness, offering insights into the design of robust and adaptable communication systems. The findings provide a deeper understanding of IRS-NOMA integration and its potential to meet the demands of beyond-5G and 6G networks.

Keywords: NOMA, IRS, generalized fading channel, and outage probability.

Power-Delay Optimization of Radiation-Tolerant SRAM Cells in Sub-20nm CMOS

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ABSTRACT

As CMOS technology scales below 20nm, conventional SRAM designs face severe challenges due to increased sensitivity to radiation strikes, leakage currents, and process variations. In space and other radiation-rich environments, ensuring both reliability and energy efficiency is essential. This paper proposes a radiation-tolerant SRAM cell optimized for power and delay performance in sub-20nm CMOS technology. The design integrates circuit-level hardening techniques with device-level optimizations to suppress single-event upsets while reducing leakage power. Extensive simulations validate the effectiveness of the proposed cell, showing enhanced read/write stability, reduced access delay, and a significantly improved power–delay product compared to conventional SRAM architectures. The results confirm that the proposed approach enables reliable and low-power operation, making it a strong candidate for future space and mission-critical memory applications.

*Keywords***:** Radiation-hardened SRAM, Power–Delay Optimization, Sub-20nm CMOS, Reliability, Space Applications, Single-Event Upset (SEU), Low-Power Memory

Protecting user location privacy from cellular service providers with a Zipper Phone

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ABSTRACT

Wireless service providers monitor every user connection's time and location. The identities of anonymous wireless service users have been successfully exposed through location inference attacks. We present Zipper phone algorithm in this paper as a method that enhances user privacy by utilising the current cellular infrastructure. A community of users can utilise Spartacus to schedule their connections in a way that keeps them anonymous with the least amount of utility loss. We assess Zipper phone algorithm from the viewpoints of a community of privacy-conscious users and a cell service provider. We also employ two datasets that contain hundreds of users' cell tower records to quantify Zipper phone algorithm 's privacy/utility trade-off. We describe and evaluate an approach for deanonymization that combines trajectory linkage and location profiling. Users can decrease their identifiability by up to 45% by changing their identities every ten minutes and going offline for 30 seconds.

Keywords: Trajectory linkage, location profiling, User profiling, Zipper phone, location inference.

Rapid Prototyping of 5G Microstrip Patch Antennas Using Python-Based Analytical

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ABSTRACT

The development of efficient, low-profile antennas is a critical requirement for the deployment of fifth-generation (5G) wireless communication systems. Microstrip patch antennas are widely adopted due to their compact size, planar geometry, and ease of integration with modern circuits. This paper presents the design and analysis of a rectangular microstrip patch antenna for 5G Sub-6 GHz applications, using a Python-based computational framework. Closed-form equations are implemented in Python to calculate patch dimensions for a 2.5 GHz resonant frequency on an FR-4 substrate, followed by numerical modeling of return loss (S11), voltage standing wave ratio (VSWR), and radiation pattern using simplified circuit-inspired and trigonometric approximations. The proposed Python workflow demonstrates rapid, reproducible evaluation of antenna performance, offering a cost-effective alternative for full-wave electromagnetic simulation in tools such as HFSS or CST. Results show a well-matched antenna with S11 below –20 dB, VSWR near 1.1, and a broadside radiation pattern with a peak gain of approximate 5 dBi, validating the feasibility of Python-based modeling for 5G antenna prototyping.

Keywords: 5G Sub-6 GHz Antenna; Microstrip Patch Antenna; Python-Based Modeling; FR-4 Substrate; Return Loss (S11); VSWR; Radiation Pattern Analysis.

Simulative Analysis of Wireless Body Area Network for Advanced Healthcare

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ABSTRACT

Wireless Body Area Networks (WBANs) enable continuous health monitoring by integrating miniature sensors either worn on or implanted within the human body. While these networks offer great promise for real-time healthcare delivery, their performance is constrained by limited battery capacity, energy-intensive transmissions, and routing inefficiencies that can degrade reliability and increase latency. This paper presents an Energy-Harvesting Dual Forwarding Scheme (EH-DFS) designed to enhance energy utilization, routing stability, and data delivery in WBANs. The proposed framework groups sensors into two logical clusters and assigns forwarding responsibilities based on residual energy, link quality, and predicted reliability. By combining ambient energy harvesting—piezoelectric, thermoelectric, photovoltaic, and RF—with a dual-forwarding recovery strategy, EH-DFS prevents premature node depletion and minimizes packet loss under dynamic conditions. A comprehensive system model is developed in which each sensor node detects physiological signals, processes the data locally, and transmits information to a sink node. Forwarding node selection incorporates a Forwarding Cost Level (FCL) metric integrating remaining energy, inter-node distance, predicted link quality, and signal-to-noise ratio (SNR). Link reliability is estimated using an Exponentially Weighted Moving Average (EWMA) of past measurements, ensuring that only stable links participate in forwarding decisions. MATLAB (R2024a) simulations compare EH-DFS against three benchmark protocols—EH-RCB, EERP, and ELR-W—using key performance indicators such as network lifetime, throughput, end-to-end delay, packet accuracy over time, power dissipation, and energy efficiency.

Results demonstrate that EH-DFS consistently outperforms the baseline schemes across all metrics. Network lifetime is extended by delaying node inactivity through balanced energy consumption and efficient harvesting. Throughput remains highest across multiple transmission rounds with reduced retransmissions, while average end-to-end delay is kept low and stable—critical for urgent healthcare applications. Packet delivery accuracy declines more slowly over time compared to competing methods, indicating robust communication even as nodes age. Power dissipation and energy-efficiency curves show that EH-DFS minimizes unnecessary transmissions and optimally allocates forwarding tasks, sustaining energy efficient

operation for longer periods. Collectively, these findings confirm that the proposed EH-DFS protocol strikes an effective balance between energy efficiency, reliability, and low latency, making it a strong candidate for deployment in energy-constrained, delay-sensitive WBAN healthcare systems and other next-generation wearable sensor networks.

Keywords: Energy-Harvesting Dual Forwarding Scheme, Forwarding Cost Level, Healthcare applications, Wearable sensor networks, Wireless Body Area Networks

Performance Analysis of OTFS Modulation in VLC System

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ABSTRACT

Visible Light Communication (VLC) has emerged as a compelling, spectrum-abundant complement to conventional radio-frequency (RF) links, offering high data rates, immunity to electromagnetic interference, and improved energy efficiency. Yet, dispersive optical channels in mobile multipath environments introduce pronounced inter-symbol and inter-carrier interference that severely constrains link reliability. These challenges are particularly acute in fast-changing scenarios such as vehicle-to-vehicle (V2V) links and dense Internet-of-Things (IoT) deployments, where channel dynamics fluctuate on sub-second timescales.

This paper introduces a dynamic VLC channel model that emulates realistic mobile multipath propagation, capturing both Doppler and delay spreads under diverse mobility patterns. On top of this model, we investigate the performance of Orthogonal Time Frequency Space (OTFS) modulation, which jointly exploits time-frequency diversity, in combination with a low complexity Message-Passing (MP) detection algorithm at the receiver. The proposed OTFS-MP framework is benchmarked against conventional Orthogonal Frequency Division Multiplexing (OFDM) employing a Minimum Mean Square Error (MMSE) detector to quantify gains under time-varying optical channels. Extensive MATLAB (R2024a) simulations demonstrate that OTFS with MP detection achieves an SNR advantage of 6–8 dB relative to OFDM in generic time-varying conditions and up to 9–10 dB under the Random Waypoint (RWP) mobility model, which closely mirrors realistic mobile VLC scenarios. Bit-error rate remains nearly invariant over a range of Doppler spreads (0.094–0.103) but exhibits greater sensitivity to delay spread (0.36–0.39), underscoring OTFS's resilience to temporal fluctuations. Throughput improves from 0.085 Mbps at 0 dB SNR to 0.13 Mbps at 30 dB SNR, with diminishing incremental gains at high SNR levels due to residual channel impairments.

These graph-backed findings confirm that combining OTFS modulation with MP detection significantly enhances link reliability, spectral efficiency, and robustness under challenging mobile VLC conditions. The demonstrated performance gains position OTFS as a strong candidate for beyond-5G VLC networks, especially for latency-sensitive and mobility intensive applications such as V2V communications and large-scale IoT systems. By uniting a realistic dynamic channel model with an advanced modulation–detection pair, this work provides a reproducible framework and new performance insights for the design of Next- Generation Optical Wireless Networks.

Evaluation of Channel Capacity under Varying Performance Metrics in Underwater Optical Wireless Communication

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ABSTRACT

Underwater Optical Wireless Communication (UOWC) is increasingly recognized as a viable high-speed alternative to conventional Underwater Acoustic Communication (UAC) owing to its broader bandwidth, lower latency, and enhanced security. However, the performance of optical links beneath the water surface is dominated by medium-dependent factors such as absorption, scattering, turbidity, and depth. This study presents a simulation-driven analysis of UOWC channel capacity under a range of system and environmental conditions, with emphasis on the interplay between transmit power, receiver efficiency, beam divergence, receiver field of-view (FOV), bandwidth, absorption coefficient, and water depth. Results demonstrate that carefully tuning transmitter and receiver parameters can significantly boost capacity at short and medium distances. Specifically, higher transmit powers, narrower beam divergence angles, and elevated receiver efficiencies increase the received optical power and channel throughput. For example, at 15 m range under moderate turbidity, a 20 W source yields a capacity exceeding 2×10^7 b/s compared with approximately 1×10^7 b/s for a 5 W source, while at ranges below 10 m all cases converge above 250 Mbps. Similarly, narrowing the beam from 60° to 30° or reducing FOV angles from 60° to 10° improves received power by concentrating optical energy and suppressing background noise. Nevertheless, across all scenarios, capacity decays exponentially with increasing depth and absorption; beyond roughly 25–30 m, the received power approaches zero regardless of transmit power, beam angle, or FOV. These findings confirm that while parameter optimization improves link efficiency in favorable conditions, the fundamental limits imposed by optical attenuation cannot be eliminated.

The analysis further indicates that bandwidth augmentation benefits short-range performance but does not offset the attenuation-driven losses at longer ranges. Consequently, UOWC is identified as highly efficient for high-data-rate, short- to medium-range submerged links in low-turbidity waters, but its standalone application becomes less viable for long-range or high-turbidity scenarios. To overcome these constraints, a hybrid communication architecture combining UOWC with acoustic or radio-frequency subsystems is proposed to ensure robust, scalable underwater connectivity while leveraging the strengths of each modality. Future work will focus on experimental validation of the presented model, exploration of advanced

modulation and coding techniques tailored to underwater optical channels, and deployment of adaptive machine-learning-based channel estimation and parameter control to further enhance link resilience, throughput, and energy efficiency.

Keywords- Channel Capacity, Field-of-View, Hybrid Communication Systems, Machine-learning, Underwater Optical Wireless Communication.

AICCT2k25125

Comprehensive Evaluation of MIMO VLC Techniques Under Varying Spectral Efficiencies and Transceiver Distances

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ABSTRACT

This paper investigates the bit error rate (BER) performance and spectral efficiency trade-offs of three prominent Multiple Input Multiple Output (MIMO) schemes tailored for Visible Light Communication (VLC) systems: Repetition Coding (RC), Spatial Multiplexing with Permutation (SMP), and Spatial Modulation (SM). The analysis spans spectral efficiencies of 4bit/s/Hz and 16bit/s/Hz, examining their behavior under varying transmitter separation distances to capture practical channel conditions. At a lower spectral efficiency, the RC scheme demonstrates the most favorable BER performance, with rapid error rate reduction as the signal-to-noise ratio increases. This robust performance is consistent across all transmitter distances, underscoring the scheme's resilience to spatial interference and channel impairments. Conversely, SMP exhibits significantly higher BER values, especially at larger distances, highlighting its vulnerability to spatial correlation and interference in VLC environments. The SM scheme provides an intermediate solution, offering improved error resilience compared to SMP while maintaining moderate complexity. At the higher spectral efficiency, BER performance naturally degrades across all schemes due to increased data throughput demands. Nonetheless, RC continues to outperform both SMP and SM, maintaining lower error floors and enhanced reliability. SM shows improved relative performance over SMP at this efficiency level, reflecting its capacity to balance spectral efficiency with error performance effectively. The study also presents a detailed comparison of achievable data rates, further illuminating the trade-offs between spectral efficiency, system complexity, and error performance. These insights are instrumental for designing VLC systems optimized for diverse applications ranging from high- speed indoor networking to low-latency optical wireless communications, where reliability and throughput are critical.

Keywords- Multiple Input Multiple Output, Optical wireless communications, Spatial Multiplexing, Visible Light Communication.

AICCT2k25128

Compact Microstrip Antenna Design for Efficient Ultra-Wideband Applications

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ABSTRACT

Ultra-Wideband (UWB) communication has attracted tremendous interest in recent years owing to its capability of supporting high data rates, low power consumption, and reliable short-range wireless connectivity. One of the most crucial elements in UWB systems is the antenna, which must provide a wide impedance bandwidth, stable gain, and consistent radiation characteristics across the entire spectrum allocated by the Federal Communications Commission (FCC) from 3.1 to 10.6 GHz. In this work, the design and implementation of a compact planar antenna for UWB applications is presented.

The proposed antenna employs a modified microstrip patch configuration with carefully optimized ground plane slots to enhance bandwidth and impedance matching. Electromagnetic simulations were carried out to evaluate parameters such as return loss, VSWR, gain, and radiation patterns. The fabricated prototype was then experimentally tested to validate simulation results. Measurements confirm that the antenna achieves a bandwidth covering the entire UWB range with return loss below –10 dB, stable omnidirectional radiation patterns, and an average gain suitable for practical applications.

The antenna exhibits a compact and simple structure, making it easy to fabricate at low cost using standard PCB technology. Its wideband performance and robust radiation characteristics make it suitable for various UWB applications, including high-speed wireless communication, radar imaging, biomedical monitoring, wireless body area networks (WBANs), and Internet of Things (IoT) devices.

This work demonstrates that the proposed antenna design offers an efficient, reliable, and cost-effective solution for modern UWB wireless systems, bridging the gap between theoretical design and practical implementation.

Keywords: Antenna Design*,* UWB, Ground Plane, VSWR

Performance Analysis of Terahertz Communication Systems

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ABSTRACT

The exponential growth in data-intensive applications and the emerging demand for ultra-high-speed wireless connectivity have driven significant interest in Terahertz (THz) communication systems, operating in the frequency range of 0.1–10 THz. This study presents a comprehensive performance analysis of THz communication systems, focusing on key parameters that influence system reliability and efficiency, such as channel modeling, path loss, molecular absorption, and noise power spectral density. The analysis evaluates the impact of various channel conditions, transmission distances, and antenna configurations on achievable data rates and signal-to-noise ratio (SNR). Simulation results demonstrate that while THz systems offer data rates in the order of terabits per second over short distances, performance degradation becomes significant with increased range due to severe attenuation and atmospheric absorption. The paper further explores the potential of beamforming and adaptive modulation techniques to mitigate these losses and enhance link quality. The findings underscore the promise of THz communication as a core enabler for beyond-5G and 6G networks, while highlighting the critical design trade-offs required to optimize performance in practical deployment scenarios.

Keywords: Terahertz (THz) communication, 5G and 6G networks, channel modeling, beamforming, adaptive modulation

AICCT2k25134

An Intelligent Electronics-Based Framework for Adaptive Signal Processing and Energy Optimization in Smart Communication Systems

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ABSTRACT

With the evolution of intelligent computing and embedded electronics, modern communication systems require adaptive, energy-efficient, and real-time signal processing architectures. This paper proposes an intelligent electronics-based framework that integrates machine learning algorithms with analog-digital hybrid circuitry to optimize signal transmission and power efficiency in smart communication systems. The core design utilizes a reconfigurable electronic circuit controlled by an adaptive neural network, enabling automatic tuning of operational parameters such as gain, frequency, and biasing based on environmental variations. The system performance is mathematically modelled as an optimization problem:

$$\min_{V_{bias}, f_c} \ P_{avg} = \frac{1}{T} \int_0^T V_{bias}(t)\, I(t)\, dt,$$

subject to the signal-to-noise constraint $(S/N) \geq \gamma_{min}$

where $V_{bias}(t)$ and $I(t)$ represent the time-varying bias voltage and current, respectively, and γ_{min} is the threshold SNR. Simulation and hardware implementation on a mixed-signal FPGA platform demonstrate 28% energy savings and enhanced signal integrity under variable channel conditions. The proposed framework bridges intelligent computation and electronic circuit design, contributing to the advancement of next-generation adaptive and energy-aware communication systems.

Keywords: Intelligent Electronics, Signal Processing, Energy Optimization, Machine Learning, Adaptive Circuits, FPGA Implementation, Smart Communication Systems, Mixed-Signal Design.

Intelligent Resource Management and Semantic Communications for 6G Wireless Networks using Gen AI

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ABSTRACT

This paper presents a framework for Intelligent Resource Management and Semantic Communications in 6G wireless networks using Generative Artificial Intelligence (Gen AI). Gen AI models are employed to predict network conditions, optimize spectrum usage, allocate power, and manage user connections in real time, enabling highly adaptive and energy-efficient network operation. In semantic communications, Gen AI extracts the intended meaning from transmitted data, sending only essential information instead of full bit streams, thereby reducing bandwidth usage and latency. This dual integration addresses the massive connectivity, ultra-low latency, and high reliability requirements of 6G applications including autonomous mobility, immersive holographic experiences, and large-scale IoT. By combining predictive resource management with meaning-driven data transmission, the proposed system enables self-learning, context-aware, and human-centric 6G networks capable of evolving with dynamic user needs and environmental constraints.

Keywords: 6G Wireless Networks; Generative Artificial Intelligence (Gen AI); Intelligent Resource Management; Semantic Communications; Spectrum Optimization; Energy-Efficient Networking.

Reconfigurable antenna: A conceptual Review

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ABSTRACT

A Reconfigurable antenna is beneficial to overcome the disadvantages of traditional antenna such as fixed Operating Frequency or fixed operating band, lack of flexibility, bulky &amp, complex multiband design. All these disadvantages make traditional antenna Less Suitable for Modern Wireless Systems. Modern systems (5G, IoT, satellite communication etc.) require adaptability, miniaturization, and multi-standard operation. The polarization, frequency and radiation characteristics of antennas can be changed in a regulated and reversible way, this is the concept of reconfigurable antenna. Principle behind the reconfigurability is achieved using software & hardware mechanisms. Different reconfigurable techniques such as electrical, mechanical, metamaterial, optical –based can be achieved by using many mechanisms such as varactor diode, PIN diodes, radio-frequency microelectromechanical systems (RF-MEMS), photoconductive elements, mechanical actuators, metamaterials, liquid crystals etc. This work aids the researcher in comprehending the many mechanics underlying antenna reconfigurability in various contexts. Reconfigurable antennas can be utilized in a variety of applications, including satellite communication, Wi-Fi, cognitive radio, MIMO systems, the Internet of Things, medicinal devices, and more. The optimization of reconfigurable antennas by machine learning is also covered in this study.

Keywords: Reconfigurable Antenna; Frequency and Polarization Reconfigurability; RF-MEMS; Varactor and PIN Diodes; Metamaterials; IoT and 5G Applications.

AICCT2k25152

A Mathematical Framework for Intelligent Resource Optimization in Next-Generation Communication Networks

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ABSTRACT

The convergence of intelligent computing and advanced communication technologies forms the foundation of next-generation networks such as 6G and edge-based IoT infrastructures. Efficient resource allocation remains a major challenge in ensuring reliability, scalability, and low-latency communication. This paper presents a novel mathematical framework that integrates machine learning–based prediction with adaptive optimization to dynamically allocate bandwidth and computational resources. The objective function for the proposed optimization model is formulated as

$$\min_{x \in \mathbb{R}^n} F(x) = \sum_{i=1}^{N} \alpha_i (r_i - \hat{r}_i)^2 + \beta \|x\|_1,$$

where r_i and $\hat{r}_i$ denote actual and predicted data rates, α_i represents adaptive priority weights, and β is a sparsity regularization coefficient ensuring efficient resource utilization. The optimization employs a gradient-based learning algorithm integrated with reinforcement feedback from network performance metrics. Experimental results validate that the proposed approach achieves up to 30% improvement in throughput and 20% reduction in communication delay compared to conventional scheduling schemes. The framework demonstrates adaptability and scalability for heterogeneous communication scenarios, making it a viable model for intelligent and autonomous 6G network management.

Keywords: Intelligent Computing, Optimization, Machine Learning, 6G Networks, Edge Computing, Mathematical Modelling, Resource Allocation, Communication Efficiency

Novel Dual-Band 28/38 GHz MIMO Antennas for 5G Mobile Applications

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ABSTRACT

In order to support 5G mobile communications, this research presents novel small microstrip line fed dual-band printed MIMO antennas that resonate at 28 GHz and 38 GHz. A two-element conventional rectangular microstrip patch antenna with an inset feed is the first design in this work. for the 38GHz and 28GHz bands. The second approach uses microstrip inset feed lines to create symmetric dual-band, two-element MIMO slotted rectangular patches. Inverted I-shaped slots placed in main patches produce the dual-band response. A symmetric dual-band four-element MIMO antenna with inverted I-shaped slotted rectangular patches is the third design. The somewhat rectangular ground plane is filled with a slot-shaped DGS. The substrate is 55 by 110 mm2, and the new antennas have significantly They fit more easily into handset devices for the upcoming 5G mobile communications since they have small planar layouts and occupy a negligible area. Larger bandwidths and improved return losses are achieved. Without the need for any additional structures, the MIMO antennas exhibit low mutual coupling. For 5G mobile applications, the antenna systems provide suitable directivity, gain, and radiation efficiency values together with expected reflection and correlation coefficient features. The antenna systems are made via photolithography, which uses optic radiation to replicate the mask on a silicon slab with the help of photo resist layers. Vector Network Analyzer is used for measurement. ZVA 67 has a port impedance of 50Ω and can measure frequencies up to 67GHz.

Keywords: 5G Mobile Communication; Dual-Band MIMO Antenna; Microstrip Line Feed; Inverted I-Shaped Slots; Defected Ground Structure (DGS); Low Mutual Coupling; High Gain and Efficiency.

AICCT2k25164

Optimization in VLSI Systems using Machine Learning Techniques

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ABSTRACT

The continuous scaling and complexity of Very Large-Scale Integration (VLSI) circuits have made traditional design and optimization techniques increasingly inefficient. Machine Learning (ML) has emerged as a powerful tool to enhance the efficiency and intelligence of chip design processes. By leveraging data-driven models, ML enables automated design space exploration, prediction of optimal circuit layouts, power consumption minimization, and performance improvement. ML algorithms assist in tasks such as placement and routing, timing analysis, and yield prediction, significantly reducing design time and human intervention. Moreover, ML-based optimization supports adaptive learning from past design data, leading to faster convergence and improved accuracy. This paper presents an overview of the role of machine learning in VLSI design optimization, highlighting its methodologies, challenges, and potential for next-generation chip development.

Keywords: Machine Learning, VLSI Design, Design Automation, Optimization, Power Efficiency, Circuit Performance, Electronic Design Automation (EDA), Chip Layout Prediction

Adaptive Rule Replacement Mechanism for Resource Depletion Attack Prevention in SDN

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ABSTRACT

In the fast-changing domain of Software-Defined Networking (SDN), reinforcing security mechanisms against advanced cyber threats remains a major concern. Among these challenges, inference attacks represent a significant danger as they allow adversaries to uncover sensitive details about SDN switch configurations and operational policies, thereby threatening network integrity and confidentiality. To counter this, our study introduces a novel dynamic rule replacement strategy for SDN switches that harnesses the power of LightGBM. The proposed model analyzes a comprehensive range of statistical parameters—such as flow rule duration, packet match field dispersion, and packet arrival frequency—to detect behavioral patterns linked to inference attacks. By adaptively modifying flow rules through real-time feature evaluation, the method enhances network robustness against such intrusions. Simulation outcomes confirm that the approach efficiently mitigates inference attacks while preserving high network performance and operational efficiency. Overall, this research advances SDN security by providing a resilient and adaptive defense framework that upholds the confidentiality, integrity, and availability of network systems amid evolving cyber threats.

Keywords: Software-Defined Networking (SDN), Inference Attack, Dynamic Rule Replacement, LightGBM, Machine Learning

Web based learning platform for deaf and mute + Sign language

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ABSTRACT

Communication barriers continue to pose significant challenges for the hearing-impaired community in India, particularly due to the limited availability and accessibility of structured Indian Sign Language (ISL) resources. The lack of ISL awareness and inconsistent learning platforms has resulted in restricted opportunities for education, employment, and social inclusion, especially in rural regions. To address this issue, we propose VAANI, a digital and inclusive ISL learning platform designed to bridge the communication gap between hearing and hearing-impaired individuals.

VAANI provides a centralized, multimodal environment that incorporates personalized learning pathways, interactive community-based practice, and the potential integration of gesture recognition for real-world application. Unlike fragmented resources, VAANI emphasizes accessibility, collaboration, and inclusivity by engaging students, families, educators, professionals, and NGOs in a unified ecosystem. The platform aims to increase ISL awareness, empower the hearing-impaired with greater opportunities, and promote inclusivity in both educational and professional domains. By combining technology with social innovation, VAANI establishes a sustainable model for communication, ensuring that the deaf community is not only supported but also meaningfully integrated into mainstream society.

Keywords: Indian Sign Language, Digital Learning, Inclusivity, Accessibility, Gesture Recognition, Hearing-Impaired Communication.

NCFET-Enabled SRAM: A Path toward Ultra Low Power in Memory Computing

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ABSTRACT

The growing demand for energy-efficient computing in data-intensive applications has motivated the exploration of advanced memory technologies capable of performing both storage and computation. Conventional CMOS-based SRAMs, though widely adopted, face significant challenges at scaled technology nodes due to high leakage power, poor scalability, and limited energy efficiency. Negative Capacitance Field-Effect Transistor (NCFET)-based SRAM has recently emerged as a promising alternative, leveraging the negative capacitance effect of ferroelectric materials to achieve improved subthreshold swing, enhanced ON-current, and reduced supply voltage operation. This work presents the design and analysis of NCFET-based SRAM cells tailored for in-memory computing applications, focusing on energy efficiency, stability, and performance trade-offs. The integration of NCFET devices within a 6T SRAM architecture demonstrates significant improvements in read/write margins, reduced static noise margin (SNM) degradation, and lower dynamic power consumption compared to conventional CMOS and CNTFET-based designs. Simulation results at nanoscale technology nodes indicate that NCFET-SRAM achieves substantial reductions in energy per operation while maintaining robust functionality under process variations. Furthermore, its intrinsic capability to support in-memory logic operations makes it a potential enabler for next-generation computing paradigms, particularly in machine learning accelerators and edge devices. Overall, the proposed NCFET-based SRAM design offers a viable pathway toward low-power, high-density, and energy-efficient in-memory computing systems, bridging the gap between memory and computation in future VLSI architectures.

Keywords: NCFET, SRAM, In-Memory Computing, Energy Efficiency, Low-Power Design, Ferroelectric Devices, VLSI Architecture

AICCT2k25121

Safety at Risk: Cyber-Physical Exploits and Their Impact on ADAS Decision-Making

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ABSTRACT

Advanced Driver Support System (ADAS) has quickly become an important part of modern vehicles, which is designed to improve safety, make driving more comfortable and support semi-autonomous features. At the same time, the way these systems rely on many sensors, electronic control units and in-vehicle networks make them sensitive to various types of dangers and attacks on the system. On the cyber side, simple messages such as message injections, spoofing, or refusal-service can disrupt communication. On the physical side, lidar can mislead the perception of tricks such as spoofing, tampered traffic signals, or GPS signal jamming. When these two types of attacks are combined, they can seriously distort how Adas explains its surroundings and how it decides to act. This paper sees these weaknesses in detail, indicating the scenarios of potential attacks and the safety risks created by them. It also discusses strategies that can make Adas more flexible, focusing on how to defend against these hybrid cyber-physical threats.

Keywords: ADAS, Cyber-Physical Security, Vehicle Networks, Sensor Spoofing, GPS Jamming, Automotive Safety, Cyber Resilience.

AI-Based RF and WiFi Signal Detection System for Hidden Mobile Phone Localization and Cheating Prevention During Classroom Examinations

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ABSTRACT

Maintaining academic integrity during classroom examinations remains a challenge due to the concealed use of mobile phones, even when such devices operate in silent or airplane modes. This research presents an automated artificial intelligence-based system that employs radio frequency (RF) and WiFi signal analytics for real-time detection, classification, and localization of unauthorized mobile phones in examination environments. The proposed system deploys distributed RF and WiFi sensors to continuously capture multi-modal signal emissions across the classroom. Captured data are processed through a deep learning model trained on labeled signal patterns to distinguish between authorized and unauthorized devices under varying operational conditions. Dynamic signal filtering mechanisms further minimize false positives by excluding signals from approved equipment. Detected devices are spatially mapped within classroom coordinates, and instantaneous alerts are generated on a central monitoring dashboard for proctor intervention. The system also supports integration with digital examination platforms for automated evidence logging and access control. Experimental validation demonstrates the proposed model's accuracy and responsiveness in identifying hidden devices under different signal strengths and obstructions. This AI-empowered detection framework establishes a scalable, data-driven solution for preserving exam integrity and preventing technology-assisted cheating.

Keywords: Mobile phone detection, RF signal analysis, Wi-Fi analytics, exam cheating prevention, classroom monitoring, artificial intelligence, device localization, real-time signal tracking, deep learning classification, academic integrity.

Track 3
Embedded Systems and IOT

Career Compass: A Web-Based Framework for Intelligent Guidance and Counseling

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ABSTRACT

In today's competitive environment, students and job seekers often struggle to select the right career path that aligns with their skills, interests, and future aspirations. Career Compass is a web-based career guidance platform designed to provide personalized support and reliable resources for informed decision-making. The system is developed using HTML, CSS, and JavaScript for the front-end, ensuring an interactive and responsive user experience. The back-end is powered by Python, which handles data processing, career assessment logic, and integration of various features. Additionally, SQL is used for database management, enabling efficient storage and retrieval of user profiles, career information, and assessment results. The platform offers tools such as career assessments, detailed profession insights, resume-building assistance, interview preparation tips, and resources for skill development. By combining a user-friendly interface with a robust back-end and secure data handling, Career Compass provides a comprehensive career guidance solution that empowers individuals to explore opportunities, define goals, and achieve professional success.
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Keywords: Career Guidance; Career Compass; Web-Based Platform; Python; HTML; CSS; JavaScript; SQL; Career Assessment; Skill Development; Professional Growth.

Game development and networking using Unity Engine

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ABSTRACT

This project focuses on developing a multiplayer game that applies modern game design research, networking methods, and engine capabilities. The main goal is to build a working prototype that balances responsiveness and consistency in online play. The game will be a low-poly 3D survival experience, supporting multiple players at the same time.

Development will be carried out using the Unity 3D engine because of its cross-platform support, rich documentation, and strong features for both 2D and 3D games. The project will implement networking techniques to reduce bandwidth usage, keep gameplay smooth, and use interest management so that only relevant data is shared with players. Networking will be managed through Photon Unity Networking (PUN) for matchmaking and in-game synchronization.

The project will follow an agile and iterative process, treating the game prototype as both a practical artifact and a way to test theoretical concepts. Unity Asset Store resources will be used for rapid prototyping, while clear pre-production planning will help avoid unnecessary features (feature creep). The final result will be a playable prototype and a case study showing how networking and design principles can be applied effectively in real game development to create a technically sound and engaging multiplayer experience.

Keywords: Multiplayer Game Development; Unity 3D Engine; Photon Unity Networking (PUN); Networking Optimization; Low-Poly 3D Design; Agile Development

IoT-Enabled Real-Time Drinking Water Quality Monitoring System for Smart Cities

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ABSTRACT

The quality of drinking water in the city plays a vital role, as it directly impacts human health. According to ASSOCHAM CSR, approximately 1.5 million people die each year worldwide due to waterborne infections. Global risk rankings from the World Economic Forum place the drinking water crisis at the top. We observe that the condition of water in public areas, such as government offices, railway stations, and individual houses where drinking water is provided, is not up to par. Therefore, to address this issue, we need to ensure the supply of clean and pure drinking water, which requires real-time water quality monitoring. Continuous quality monitoring is necessary to guarantee a safe supply of drinking water. In this paper, we have developed a prototype design for real-time monitoring of the water quality at different junctions of the pipeline in the city. Several sensors make up the system, which can measure the physicochemical parameters of water quality. These parameters are used to detect pH values, total dissolved solids, and suspended particles in water. The quality of water is compared with the reference value set. The measured values from the sensors are being processed by the core controller. The entire sensor data is shown on the display unit and is displayed via the ESP32 microcontroller and IoT. The user gets a message of the findings indicating that the system can successfully process, transmit, and display the readings of physicochemical parameters. This system's installation in the water guarantees the supply of high-quality water to the people of the city.

Keywords: pH sensor, IoT, water quality, smart city, TDS.

AICCT2k25126

Modern Web-Based Quizzing Platform for Secure Assessments with Real-Time Analytics

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ABSTRACT

This paper presents the design and development of a robust, secure, and feature-rich online quizzing platform to enhance digital education and assessment. The primary objective is to create a reliable web application that enables educators to seamlessly create, manage, and deploy a wide variety of quizzes, while providing students with an intuitive and stable testing environment. The platform supports diverse question formats, including multiple-choice questions (MCQ) and multimedia elements such as images, attachments, and embedded videos, facilitated by rich text editor libraries. A key feature is the comprehensive teacher dashboard, which provides an at-a-glance view of student results and detailed performance analytics for data-driven pedagogical insights. A standout addition is an automated daily quiz generator; this function intelligently creates randomized quizzes from a content bank of teacher-uploaded materials, including PDFs and lecture notes. This provides students with a powerful tool for continuous practice, knowledge reinforcement, and preparation for summative exams. The system architecture utilizes a modern technology stack, featuring a dynamic frontend (React/Angular), a powerful backend (Node.js/Python), a scalable database (MongoDB/PostgreSQL), and cloud storage (AWS S3) for efficient asset handling. By ensuring a clear separation of roles through a secure login system, the platform delivers a fully functional, scalable solution designed to improve the efficiency, accessibility, and integrity of online assessments for educational institutions, corporate training, and competitive examination preparation.

Keywords: Online Quizzing Platform; Digital Education; Automated Quiz Generation; Performance Analytics; React/Angular; Node.js/Python; MongoDB/PostgreSQL.

Artificial Intelligence enabled Next Generation Human-Robot Interaction systems for Collaborative Future

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ABSTRACT

Artificial Intelligence (AI) is driving the next generation of Human-Robot Interaction (HRI) systems, transforming robots from task-specific machines into intelligent collaborators. AI-enabled robots combine perception, learning, and adaptive control to operate effectively in dynamic, real-world environments. Beyond autonomy, the focus is on building trust, safety, and seamless communication between humans and robots. Techniques such as machine learning, computer vision, natural language processing, and cognitive control allow robots to perceive surroundings, interpret human intentions, and respond naturally. The evolution of these systems is shifting towards socially aware, emotionally intelligent, and ethically responsible robots that can work alongside humans in healthcare, manufacturing, defense, and service sectors. By enabling collaborative robots (cobots) that share workspaces safely and intuitively, AI-powered HRI systems hold the potential to redefine human-robot partnerships and contribute to a more collaborative future.

Keywords: Artificial Intelligence, Machine Learning, Human-Robot Interaction (HRI), Collaborative Robots (Cobots), Machine Learning, Computer Vision, Natural Language Processing, Adaptive Control,

Technology-Enabled Frameworks for Strengthening Mental Health Support Systems in Higher Education Institutions

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ABSTRACT

Students' mental health concerns in higher education institutions have emerged as a critical challenge, with academic pressure, social transitions, and digital influences significantly affecting overall well-being. The competitive academic environment, coupled with the pressure to excel, often leads to heightened stress, anxiety, and depression. Furthermore, the pervasive use of digital media and the culture of constant comparison amplify feelings of isolation and inadequacy. Although universities are increasingly acknowledging the need for mental health services, barriers such as stigma, limited resources, and delayed interventions continue to hinder timely and effective support. In this context, this paper proposes technology-enabled frameworks as a transformative approach to strengthening mental health support systems in higher education institutions.

Keywords: Technology Enabled Framework, Mental Health, Digital Devices

IoT-Enhanced Crop Monitoring with Deep Learning: Precision Disease Detection in Rice and Sugarcane Cultivation

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ABSTRACT

Internet of Things (IoT) compatible crop monitoring and data collection devices enhance soil condition monitoring, water, and fertilizer management. These devices play a pivotal role in early disease detection and monitoring pest reproduction. This research primarily focuses on improving the accuracy of plant disease detection by deeply understanding the causative agents and assessing their impact on crops. To realize this, we employ a deep learning approach combined with a transfer learning model. This model ingests features from a unique feature extraction process that merges grayscale properties, morphological component analysis, and the capabilities of the Deep Convolutional Neural Network (Darknet53). This integration aids in extracting detailed hidden features, subsequently optimizing the training of the network through the backpropagation in the transfer learning model. Further, the refined features are subjected to backpropagation within the transfer learning model. This method effectively identifies system errors and determines the most prevalent causative agents in plant diseases. Our comparison of results before and after using the transfer learning model attests to its effectiveness in disease detection. Our proposed model stands out in revealing concealed features in grayscale properties using morphological component analysis. When applied to rice and sugarcane crops, it achieved an impressive 91.2% precision, surpassing five other pest detection techniques. Consequently, this emphasizes proactive crop disease prevention, leading to increase yields. These IoT solutions empower farmers to make informed decisions, enhancing yield while reducing maintenance costs.

Keywords: Internet of Things (IoT); Crop Monitoring; Plant Disease Detection; Deep Learning; Transfer Learning; Darknet53; Morphological Component Analysis; Precision Agriculture.

Intelligent Hybrid Framework for Secure Data Transmission in IoT-Enabled Smart Environments Using Machine Learning and Blockchain Technologies

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ABSTRACT

The rapid proliferation of the Internet of Things (IoT) has transformed modern communication systems by enabling seamless connectivity and intelligent decision-making across diverse smart environments. However, this exponential growth has also introduced significant challenges related to data security, privacy, and network scalability. This research proposes an intelligent hybrid framework that integrates Machine Learning (ML) algorithms with Blockchain Technology to ensure secure, efficient, and trustworthy data transmission in IoT networks. The proposed system employs anomaly detection models based on supervised and unsupervised ML techniques to identify malicious activities in real time, while blockchain-based decentralized validation enhances data integrity and transparency. Experimental simulations demonstrate improved accuracy, reduced latency, and enhanced resilience against cyberattacks compared to traditional centralized IoT architectures. The findings highlight the potential of combining intelligent computing and distributed communication technologies to create a more secure and adaptive IoT ecosystem. This study contributes to the growing field of AI-driven cybersecurity and provides a scalable solution framework for future smart cities, healthcare systems, and industrial automation applications.

Keywords: Intelligent Computing, Machine Learning, Blockchain, Internet of Things (IoT), Cybersecurity, Data Integrity, Edge Computing, Secure Communication, Smart Environments.

Machine Learning Approaches for Enhancing Security in IoT Systems

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ABSTRACT

The exponential growth of the Internet of Things (IoT) has revolutionized connectivity, yet its limited resources and decentralized design introduce serious security challenges. Traditional methods struggle to adapt to evolving threats. This paper explores machine learning (ML) paradigms—supervised unsupervised, reinforcement, and lightweight learning— for strengthening IoT security. We propose a layered ML-based framework that integrates anomaly detection, intrusion classification, and adaptive policy enforcement. Experimental evaluation with benchmark datasets demonstrates enhanced detection accuracy, adaptability, and reduced computational overhead compared to conventional systems.

Keywords: IoT Security, Machine Learning, Anomaly Detection, Intrusion Detection, Reinforcement Learning, Lightweight Models, Secure IoT Communication.

AICCT2k25150

Deep Guard: A Hybrid ResNeXt-LSTM Architecture for Automated Deepfake Detection in Digital Media

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ABSTRACT

Deepfake technology, which manipulates digital content to create convincingly fake videos that defy conventional verification techniques, has become a serious threat to information integrity. This study presents DeepGuard, a novel detection framework that combines temporal pattern recognition using Long Short-Term Memory (LSTM) architectures with spatial feature analysis using ResNeXt convolutional networks. By analyzing both frame-level manipulation artifacts and sequential temporal inconsistencies typical of synthetic video generation, the suggested hybrid methodology overcomes the drawbacks of single-modality detection techniques. Our system architecture combines a web-based deployment platform with a PyTorch-based model implementation, FastAPI backend infrastructure, and React/Next.js frontend technology. The framework produces detailed analytical reports that pinpoint particular manipulated video segments in addition to quantitative authenticity evaluations. Feasibility analysis shows that by carefully applying transfer learning techniques and adapting the pretrained model, a successful prototype can be developed in a limited four to five-month period. By offering a clear, understandable method for thwarting multimedia disinformation, this work advances the field of digital media forensics.

Keywords: Deepfake Detection, ResNeXt Architecture, LSTM Networks, Hybrid Neural Networks.

AICCT2k25160

Improving Diabetes Prediction Accuracy through Advanced Feature Engineering Techniques

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ABSTRACT

Diabetes mellitus continues to be a significant public health issue globally, highlighting the need for precise and prompt prediction to facilitate early intervention and treatment strategies. This study proposes a method to enhance the accuracy of diabetes prediction through advanced techniques in feature engineering applied to clinical datasets. The research highlights how feature selection, transformation, and extraction methods—such as correlation-based filtering, recursive feature elimination, and principal component analysis—affect model performance. A variety of machine learning algorithms, including Logistic Regression, Random Forest, Support Vector Machine, and Gradient Boosting, were assessed both before and after the optimization of features. Experimental findings indicate that the addition of engineered features greatly improved predictive accuracy, precision, and F1-scores in comparison to baseline models. The results emphasize the significance of feature engineering in developing robust, high-performing predictive models for diabetes diagnosis and provide practical insights for the integration of data-driven approaches into healthcare analytics.

Keywords: Diabetes Prediction, Feature Engineering, Machine Learning, Classification, Healthcare Analytics

Dynamic Anonymous and Post-Quantum lattice-based Efficient Provable Secure Signature Scheme for VANETs

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ABSTRACT

The advancement of communication technologies within vehicular systems has led to the origination of Vehicular Ad-hoc Networks (VANETs). VANETs enable vehicles and traffic authorities to exchange real-time information for improved road safety and transportation efficiency. Nevertheless, ensuring the security and integrity of data transmitted over open networks poses a substantial challenge. Most existing authentication schemes for VANETs rely on number-theoretic cryptographic methods, which are vulnerable to quantum computing attacks. Lattice-based signature schemes have emerged as promising quantum-resistant alternatives. However, they face challenges such as susceptibility to side-channel attacks, key escrow issues, and the need for vehicles with limited storage capacity to handle multiple pseudonym identities. To address these problems, this paper introduces the first lattice-based dynamic anonymous and escrow-free signature scheme designed specifically for post-quantum VANET environments. The proposed scheme ensures high levels of security, eliminates key escrow, and reduces storage requirements. A comprehensive security analysis against real-world threats demonstrates that the scheme outperforms existing models, and performance evaluations based on implementation and simulation show its suitability for quantum-secure VANET communications.

Keywords: Vehicular Ad-hoc Networks (VANETs); Post-Quantum Cryptography; Lattice-Based Signature Scheme; Dynamic Anonymous Authentication; Escrow-Free Security; Quantum-Resistant Communication; Data Integrity.

Predictive Maintenance Using Embedded Machine Learning in Industrial Systems

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ABSTRACT

Predictive maintenance is a transformative approach in industrial automation that utilizes machine learning (ML) to enhance the reliability, safety, and efficiency of equipment operations. By integrating ML algorithms into embedded systems, industries can achieve real-time monitoring and analysis of equipment health directly at the edge. These embedded ML systems process sensor data to identify performance anomalies, predict potential failures, and optimize maintenance schedules proactively. This approach significantly reduces unplanned downtime, maintenance costs, and human intervention. Furthermore, the combination of embedded hardware and ML enables adaptive, data-driven decision-making with minimal latency. This paper discusses the architecture, methodologies, challenges, and benefits of implementing predictive maintenance through embedded machine learning in modern industrial environments.

Keywords: Predictive Maintenance, Embedded Systems, Machine Learning, Edge Computing, Industrial Automation, Fault Diagnosis, Condition Monitoring.

Comparative Analysis of Quantum Encoding Techniques for Machine Learning Applications

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ABSTRACT

Quantum Machine Learning (QML) combines the computational advantages of quantum computing with the adaptive capabilities of machine learning, promising significant acceleration for data-driven tasks. A critical step in any QML workflow is the *encoding* of classical data into quantum states, as this process directly influences model performance, circuit complexity, and hardware feasibility. This study presents a comprehensive comparative analysis of major quantum data encoding techniques, including basis, amplitude, angle (rotation), phase, and hybrid encoding schemes. Each method is evaluated in terms of computational efficiency, qubit resource requirements, expressive power, noise resilience, and scalability on near-term quantum hardware. Using benchmark datasets and simulated quantum classifiers implemented in Qiskit and PennyLane, we assess the impact of encoding choice on downstream learning performance. Our results highlight distinct trade-offs between expressive capacity and practical feasibility: while amplitude encoding achieves high representational efficiency, it suffers from costly state preparation, whereas angle and hybrid encodings offer superior robustness for noisy intermediate-scale quantum (NISQ) devices. The findings provide actionable insights into selecting optimal encoding strategies for various QML applications and suggest directions for developing adaptive or hardware-efficient encoding frameworks.

Keywords: Quantum Machine Learning (QML); Quantum Data Encoding; Amplitude Encoding; Angle Encoding; Hybrid Encoding; Qiskit; PennyLane; NISQ Devices.

Integration of Internet of Things (IoT) with Image Processing for Intelligent Automation

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ABSTRACT

The convergence of the Internet of Things (IoT) and image processing technologies has revolutionized the way visual data is collected, analyzed, and utilized for intelligent decision-making. IoT-enabled image processing systems integrate smart sensors, embedded cameras, and connected devices to capture real-time images and transmit them to edge or cloud platforms for analysis. This fusion enables a wide range of applications including smart surveillance, healthcare diagnostics, agricultural monitoring, environmental sensing, and industrial automation. Edge computing further enhances system responsiveness by allowing real-time processing closer to the data source, thereby reducing latency and bandwidth consumption. Cloud integration, on the other hand, supports large-scale analytics and machine learning for pattern recognition and predictive insights. Despite these advancements, challenges such as data security, interoperability, power management, and communication efficiency continue to affect large-scale deployments. Ongoing research in lightweight deep learning models, 5G connectivity, and secure edge frameworks promises to make IoT-based image processing systems more efficient, adaptive, and sustainable in the near future.

Keywords: IoT, Image Processing, Edge Computing, Smart Sensors, Cloud Analytics, Real-Time Monitoring, Intelligent Automation, Computer Vision, Deep Learning, Smart Systems

SpectraGuard 24×7, an IoT-enabled surveillance system that integrates hyperspectral imaging

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ABSTRACT

The convergence of the Internet of Things (IoT) and image processing technologies has revolutionized the way visual data is collected, analyzed, and utilized for intelligent decision-making. IoT-enabled image processing systems integrate smart sensors, embedded cameras, and connected devices to capture real-time images and transmit them to edge or cloud platforms for analysis. This fusion enables a wide range of applications including smart surveillance, healthcare diagnostics, agricultural monitoring, environmental sensing, and industrial automation. Edge computing further enhances system responsiveness by allowing real-time processing closer to the data source, thereby reducing latency and bandwidth consumption. Cloud integration, on the other hand, supports large-scale analytics and machine learning for pattern recognition and predictive insights. Despite these advancements, challenges such as data security, interoperability, power management, and communication efficiency continue to affect large-scale deployments. Ongoing research in lightweight deep learning models, 5G connectivity, and secure edge frameworks promises to make IoT-based image processing systems more efficient, adaptive, and sustainable in the near future.

Keywords: IoT, Image Processing, Edge Computing, Smart Sensors, Cloud Analytics, Real-Time Monitoring, Intelligent Automation, Computer Vision, Deep Learning, Smart Systems

Track 4

Sustainable Technologies for Future

Recent Advancements on Solar Photovoltaic (SPV) In India

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ABSTRACT

In today's scenario, use of solar photovoltaic (SPV) energy is growing day by day as compared to other renewable energy sources. The reason behind is continuous advancement in technologies, more efficient, long life, government subsidies, installation requires less space, lower maintenance, higher electricity board bills etc.

Few years ago, the available power rating of solar panels ranged from 300 Wp to 400 Wp with 60-cell panels for residential use and 72-cell panels for commercial use in 400-460 Wp range in mono perc half cut solar panels (which generate electricity from one side only). Now a days, advanced technologies are used in designing solar panels which result in increase of solar power rating from 550 Wp to 620 Wp for residential & 700 + Wp for commercial purpose with 144-156 cells. Also, the bifacial technology is developed in solar modules which can generate the electricity from both sides i.e. front plate generates the maximum (100 %) output from the sun & rear plates can also generate a small amount of electricity (10 - 15 %) by the heating generated from the reflection of sun from the ground. Therefore, it is called bifacial panels since plates can generate electricity by sunlight as well as the heat of the sun.

In addition to this, panels comes in two types according to the quality and based on silicon doping, they are P- type & N- type with N- type generally being more efficient, more resistant to degradation, and longer-lasting but more expensive, while P- type is a more mature, lower-cost technology still suitable for many standards applications. The main difference is the dopant used: P- type silicon is doped with boron creating holes (positive charge carriers), and N- type is doped with phosphorus creating free electrons (negative charge carriers). Thus, P- types solar modules is good for residential and small-scale commercial projects and N- type solar modules are ideal for large scale projects to provide long last services.

Generation capacity of solar panels is also improved by reducing the gaps between the cells to 0.5 mm–0.6 mm which was 2mm–3 mm in the previous. This increases the panel surface area available to absorb sunlight and generate power. The reduction in gap is done by using small wire interconnects, smart soldering or shingled cell technology to overlap or tightly tie cells and use of segmented ribbons like LONGi's triangular design, which flattens and bends behind the cell to minimize spacing requirements.
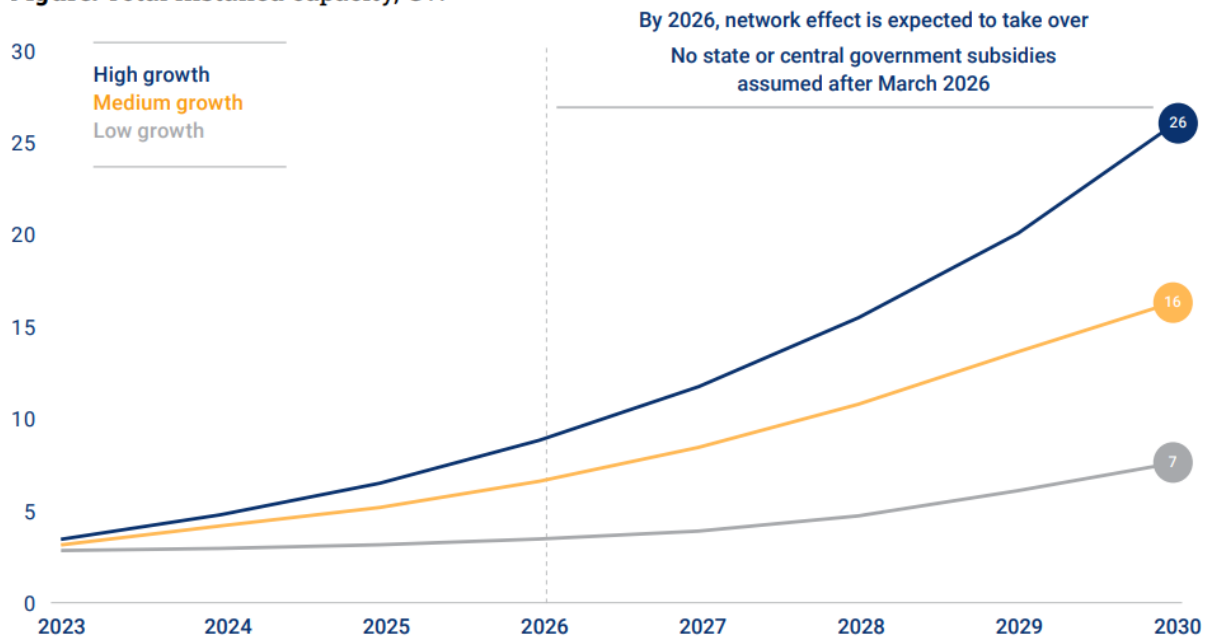
Generation of electricity is also improved to 4 – 6 units (average) per kilowatt per day due to high watt peak capacity panels available in the market. Which was previously 2-3 units per

kilowatt per day. This helps in fulfil the household load with low budget & less number of panels.

The leading manufacturing companies of solar modules in India are, Tata Power Solar, Adani Solar, Servotech Renewable Power System Ltd., Waree Energies Ltd., Vikram Solar, Saatvik Green Energy Pvt. Ltd., Renewsys India and so on.

The below graph shows the total installed capacity in india till now and expected grow till 2030. It is also assumed that no state or central government subsidies will apply after March 2026 which directly make an impact on number of installations.

Figure: Total installed capacity, GW

Source: BRIDGE TO INDIA research

Keywords: Solar Photovoltaic (SPV); Bifacial Solar Panels; Mono PERC Technology; Shingled Cell Technology; Solar Panel Efficiency; Renewable Energy Advancement.

The Evolution of Renewable Energy Sources: Emerging Types and Integration Approaches.

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ABSTRACT

Renewable energy sources (RES) are evolving rapidly, offering sustainable alternatives to conventional fossil fuels. This paper reviews emerging RES technologies such as advanced photovoltaics, offshore wind, marine energy, bioenergy and geothermal systems, highlighting their potential to diversify the energy mix. It also examines integration approaches that address challenges of variability, intermittency and grid stability. Key strategies include smart grids, energy storage, demand response, power electronics and artificial intelligence-based lo;./optimization. Together, these innovations enhance system flexibility and resilience, supporting large-scale deployment of RES. The review underscores the role of technological progress and policy support in shaping a reliable, low-carbon energy transition.

Keywords: Renewable energy, Emerging technologies, Grid integration, Smart grids, Energy storage, Low-carbon transition.

Green Building Rating for A Green Future of Developing Country

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ABSTRACT

Indian construction industry is witnessing highest growth rate from last 25 years, which is having an adverse effect on the environment and scarcity of natural resources for construction. The promotion of the concept of green building in construction industry is the need of an hour. For this purpose, the initial screening has been incorporated with detailed study in the methodology to rate the chosen building for its various features according to the rating system of Leadership in Energy and Environmental Design (LEED) and suggest measures to improve the performance of the building. In the present study, an educational institute has been chosen to assess the efficient use of resources and designated as green building, yellow building and red building based on the total score earned by the building as per the rating system of Leadership in Energy and Environmental Design (LEED).

Keywords: Green Technology, sustainable development, green building, screen out, LEED.

AICCT2k25143

Integration of Remote Sensing and Geographic Information Systems for Monitoring Urban Land Use Changes in Megacities: A Case Study of Mumbai, India

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ABSTRACT

Rapid urbanization in megacities like Mumbai, India, drives significant land use and land cover (LULC) changes, challenging sustainable development. This study leverages remote sensing (RS) and Geographic Information Systems (GIS) to analyze spatiotemporal LULC dynamics in Mumbai from 2000 to 2023, aiming to inform resilient urban planning. High-resolution Landsat-8 and Sentinel-2 imagery was processed using supervised classification (Random Forest, Support Vector Machines) to produce LULC maps with over 92% accuracy. These maps, integrated into ArcGIS Pro, combined with population, infrastructure, and climate data, enabled comprehensive overlay analysis. Change detection, including post-classification comparison and NDVI thresholding, revealed a 35% increase in built-up areas, a 22% loss in green cover, and increased flood vulnerability in coastal zones. The RS-GIS framework enhances precision in monitoring urban expansion and environmental degradation, supporting predictive modeling for future growth under climate change scenarios. This approach facilitates cost-effective, data-driven strategies like green infrastructure development for megacity management in developing nations. The findings advocate for RS and GIS adoption in global urban sustainability frameworks, with potential for machine learning integration in real-time monitoring. This study underscores the critical role of geospatial technologies in addressing urbanization challenges.

Keywords: Remote Sensing, GIS, Land Use Change, Urban Expansion, Mumbai, Sustainability

Advancing Wetland Identification in India: Integrating Geospatial Technologies and Ecological Criteria for Conservation

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ABSTRACT

India's rapidly evolving approach to wetland identification leverages advanced geospatial technologies—including high-resolution satellite remote sensing, GIS, and multi-temporal analysis—to map, classify, and monitor the country's diverse aquatic ecosystems. The 2024 National Wetlands Atlas, spearheaded by the Space Applications Centre (ISRO), set a new benchmark by cataloging over 3.5 million wetlands at unprecedented spatial resolution, offering vital insight into the distribution, types, and extents of these critical habitats. This comprehensive geospatial assessment is complemented by inter-disciplinary ecological criteria, such as hydrological connectivity, seasonal inundation dynamics, and biological indicators, improving accuracy through extensive ground-truthing and stakeholder collaboration. The integration of optical, radar, and LiDAR data captures the highly dynamic and varied nature of wetlands, addressing persistent cartographic challenges. These innovations inform regulatory frameworks and conservation policies, supporting sustainable management and international commitments such as the Ramsar Convention. This research underscores the essential role of integrated technology and ecological expertise in advancing wetland conservation and resource planning in India's complex environmental context.

Keywords: Wetland mapping, Remote sensing, Geospatial technology, Wetland classification, Conservation policy, Wetland inventory.

Advancing Wetland Identification in India: Integrating Geospatial Technologies and Ecological Criteria for Conservation

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ABSTRACT

The advancement of sustainable and durable concrete materials has prompted extensive research into the incorporation of recycled and industrial waste products for enhanced performance. This experimental study investigates the feasibility of producing High Strength Self-Healing Concrete (HSSHC) using recycled and waste materials as partial replacements for conventional concrete ingredients. The research primarily focuses on evaluating the mechanical, durability, and self-healing characteristics of concrete when 20% Recycled Fine Aggregate (RFA) and 20% Recycled Coarse Aggregate (RCA) are used as aggregate substitutes, along with 10% Fly Ash and 5% Silica Fume as supplementary cementitious materials. Additionally, encapsulated Bacillus subtilis bacteria and calcium lactate (3% by weight of cement) were incorporated as a self-healing agent to enhance crack-repair capability. Fresh concrete properties, compressive and split tensile strength, water absorption, ultrasonic pulse velocity, and self-healing efficiency were assessed. The results revealed that the optimized HSSHC mix demonstrated strong self-compacting ability, a 12–15% increase in strength after 56 days due to continued healing, and up to 75–85% autonomous crack sealing within 28 days. The study confirms that recycled and waste materials, combined with bio-based self-healing mechanisms, can produce environmentally responsible, durable, and high-performance concrete suitable for long-term structural applications.

Keywords: Fly ash, Silica fume, Workability, Durability, Self-healing concrete

AICCT2k25157

Optimization and Performance Analysis of Renewable Energy Systems for Sustainable Power Generation

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ABSTRACT

The global energy crisis and environmental degradation have driven the transition from conventional fossil fuels to renewable energy systems such as solar, wind, and biomass. These clean and sustainable energy sources play a vital role in meeting the growing energy demand while reducing greenhouse gas emissions. This study focuses on the optimization and performance evaluation of renewable energy systems to enhance their efficiency and reliability. Various factors such as solar irradiance, wind speed, temperature, and load variations are analyzed to determine their influence on system output and stability. The integration of hybrid systems, combining solar and wind energy, is also explored to ensure continuous power generation under variable climatic conditions. Simulation and experimental analysis demonstrate that proper parameter selection, component design, and system integration can significantly improve energy conversion efficiency and reduce operational costs. The study emphasizes that renewable energy technologies, when optimized and managed effectively, offer a sustainable solution to the world's increasing energy needs. The findings provide a strong foundation for future developments in clean energy systems and contribute to global efforts toward environmental sustainability and energy security.

Keywords: Renewable energy, solar energy, wind energy, sustainability.

Explainable AI and Its Role in Smart Cities

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ABSTRACT

The rapid integration of Artificial Intelligence (AI) in smart city infrastructures has revolutionized urban management, enabling data-driven decision-making in domains such as traffic control, energy optimization, public safety, waste management, and citizen engagement. However, as AI systems become more complex and autonomous, their "black-box" nature poses challenges in transparency, accountability, and trust. Explainable Artificial Intelligence (XAI) emerges as a crucial paradigm aimed at making AI systems' decisions understandable and interpretable to humans without compromising their performance.

In the context of smart cities, XAI facilitates informed decision-making by providing clear justifications for automated predictions and actions. For instance, explainable models in traffic management can elucidate why certain routes are optimized, or in public safety, how anomaly detection systems identify potential threats. This interpretability enhances trust among citizens, policymakers, and system administrators, ensuring that AI decisions align with ethical, legal, and societal standards. Moreover, XAI supports accountability and compliance with data governance frameworks by making algorithmic processes auditable and transparent.

By integrating XAI into smart city ecosystems, urban administrations can achieve responsible, human-centric, and sustainable AI deployment, balancing technological advancement with social acceptance and ethical governance. Future research in this field is directed toward developing scalable, domain-specific explainability techniques that bridge the gap between technical accuracy and human comprehension, fostering greater citizen trust and inclusivity in AI-driven smart urban environments.

Keywords: Explainable AI (XAI), Smart Cities, Transparency, Accountability, Ethical AI, Urban Governance, Data-driven Decision Making.

Machine Learning Applications in Molecular Design and Property Prediction

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ABSTRACT

This review systematically examines the transformative impact of artificial intelligence (AI) and machine learning (ML) in computational chemistry over the past decade. As chemical datasets surpass 100 million compounds and AI publications in the field exceed 10,000, intelligent computational tools are reshaping drug discovery, materials design, and synthetic planning. The review critically assesses methodological limitations, including data scarcity in rare chemical spaces, poor model interpretability, and limited generalization.

Keywords: Artificial Intelligence, Machine Learning, Computational Chemistry, Drug Discovery, Molecular Design, Deep Learning, Graph Neural Networks, Generative Models, Uncertainty Quantification.

Machine Learning-Assisted Evaluation of Crack-Healing Performance and Durability of Bacteria-Integrated Alkali Activated Calcined Clay Concrete

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ABSTRACT

The integration of bacteria into alkali-activated calcined clay concrete (AACC) represents a promising strategy for enhancing the self-healing capacity and durability of sustainable construction materials. This study investigates the crack-healing performance and long-term durability of bacteria-incorporated AACC using machine learning (ML) techniques to enable predictive evaluation. Experimental investigations were conducted on AACC specimens with embedded ureolytic bacteria, focusing on crack closure, compressive strength recovery, and permeability reduction over curing periods. High-resolution imaging and non-destructive testing provided quantitative data on crack healing, which served as input for supervised ML models. Various algorithms, including random forests, support vector regression, and artificial neural networks, were employed to establish correlations between bacterial activity, crack dimensions, and environmental conditions. The ML-assisted analysis demonstrated high accuracy in predicting healing rates and performance under varying loading and exposure conditions, offering a robust framework for optimizing bacterial dosages and mix designs. Results indicate that bacterial incorporation significantly improves crack closure efficiency, reduces water ingress, and enhances mechanical recovery, with predictive models successfully capturing complex interactions between mix parameters and healing kinetics. This integrated experimental–computational approach provides a novel methodology for accelerating the design and deployment of resilient, sustainable AACC systems with self-healing capabilities.

Keywords: Alkali-Activated Calcined Clay Concrete (AACC), Bacterial Self-Healing, Crack- Healing Performance, Durability, Machine Learning, Predictive Modeling.

AICCT2k25144

Role of Chemistry in Sustainable Technologies for the Future through AI

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ABSTRACT

The integration of Artificial Intelligence (AI) into chemistry has opened new frontiers for creating sustainable technologies that address global challenges like energy scarcity, climate change, pollution, and resource depletion. Chemistry lies at the heart of sustainable development, and AI acts as a catalyst that accelerates innovation, efficiency, and precision in this field.

1. Green Chemistry and Environmental Sustainability

AI helps chemists design eco-friendly reactions and non-toxic materials by predicting reaction pathways and minimizing hazardous byproducts. Machine learning models can simulate thousands of reaction conditions virtually, reducing waste and laboratory experiments. This aligns with the 12 principles of green chemistry, emphasizing resource efficiency and environmental protection.

2. Renewable Energy and Storage

In the development of sustainable energy technologies, such as solar cells, fuel cells, and batteries, AI assists in discovering and optimizing new materials like perovskites and solid-state electrolytes. Predictive algorithms analyze molecular properties and stability to create longer-lasting, energy-efficient solutions crucial for a green future.

3. Waste Management and Recycling

AI-driven chemical analysis aids in waste segregation, plastic degradation, and chemical recycling. By using deep learning models to identify and classify materials, industries can develop processes that convert waste into valuable chemicals or fuels—contributing to a circular economy.

4. Water Purification and Environmental Monitoring

AI enhances chemical sensor design for detecting pollutants, heavy metals, and microplastics in water and air. Smart filtration systems use AI-optimized materials like graphene-based

membranes for more effective purification and reuse of water, ensuring sustainable resource management.

5. Sustainable Agriculture and Food Chemistry

AI-guided chemical formulations in fertilizers and pesticides enable precision agriculture, reducing harmful runoff and improving soil health. Chemical sensors integrated with AI models can monitor nutrient cycles and predict crop health, balancing productivity with ecological safety.

6. Drug and Material Discovery

Through AI, chemistry accelerates the discovery of sustainable pharmaceuticals and biodegradable materials. By predicting molecular interactions, AI reduces the time, cost, and carbon footprint of experimental research—contributing to both health and sustainability goals.

The fusion of AI and chemistry is transforming the landscape of sustainable technology development. By enabling smart material design, optimizing energy use, and reducing waste, this interdisciplinary approach empowers scientists to build a greener, cleaner, and more sustainable future. As AI continues to evolve, its synergy with chemistry will play a central role in achieving the UN Sustainable Development Goals (SDGs) and ensuring a resilient planet for generations to come.

Keywords: Artificial Intelligence, Sustainable Chemistry, Green Chemistry, Renewable Energy, Waste Management, Environmental Sustainability