



The Book of Abstracts of Engineering Advances 2025

Second International Conference

Sanjay M. Gulhane, Amevi Acakpovi, Felix Kutsanedzie, Laxman B. Abhang
Editors



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The Book of Abstracts of Engineering Advances 2025: Second International Conference

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Preface

It is with immense pride that we present the Book of Abstracts of Engineering Advances 2025: Second International Conference, hosted by Pravara Rural Engineering College, Loni, Ahilyanagar, Maharashtra, India (affiliated with Savitribai Phule Pune University, Pune). This conference was organized in association with Technology Research and Innovation Centre, Pune, India; Accra Technical University, Accra, Ghana; Academy of Nanotechnology and Waste Water Innovations, South Africa. Engineering Advances 2025 is organized in online mode from 29 – 30 December 2025.

This conference served as a dynamic platform for researchers, scientists, and academicians from around the globe to present their pioneering work across various engineering disciplines. By fostering the exchange of innovative ideas and cutting-edge research, *Engineering Advances 2025* aimed to strengthen academic and industrial collaborations and advance the frontiers of engineering knowledge.

The conference received an overwhelming response, with 464 submissions from 19 countries, including Algeria, Belarus, Ghana, Japan, India, Indonesia, Italy, Iraq, Malaysia, Morocco, Nigeria, Peru, Philippines, Poland, South Africa, Turkey, United Arab Emirates, United States of America and Zambia. Contributions from more than 1,500 authors enriched the event with their diverse insights and expertise.

We are immensely grateful to the authors, reviewers, session chairs and organizing committee members for their unwavering efforts and dedication. The invaluable support and collaboration from our partner institutions played a vital role in the success of this event.

We hope that this collection of scholarly work will inspire innovation and provide a strong foundation for future advancements in the field of engineering.

***Sanjay M. Gulhane,
Amevi Acakpovi,
Felix Kutsanedzie,
Laxman B. Abhang
Editors***

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Keynote Speech: 01

AN OVERVIEW ON ADVANCES IN CIVIL ENGINEERING

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ABSTRACT

Civil Engineering has undergone significant transformation in recent decades, driven by rapid technological progress, growing urbanization, and the need for sustainable infrastructure. This overview presents recent developments in Civil Engineering across key domains, including Structural Engineering, Construction Materials, Geotechnical Engineering, Transportation Systems, Water Resources, and Environmental Engineering. Emphasis is given on the adoption of innovative materials such as High-Performance Concrete, Fibre Reinforced Composites, and Smart Materials as well as modern construction techniques like Building Information Modelling (BIM), Automation and 3-D Printing. The integration of digital technology like Artificial Intelligence, Sensing Systems, and Data Driven Design, has enhanced efficiency, safety, and decision making throughout the project life cycle. Additionally, the paper highlights the growing focus on sustainability, resilience and climate adaptive infrastructure to address environmental challenges and natural hazards. By incorporating recent research trends and practical applications, this overview aims to provide a brief understanding of how contemporary advancements are reshaping the Civil Engineering profession and contributing to the development of safer, more durable, and sustainable built environment.

Keynote Speech: 02

Experimental Approaches in Aerodynamic Testing of Engineering Structures: From Laboratory Models to Real-World Applications

Dr Dhiraj Kumar

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ABSTRACT

Wind tunnel testing is an important experimental tool for studying the aerodynamic behavior of engineering structures exposed to fluid flow. This lecture discusses how aerodynamic testing is used to understand flow–structure interaction and flow-induced vibration that can affect the safety and performance of large-scale structures. Selected classic examples are used to explain how aerodynamic forces can lead to oscillations and flutter, and why experimental studies are often necessary in addition to analytical and numerical methods. The lecture outlines key considerations for physical modeling in wind tunnel experiments, including important flow and structural parameters that influence the accuracy of test results and their consistency with the response of actual structures. Practical aspects of model design and fabrication are discussed with reference to the testing of chimneys, natural draft cooling towers, and other engineering structures. An overview of commonly used instrumentation, calibration methods, and testing procedures in wind tunnels is also presented. Overall, the lecture aims to connect basic aerodynamic concepts with practical experimental approaches, offering useful insights for students, researchers, and engineers involved in the aerodynamic testing of engineering structures.

Keynote Speech: 03

Development of Efficient Wind Turbine Designs for Decentralized Energy Systems

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ABSTRACT

The increasing demand for clean and sustainable energy has driven significant research toward improving the performance of small-scale wind energy conversion systems. Savonius wind turbines are particularly suitable for low-wind-speed applications due to their simple construction and self-starting capability; however, their efficiency remains relatively low. This study presents a detailed computational and experimental investigation of an elliptical-bladed Savonius wind turbine aimed at enhancing aerodynamic performance. The elliptical blade profile was developed by modifying the conventional semicircular geometry using an optimized ratio of the semi-minor to semi-major axes and an appropriate sectional cut angle. Numerical simulations based on the Reynolds-Averaged Navier–Stokes equations were conducted to analyze flow behavior, torque coefficient, and power coefficient over a range of tip speed ratios. The numerical results show that the elliptical profile significantly improves performance, achieving a maximum power coefficient of approximately 0.33 at a tip speed ratio of 0.8 for the optimal cut angle of 47.5° . Wind tunnel experiments were carried out to validate the numerical findings, where torque and power measurements were obtained for an arc-elliptical bladed rotor at different wind speeds and Reynolds numbers. The experimental results exhibit good agreement with the numerical trends and confirm the superior performance of the elliptical profile. Overall, the study demonstrates that elliptical blade geometry is an effective approach for improving the efficiency of drag-based Savonius wind turbines for small-scale and decentralized power generation.

Keynote Speech: 04

Future-Proofing Data: A Deep Dive into Quantum and Post-Quantum Security

Dr. M.R.M. Veeramanickam
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ABSTRACT

Quantum computing is rapidly approaching a tipping point where its ability to break classical encryption methods will reshape global cybersecurity, making quantum cryptography and post-quantum cryptography essential pillars of future communication. Unlike traditional systems that rely on mathematical complexity, quantum cryptography secures information through the fundamental laws of physics—principles like superposition, entanglement, and the no-cloning theorem—ensuring theoretically unbreakable protection against even the most powerful adversaries. At the same time, post-quantum algorithms such as lattice-based Kyber and Dilithium are being standardized to safeguard billions of devices and critical infrastructures from “harvest now, decrypt later” threats. Together, these advances highlight a near-future landscape where quantum-safe technologies are not optional but vital, enabling governments, industries, and societies to build resilient trust in the digital age.

An Ensemble Learning Approach for Prediction of Cardiovascular Disease

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ABSTRACT

Cardiovascular diseases (CVD), including coronary heart disease, myocardial infarction, and vascular disorders, are the leading cause of death worldwide and in Portugal, affecting diverse populations and threatening up to one-third of the global population. Early detection and management, complemented by psychological support and lifestyle guidance, are vital for reducing disease burden. This study presents an ensemble predictive framework integrating machine learning (ML) and deep learning (DL) techniques to forecast individual CVD risk and identify key contributing factors. Five classification algorithms were applied to a publicly available cardiovascular dataset, with Random Forest employed for feature selection. The novelty lies in combining ML and DL models to enhance predictive accuracy beyond traditional single-model approaches. Experimental results show that the DL ensemble achieves up to 95% accuracy, while identifying critical risk features. The proposed approach offers a powerful tool for early risk assessment, informed clinical decision-making, and improved cardiovascular healthcare outcomes.

Keywords: *Machine learning, Deep learning, Ensemble model, Random Forest, Feature selection, Myocardial infarction, Coronary artery disease.*

Intelligent Classification of Plant Leaf Diseases Using Adaptive Neuro-Fuzzy Systems

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ABSTRACT

Plant leaf diseases pose a significant challenge to agriculture, causing substantial reductions in both crop yield and quality. Traditional manual methods for disease identification are time-consuming, labor-intensive, and prone to errors, emphasizing the need for an automated and accurate detection system. This study proposes an intelligent framework for the identification and classification of plant leaf diseases using an Adaptive Neuro-Fuzzy Inference System (ANFIS). The methodology involves three stages: segmentation of infected regions using the K-means clustering algorithm, extraction of texture and shape features from the segmented areas, and classification of diseased leaves using ANFIS. The system effectively captures relevant visual features and provides precise categorization, achieving high accuracy and robustness. By integrating K-means clustering with ANFIS, the framework outperforms traditional manual and basic automated approaches. This scalable and efficient system enables early disease detection, supports precision agriculture, reduces crop losses, and promotes sustainable farming practices.

Keywords: *Adaptive Neuro-Fuzzy Inference System (ANFIS), K-Means Clustering, Feature Extraction, Image-Based Classification, Precision Agriculture*

Paper ID: 11010

LIGHTWEIGHT TRANSFER-LEARNER FRAMEWORK FOR MULTISTAGE ALZHEIMER'S DETECTION IN MRI SCANS

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ABSTRACT

Millions of people around the world experience memory loss and cognitive decline due to Alzheimer's disease (AD), which is a progressive neural disorder. Detecting it early with MRI imaging can significantly improve diagnosis and treatment planning. However, manual interpretation of MRI scans is often subjective and time consuming. This study introduces an automated and lightweight deep learning method for classifying the stages of Alzheimer's using transfer learning with MobileNetV3. The preprocessing steps involve resizing, normalizing, and enhancing the MRI images to improve generalization capability. Additionally, data augmentation techniques like rotation, flipping, and brightness adjustment are applied to help the network learn from multiple variations, allowing the model to become more reliable and less overfitted. MobileNetV3 has frozen feature extraction layers along with custom dense layers. It categorizes MRI scans into four categories: Non-Demented, Very Mild Dementia, Mild Dementia, and Moderate Demented. The performance of the model is evaluated using the metrics such as accuracy, precision, recall, and F1-score, ensuring a comprehensive assessment of classification effectiveness. Furthermore, a web interface has been built on Streamlit that allows real-time image uploads and instant predictions, making it useful for clinical and research applications. This study connects AI-based image analysis to healthcare by providing an efficient and clear way to detect Alzheimer's. Additionally, it demonstrates high efficiency in computation, making it suitable to deploy on low-resource devices and environments.

Keywords: *Alzheimer's disease; anomaly detection; deep learning; MRI image classification; transfer learning, overfitting.*

AI-Based Early Detection and Staging of Eye Diseases Using Fundus Image

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ABSTRACT

The disease of eye such as diabetic retinopathy, glaucoma, and due to age related macular degeneration is increasing worldwide, leading to vision impairment and blindness. Early detection and staging of the conditions are important for the clinical intervention. The objective of the project is to develop an AI(Artificial intelligence)-based framework is to detecting automatically various eye disease and determining by the retinal fundus images. The methodology employs a convolutional neural network architecture trained on a dataset of labeled fundus images. The preprocessing of data and augmentation techniques were applied to the enhance model generalization. The novelty of the project is combining the disease classification with the stages prediction in a automated system it is in both diagnostic and prognostic insights. The model is achieving the accuracy ,sensitivity, and multiple disease classes. The results is demonstrate the effectiveness of the AI is rapid, non-invasive and eye disease detection. And the conclusion the system has the potential to support in large scale, it reduce diagnostic load and it can detect early intervention and improving the patient outcomes.

Keywords: *Artificial intelligence(AI); convolutional neural network; Staging disease; Fundus imaging.*

An Intelligent IoT and Machine learning based model for Converting Conventional Air Conditioners into Smart Air Conditioners

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ABSTRACT

In recent years, the demand for smart air conditioners (ACs) has expanded swiftly due to the need for comfort, automation, and energy efficiency. However, upgrading conventional AC units to smart systems is often expensive. To overcome this, the present research proposes a cost-effective IoT-based device that transforms a non-smart AC into an intelligent, smart AC. The developed model automatically adjusts cooling based on room temperature, occupancy, humidity, and CO₂ concentration without requiring a remote control or mobile application. The main objective of this study is to design and implement a low-cost, power-saving system that functions automatically without human intervention. The model is built using an ESP32 microcontroller interfaced with two proximity sensors, two temperature sensors, two humidity sensors, and one CO₂ sensor. One temperature and humidity sensor pair are placed outside the room, while the other pair and CO₂ sensor are located inside. The system monitors these parameters in real time and utilizes a logistic regression algorithm to predict whether high cooling is necessary. When occupancy exceeds four persons and environmental factors indicate increased CO₂ and humidity, the device automatically reduces the AC's temperature to an optimal value. Experimental results give up to 80% accuracy in occupancy detection and improved cooling efficiency under crowded conditions. This economically feasible model provides a practical solution for domestic environments, senior citizens, and educational institutions, enabling intelligent control of traditional AC units without manual operation. This model is useful in conference halls of school or colleges. Also useful for senior citizens on domestic platform.

Keywords— IoT, ESP32, smart air conditioning, logistic regression, occupancy detection, energy efficiency.

AUTOMATED ATTENDANCE SYSTEM USING DEEP LEARNING – BASED FACE RECOGNITION WITH INSIGHTFACE MODEL

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ABSTRACT

The management of attendance is still a crucial administrative task in both education and business sectors. Nevertheless, even with the progress made in technology, the need for proper systems that are contactless and fully automated continues to exist because of the drawbacks that come with the manual and hardware-based systems. Manual approaches of attendance such as RFID tags, barcode scanning, and fingerprint recognition have their limitations like proxy attendance, hygiene issues, and maintenance complexities among others. To solve these problems, a paper has been written proposing a deep learning–based face recognition attendance system which is using InsightFace Buffalo_L model with ArcFace embeddings for highly discriminative facial representation. The system is to be structured as a workflow in which the machine learning process will go through image acquisition → Preprocessing → face detection and alignment → feature embedding extraction → cosine similarity–based matching → attendance logging → dashboard visualization. The backend will be done through FastAPI, allowing for real-time automation and also smooth integration of a web-based interface for visualization and report generation. The experiment to assess the system gave superior outcome of 96.4% recognition accuracy which indicates that the model is strong and able to generalize well across various lighting conditions and orientations of the face. The system brings a whole new level of accuracy, scalability, and operational reliability over traditional attendance methods, therefore it becomes a practical and efficient solution for modern institutions and organizations.

Keywords: *Face Recognition; Attendance Automation; Deep Learning.*

CLICKandBOOK – Smart venue booking and visualization system using MERN stack

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ABSTRACT

In real life scenarios, managing multiple events across auditoriums, seminar halls and classrooms we face confusion in seating arrangements and hence managing event venues often becomes complex. This is due to manual coordination, bookings being overlapped and lack of visualization. For this problem statement, the proposed solution "CLICKandBOOK" which is made to be AI-enhanced seat booking system in venues and is in the making with MERN (MongoDB, Express.js, React.js, Node.js) Stack to ensure event organization process to be completely clumsy free and efficient. "CLICKandBOOK" automates the booking process with the help of we interface which assures users to view, select and reserve seats in the venues seamlessly. Double reservations are prevented and it supports real-time booking status updates. "CLICKandBOOK" serves its purpose in events happening in the biggest of auditoriums to smallest of classrooms. The event co-ordinator is expected to capture the picture of the venue and to post it in our web, our web will convert the pictures to 2D animated visualization hence making it easier for seat booking. After this process the link is to be shared with the audiences, they can book the seats accordingly through mail id(if no payment is required) or transaction. This system so far exist only in theatre booking (some shows too) but we feel implementing this concept with our own modification in educational institutions and all other places where such events are being conducted. This makes the event to take place seamlessly in regards with seat booking no matter how small or big the event is. The novelty "CLICKandBOOK" highlights is that it's fully MERN based automation, Visual 2D layout conversion, Real time conflict free booking, Scalable for any venue size, Emphasis on clutter-free user experience

Keywords: *MERN stack, Smart venue booking, 2D visualization, scalable event management real-time automation system*

AUTOASSESS: AN LLM-INTEGRATED PLATFORM FOR AUTOMATED, FAIR, AND EXPLAINABLE CODING ASSESSMENT

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ABSTRACT

Assessing programming assignments at scale is difficult because traditional test-case grading only captures whether code runs, not how well it is written, how original it is, or how useful the feedback is for learning. This paper introduces AutoAssess, an AI-assisted assessment system built to automate question generation and grading while keeping instructor control and student learning at the center. Our goals are to (1) generate and deliver varied coding tasks, (2) combine correctness checks with code-quality evaluation and plagiarism detection, and (3) match the right AI model to each task to keep the process accurate and efficient. The system follows a clear pipeline: question generation → execution of visible and hidden test cases → LLM-driven code-quality scoring → embedding-based similarity checks for originality → human-readable feedback synthesis. A lightweight routing layer sends simple jobs to gemini flash/lite models and reserves pro models for deeper analytical grading. Two methodological contributions are a tunable holistic grading formula - $\text{final_score} = \text{clamp}(\alpha * \text{raw_test_score} + \beta * Q(\text{code quality}) - \gamma * E(\text{error}), 0, 100)$ (defaults: $\alpha = 0.75$, $\beta = 0.25$, $\gamma = 1.0$) and an optimal-question derivation using a $\sqrt{n}$ heuristic under uniqueness and difficulty-variance constraints. Pilot studies show strong agreement with expert graders, more actionable feedback for learners, and dependable plagiarism flags in classroom simulations. AutoAssess thus offers a practical, explainable, and instructor-friendly alternative to purely manual or opaque automated grading approaches.

Keywords: *Automated coding assessment; Holistic grading; LLM prompt routing; Plagiarism detection.*

Deforestation Prediction System through Deep Learning Techniques Using Remote Sensing and GIS Dataset

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ABSTRACT

Deforestation is a critical threat to biodiversity and ecosystem. Therefore, understanding the causes, predicting deforestation rate and conserving natural resources is essential. This paper introduces a deep learning framework to forecast forest loss, risk and intervention scenarios. The work applies deep learning techniques over multi-modal data sources from Landsat and Sentinel-derived NDVI/EVI, MODIS fire data, Hansen forest-loss maps, OpenStreetMap roads and urban layers, SRTM DEM, Copernicus Land Use/Land Cover, and WDPA protected areas to study local environmental and anthropogenic drivers. The spatial features and interactions are modeled using Generative Adversarial Network (GAN). Temporal Convolutional Network (TCN) is applied for temporal dynamics like vegetation and fire events. A fusion layer integrates these embeddings and forecast forest loss risk probabilities as High, Medium and Low. The what-if scenarios like establishment of new roads, protected areas are simulated using a counterfactual layer. It aids before-and-after imagery and analysis. Genetic algorithm is used for feature selection and hyperparameter tuning. The proposed framework delivers a district-specific work flow for deforestation forecasting and also generates notifications for high-risk zones. The framework is developed and analyzed for a specific region in Tamilnadu state of India, Theni district.

Keywords: *Deforestation prediction, GAN, Temporal Convolutional Network, NDVI/EVI, Forest-loss risk, Counterfactual analysis, Genetic Algorithm, Google Earth Engine.*

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SELF-ADAPTIVE VISION-BASED SMART PARKING SYSTEM

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ABSTRACT

Effective urban parking space management continues to be a major issue owing to limited spaces, bad parking practices, and congestion in parking lots. There are many existing smart parking systems, but too many use fixed position sensors, require manual slot configurations, or rely on single angle detection with cameras which decreases their performance under changing environmental conditions. Currently existing computer vision approaches for parking detection struggle with detecting partially occupied parking spots, occlusions, and changing weather and lighting conditions resulting in incorrect occupancy reporting or inefficient parking space utilization. To improve existing methods, we propose a Self-Adaptive Vision Based Smart Parking System utilizing **YOLOv8-Seg** for realtime vehicle and ambient slot segmentation and a **Dynamic Slot Mapping** workflow. Our system utilizes the usage of multiple angle **CCTV** video capture during installation for a specific area to develop a specific slot model for the area and a separate vehicle detection model. Every parking slot is then monitored for occupancy and data is classified as Free, Partially Parked, or Parked. The visual representation is shown in realtime with a colorized bounding box around the vehicle with the key and parking space number announced to the driver and administrator. Our workflow provides realtime execution without the need for specific repository storage. Our experimental findings indicate high degrees of accuracy of parking occupancy under dynamic conditions and relatively fast execution time (~ **30 FPS**).

Keywords: *YOLOv8-Seg, Smart Parking System, Dynamic Slot Mapping.*

AI-Driven Multilingual Voice Interface for Campus Navigation and Information Assistance

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ABSTRACT

Artificial Intelligence (AI) alongside Natural Language Processing (NLP) has emerged as a key force in the development of smart voice-controlled systems that not only change but also smooth the way for human-computer interactions. In the academic scenarios like schools, colleges, and universities, there is a rising demand for offline multilingual voice assistants to improve communication and facilitate accessibility. As in the case of Google Assistant and Alexa—robust existing systems—they still demand a good internet connection and have very few multilingual functions. The present project proposes what it calls a Multilingual AI Voice Assistant for Campus Navigation and Announcements, which is set to address this concern. The system consists of OpenAI Whisper for correct and precise speech recognition, Deep Translator for rapid translation into Hindi and Tamil, and either pyttsx3 or gTTS for spoken output. The art of User Interface is achieved through PySide6 that caters to both voice and button-based interaction. The operation of the system is a sequence of stages namely capturing the voice, transcription of voice, translation of text, and speaking it out for purposes of guiding or announcing. The offline model gives not only a faster response time but also greater privacy and access without being dependent on the internet. The experimental results support the claims of high recognition accuracy, prompt translation, and natural-sounding voice synthesis. The project presents an intelligent solution that is multilingual and user-friendly thereby facilitating communication and navigation around the campus in a more efficient way.

Keywords: *Multilingual Voice Assistant, Speech Recognition, Campus Navigation.*

FAKE NEWS DETECTION USING NATURAL LANGUAGE PROCESSING

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ABSTRACT

The rapid expansion of digital media and online communication has created an unprecedented ability to rapidly disseminate misinformation or disinformation in such a way as to undermine public trust and stabilize social norms. This project aims to develop an AI-based Fake News Detection System that uses Natural Language Processing (NLP) and aesthetic transformer-based models utilizing contexts, such: BERT, as well as RoBERTa, to classify actual news articles vs. fake news articles. The system can process both raw text and URL inputs, with the articles automatically scraped, cleaned, and evaluated for linguistic patterns extracted from valid as well as fake articles. For model integrity, an ensemble model, including both BERT as well as RoBERTa will enhance and increase the overall performance of the models through weighted voting. Finally, a trusted-source verification layer, identifies legitimate data / source to reduce false-positives of trusted or legitimate article data. The front-end, designed using "Streamlit," enhances the usability of users being able to check the initial assessment of validation in real time while offering a few tools for explainability from a highlighting of keywords in articles as well as importance while providing contextual reasoning for assessments. Experimental evaluations of the models demonstrates good classification performance while offering good generalizability performance with field setting from validity / fake dataset and other unseen data's. Overall, the intent of this authentication system utilizes modern NLP and AI to support responsible information consumption, validation, and to contribute to a safer, trustworthy, digital information environment.

Keywords: Fake news detection ; Deep Learning ; Natural Language Processing.

A Comparative Evaluation of Deforestation Detection Techniques

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ABSTRACT

Deforestation is one of the major reasons for ecosystem degradation, carbon dynamics, and biodiversity loss. Therefore, monitoring deforestation and its causes is essential. Existing systems largely rely on single modal and coarse global datasets. Effective understanding of deforestation causes and its effects needs a much deeper approach to visualize it in smaller region specific like district level. This work presents a comparative analysis of conventional deforestation detection techniques like Normalized Difference Vegetation Index (NDVI) differencing, Normalized Burn Ratio (NBR), supervised classification methods (CART and SVM), and global forest-loss products. These conventional methods are implemented in Google Earth Engine (GEE) for Theni district, Tamilnadu, India. The work individually analyzed various spatial and temporal datasets including Landsat-8, MODIS, Copernicus Land Use/Land Cover, SRTM DEM, and OpenStreetMap to study their contribution in detecting forest-loss patterns. The study also evaluates spatial-temporal variables like vegetation index, land-use, elevation, slope and proximity. The work further provides a systematic framework to understand how different datasets aid deforestation monitoring and influencing spatial drivers of forest loss which further helps to make decisions on conservation plans.

Keywords: *Deforestation monitoring, Google Earth Engine, NDVI, NBR, Landsat-8, MODIS, spatial analysis, temporal analysis.*

A MODULAR RAG CHATBOT FOR COLLEGE INFORMATION SYSTEMS USING ADVANCED DOCUMENT PARSING AND A SERVERLESS VECTOR DATABASE

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ABSTRACT

We developed a Retrieval-Augmented Generation (RAG) chatbot specifically designed to address the information accessibility gap in higher education settings. Students and staff frequently struggle to locate accurate institutional information scattered across numerous, disparate PDF documents and web portals. Existing methods include manual user searching and baseline chatbot implementations. This scattered nature of information makes finding accurate data difficult and time-consuming. Furthermore, baseline chatbots suffer from low retrieval accuracy and a high tendency to provide fabricated information (hallucinations). Our system's implementation is built on three key open-source technologies: Docling for document parsing, LanceDB as a serverless vector database, and OpenRouter as an orchestration tool for Large Language Models (LLMs), integrating models like Mistral-7B and Llama-3-70B. The system's flow involves Docling extracting content while critically maintaining original structure and semantic relationships for accurate knowledge representation. The processed content is stored in LanceDB, which provides fast semantic search capabilities. OpenRouter then manages queries and responses, flexibly integrating with various language models. The system is accessible via web-based interfaces and API access. This model offers advantages: it is cost-effective, as LanceDB provides high-speed search without dedicated infrastructure; flexible, since OpenRouter allows balancing performance and operational costs; accurate, due to Docling's structure-aware parsing; and maintainable, thanks to its modular design. Testing revealed marked improvements in retrieval accuracy over baseline chatbots. Users consistently received contextually appropriate responses grounded in source documents, with measurably fewer instances of fabricated information and response latency remaining acceptable for interactive use.

Keywords: conversational AI; document parsing; educational technology; retrieval-augmented generation; vector database.

Enhanced Outline Preservation Based Segmentation (OPBS) Algorithm with Similarity Search Based Hybrid Classification (SSHC) For Liver Image Segmentation from CT Scan Image: A Comparative Analysis with KNN, SVM and CNN Classifiers

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ABSTRACT

Cancer is among the highly ranked cause for loss of human life. According to World Health Organization Global Cancer Observatory report the death ratio results to 87.59%. Computer Aided Detection and Diagnosis (CAD) is improving with the evolution in technology and techniques. In computer aided detection, diagnosis and treatment of liver cancer, different imaging modalities are used. Preferred imaging modality is Computed Tomography (CT scan). In medical image processing segmentation of liver image remains a challenging task due to variety of reasons. Being a soft organ, the liver shape is highly dependent on adjacent organs within the abdomen. Many times, clearly defined edges are not visible on many sides of the liver. The intensity differences between the images of liver and nearby organs are very small. Tissue linkage, low contrast, and overlapping of different organs are also major challenging problems. OPBS algorithm is presented in the year 2020, for liver image segmentation from CT scan images. The study presents a modified OPBS algorithm. Classification is implemented using SSHC and results are compared with standard classifiers like KNN, SVM and CNN. The experiment is carried out using IRCAD dataset. The novelty is in the selection of outline pixels for better segmentation results. Results are found better in comparison with previous study. Novelty lies in comparative analysis of results with KNN, SVM and CNN classifiers also. Study also highlights the need of data augmentation in medical image processing.

Keywords: *Liver Cancer; CT scan; OPBS; SSHC; KNN SVM CNN Classifiers.*

Deep Learning and Computer Vision Approaches for Cattle and Buffalo Breed Identification: A Comprehensive Review

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ABSTRACT

Accurate identification of cattle and buffalo is central to the effective use of technology within today's agricultural industry; it allows for precision agriculture, supports disease prevention and eradication, and enhances breed identification and traceability. Although traditional methods of cattle/buffalo identification including ear tags and RFID tags have been widely used, they are limited due to ongoing maintenance costs, the need for significant amounts of manual labor, and the potential for them to be tampered with. Therefore, this paper will provide a comprehensive analysis of computer vision and deep learning techniques that have been used to automate livestock identification. The primary goal of this paper is to evaluate and compare different hybrid and explainable methods that can be used to increase the accuracy of livestock recognition, while maintaining the ability to scale and maintain transparency when implementing these methods in real world farm environments. These evaluation methods include: Convolution Neural Networks (CNN); Real-Time Detectors based on YOLO; Generative Adversarial Networks (GANs) for creating artificial data for training; and Attention-Based Transformer Models for Multi-Breed Classification. This paper provides an original synthesis of both Deep Learning and Explainable Artificial Intelligence (XAI) strategies to create robust and interpretable animal recognition systems. The results indicate that Hybrid Frameworks using GANs and CNNs result in the highest level of performance under noisy and changing light conditions; however, XAI enabled models also significantly enhanced the interpretation of the model output while still providing rapid detection capabilities.

Keywords: *cattle identification; computer vision; deep learning; explainable AI; YOLO.*

A Reproducible Framework for K-Means Clustering: Evaluation, Visualization, and Applications Using the Iris Dataset

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ABSTRACT

Clustering algorithms, including K-means, represent an important facet of unsupervised learning because they divide or cluster similar data into one or more cohesive groups without requiring class labels. This work acknowledges the importance of clear understanding and effective manipulation of a dataset for integer-preparation, and outlines a K-means clustering pipeline based on K-means clustering using the Iris dataset, a classic dataset in the areas of pattern recognition, and a clear data analysis framework. This work includes a brief literature review and extensive preprocessing and feature standardization, as well as the use of the Elbow method and the Silhouette method to identify the number of clusters. Evaluation includes the Silhouette Score, Davies- Bouldin Index, and Calinski- Harabasz Score to assess clustering quality and separation. Visual elements presented include principal component analysis (PCA), heatmaps of heat overlap, and detailed plot distributions for the clusters and the group's characteristics. The results provide evidence that the K-means model summarizes Iris flowers into two recognizable groups (clusters) using mostly petal-related features. While the model provides clear separation, improved metrics, and visual attributes for the combinations of features, the K-means workflow discussed here represents a reproducible format that is easy to implement in Google Colab and shorter educational template for further K-means experimentations, and as a basis of experiments to compare clustering experiments too. Applications of clustering effectively range from the biological domain (i.e. taxonomy or simply patterns) to real-world datasets with their own measurable patterns.

Keywords:- *K-means clustering, unsupervised learning, Iris dataset, cluster analysis, feature standardization, Elbow method, Silhouette score, principal component analysis (PCA), cluster validation, data visualization, machine learning, cluster centroids, evaluation metrics, pattern recognition.,*

Optimized Relaxation for Industrial Process Control and Inverse Modeling

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ABSTRACT

Partial differential equation (PDE) constrained inverse problems represent a fundamental challenge in industrial process modelling and control systems. Traditional approaches often suffer from non-convex optimization landscapes, sensitivity to initial conditions, and computational intractability for real-time applications. However, the inverse problem of estimating model parameters from limited measurement data remains particularly challenging. These limitations have motivated the development of relaxation techniques that can mitigate nonlinearity while maintaining physical consistency. Our contributions address three critical aspects of industrial inverse problems. The foundation of our work builds upon the constraint relaxation methodology introduced by van Leeuwen and Herrmann, which reformulates the PDE-constrained optimization as a joint parameter-state estimation problem. We demonstrate how data-driven reduced-order models can be naturally incorporated within this framework, enabling efficient implementation while maintaining theoretical guarantees. First, we establish a continuous formulation that provides a common analytical framework applicable to diverse industrial applications. Second, we characterize the limiting behaviour of the relaxed formulation, revealing an interpolation between solution-residual and PDE-residual minimization. By providing a mathematically rigorous yet computationally feasible approach to inverse problems, we enable more accurate parameter estimation, improved model predictive capability, and enhanced decision-making in complex engineering systems. The methodology is particularly relevant for industries requiring real-time optimization, such as chemical processing, energy systems, and manufacturing automation.

Keywords: *Inverse problems; PDE-constrained optimization; industrial process control; relaxation methods; data-driven modeling; reduced-order models; process optimization.*

SURVEY ON MULTIMODAL MACHINE LEARNING FOR MENTAL HEALTH DETECTION IN ASIAN SUBCONTINENT

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ABSTRACT

The rapid rise of depression, anxiety, and stress disorders across the Asian subcontinent reflects the urgent need for scalable, culturally sensitive mental health detection systems. Traditional unimodal approaches relying on single data types such as text, speech, or facial expressions often fail to capture the complex and context-dependent nature of human emotions. The study classifies models based on fusion strategies, datasets, and architectures, highlighting the integration of audio, video, text, and behavioural cues. The methods show that hybrid attention and transformer-based fusion achieve the highest accuracy, while federated and privacy-preserving designs are emerging to ensure data security. Results indicate improved detection performance and cultural adaptability compared to unimodal systems. However, persistent challenges include dataset imbalance, ethical compliance, and generalization across languages. This work concludes with recommendations for developing explainable, privacy-aware, and resource-efficient AI frameworks tailored to Asia's diverse sociolinguistic landscape.

Keywords: *Asian Subcontinent; Deep Learning; Depression Detection; Mental Health AI; Multimodal Learning*

Comparative Analysis and Future Directions of CNN and Vision Transformer Models for Skin Cancer Detection

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ABSTRACT

Skin cancer, particularly melanoma, is one of the most aggressive and fatal forms of cancer, and its early detection is crucial for improving patient survival. Traditional diagnosis methods are often limited by accessibility, subjectivity, and resource constraints, especially in rural and underserved regions. Recent advancements in deep learning and computer vision have significantly enhanced the potential for automated skin lesion detection and classification. This review consolidates existing research that explores a variety of deep learning models—ranging from Convolutional Neural Networks (CNNs) and transfer learning techniques (ResNet, DenseNet, EfficientNet, Inception) to hybrid approaches incorporating optimization algorithms, ensemble models, and Vision Transformers. Several studies address critical challenges such as class imbalance, dataset diversity, segmentation accuracy, and interpretability by employing strategies like data augmentation, Generative Adversarial Networks (GANs), and Explainable AI (XAI) frameworks including Grad-CAM and SHAP. Deployment aspects, including mobile and web-based diagnostic platforms using TensorFlow.js and TensorFlow Lite, have also been investigated to enhance accessibility in telemedicine. Experimental results across benchmark datasets such as HAM10000 and ISIC consistently demonstrate the potential of deep learning for reliable, non-invasive skin cancer diagnosis, with reported accuracies often exceeding 90%. Despite these advances, challenges remain in achieving clinical-level robustness, handling heterogeneous image features, ensuring fairness across diverse populations, and addressing privacy and ethical concerns. This review highlights current methodologies, identifies gaps, and suggests future research directions in explainability, federated learning, multimodal integration, and clinical adoption to bridge the gap between research and real-world dermatological practice.

Keywords: *Convolutional Neural Network; Explainable AI; Hybrid Deep Learning; Medical Image Analysis; Skin Cancer Detection; Vision Transformer*

A Comprehensive Review on CNN and GAN-Based Approaches for Citrus Leaf Disease Detection

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ABSTRACT

Citrus diseases result in significant loss to citrus production and subsequently reduce farmer income. Citrus leaf disease diagnosis has traditionally been conducted by hand, which is time consuming and often less than accurate. An objective of this study was to develop a quicker and more efficient method for citrus leaf disease identification through the application of computer vision and machine learning to processed images. Researchers obtained images of citrus leaves directly from farmers, along with additional information including the type of tree; distance between the trees; average fruit yield per tree; and weather conditions. Researchers found that many prior studies of image processing techniques indicated that they had demonstrated 80 – 90 percent accuracy. Conversely, researchers also found that deep learning architectures, particularly those based upon convolution neural networks (CNN), have shown significantly higher levels of accuracy (>99%). While CNN's offer a level of accuracy that could be very beneficial to farmers, they are computationally intensive and can be problematic when adapting to varying environmental conditions. Therefore, researchers concluded that models utilizing deep learning methods that are trained on locally collected data will provide improved accuracy in real-world field conditions. As a result of these findings, future research should focus on creating and testing low cost, easily used, and easily interpreted models for use by farmers to quickly detect disease in their fields in real time.

Keywords: *Citrus Leaf Disease, Image Processing, Machine Learning, Deep Learning, Convolutional Neural Network (CNN), Generative Adversarial Network (GAN), Computer Vision, Crop Disease Detection, Agricultural Automation, Precision Farming*

An Interpretable Multimodal Large Language Model for Transparent Healthcare Decision support

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ABSTRACT

Modern healthcare increasingly depends on the integration of diverse data such as electronic health records (EHRs), clinical text, and medical images to support accurate decision-making. Conventional artificial intelligence (AI) models often process these data types separately and lack interpretability, reducing their trustworthiness in clinical settings. This study introduces an Interpretable Multimodal Large Language Model (I-M-LLM) designed to unify heterogeneous medical data while providing transparent reasoning. The proposed model integrates three components: interpretable fusion of structured EHRs and clinical notes for feature-level explanations, Vision Transformer based image encoding aligned with longitudinal EHR data for multimodal learning, and pixel-level grounding that enables region-specific visualization and visual question answering. Interpretability is enhanced using Shapley values, Integrated Gradients, and attention-based visualizations. Experimental results on MIMIC-IV, CheXpert, and MeCoVQA datasets show that I-M-LLM improves diagnostic accuracy, interpretability, and clinician confidence compared with existing unimodal and multimodal systems. The findings demonstrate that transparent multimodal learning can significantly enhance the reliability and acceptance of AI-driven healthcare.

Keywords: *Clinical decision support; Electronic health records; Explainable artificial intelligence; Multimodal learning; Vision Transformer;*

AI Based Exam Proctoring System in Offline Examination

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ABSTRACT

Maintaining academic integrity during offline examinations has become increasingly important as traditional invigilation methods often fail to detect subtle or organized cheating behaviours. This paper presents a comprehensive survey of recent research efforts that apply artificial intelligence and deep learning to develop reliable offline exam proctoring systems. Techniques such as convolutional neural networks, skeleton-based pose estimation, and multimodal fusion have shown strong potential for identifying cheating-related activities in real time. Despite promising results, several challenges persist, including limited publicly available datasets, real-time performance constraints, ethical considerations, and the need for interpretable models. The review concludes that future work should focus on developing lightweight and explainable AI architectures, privacy-preserving frameworks, and standardized datasets for practical classroom deployment. Overall, this study provides a consolidated understanding of current progress and highlights the direction for creating trustworthy AI-based offline exam monitoring systems.

Keywords: AI in education; classroom monitoring; computer vision; deep learning; offline cheating detection

DEEP LEARNING AND COMPUTER VISION APPROACHES FOR REALTIME DROWSINESS DETECTION: A COMPREHENSIVE REVIEW

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ABSTRACT

Roadway fatalities are dangerous due to the number of roadway deaths. Roadside accidents occur at an alarming rate and make up approximately thirty percent of all roadway fatalities in India. Several types of accidents occur as a result of factors such as speeding, roadways that are poorly maintained or constructed, and distracted driving. The percentage of drowsy driving increases to forty-three percent when a driver becomes fatigued. The internet of things is being used to develop a drowsy detection system through artificial intelligence. A comparison of methods of detecting tiredness is discussed below. These systems use various forms of data from both vehicles, and vehicles to infrastructure. They continually monitor the vehicles' location in the lane, its speed, braking behavior, environment, and behaviors related to how the driver is operating the vehicle. These systems have made sharing information much easier so that accident prone areas can be identified and the infrastructure improved. Tiredness is detected in real time using a combination of models (random forest, svm and gradient boosting) that collect data from sources such as the eye aspect ratio and the heart rate variability of the driver. Multi-modal sensors, predictive modeling, and real-time networking will help support the development of smart traffic systems for safer travel and reduce the risks associated with fatigued drivers and improve accident avoidance.

Keywords: *Ensemble Learning, Real-Time Monitoring, Road Accident Prevention, Machine Learning, Driver Fatigue, Intelligent Transportation Systems, Risk Assessment, Computer Vision, Multimodal Detection System, Safety-Critical Applications.*

FITCO:AI Based Interactive Fitness Trainer

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ABSTRACT

Many individuals perform physical exercises without proper supervision, which often results in incorrect movements and poor posture. These errors can cause injuries, muscle strain, and reduce the overall effectiveness of workouts. Although a human trainer can help correct form, continuous access to one is not always feasible. To address this limitation, our paper FitCo serves as a virtual fitness trainer that uses a standard camera to monitor users and provide real-time guidance during exercise. FitCo continuously tracks body movements through pose estimation to detect key joint positions, including shoulders, elbows, hips, and knees. It determines whether each exercise is performed correctly by comparing the user's joint angles with the ideal reference posture for that activity. If an incorrect posture is detected, the system immediately provides both audio and visual feedback, allowing the user to make instant adjustments. Additionally, the system records important workout information such as repetition count, posture accuracy, and overall performance progress. Delivering real-time feedback and tracking user performance, FitCo helps minimize posture-related errors, ensures safer workouts, and enhances training effectiveness. The system is versatile and can be conveniently used at home and gyms, or in rehabilitation centers without requiring any specialized Trainer.

Keywords: *computer vision; Fitness training; Pose Estimation; Posture Correction; Real Time Feedback;*

DRONE ASSISTED AGRICULTURAL HEALTH MONITORING WITH Edge AI & NDVI

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ABSTRACT

Agriculture continues to be the cornerstone of India's economy, employing nearly half of the nation's population and contributing substantially to its GDP. Despite technological progress, traditional crop monitoring methods remain labour-intensive, subjective, and spatially limited. The integration of unmanned aerial vehicles with Edge AI and the NDVI introduces a transformative framework for precision and sustainable farming. This review presents a comprehensive study of a drone-assisted agricultural health monitoring system that combines multispectral imaging, on-device intelligence, and cloud-supported analytics. The proposed framework is structured around five functional modules: the Drone Platform, Data Acquisition and Pre-processing, Edge AI for Analysis and Decision-Making, Applications and Actions, and Communication & Cloud Interface. The approach enables drones to collect high-resolution imagery, process it locally through Edge AI models such as CNNs and YOLO architectures, and identify patterns of stress, pest infestation, or nutrient deficiency in real time. By linking localised intelligence with centralised cloud analytics, this architecture supports precision interventions such as variable-rate irrigation, disease control, and yield prediction. The integration of NDVI with lightweight AI algorithms ensures faster decision-making, reduced bandwidth usage, and scalable farm management. The study highlights how such a framework can advance data-driven, resource-efficient, and climate-resilient agriculture for future farming systems.

Keywords: NDVI, Edge AI, Drone, Precision Agriculture, Crop Health Monitoring, Raspberry Pi, Smart Farming

SiRouteNet: Learning Signal-Integrity–Aware Cost Maps for Constraint-Driven PCB Autorouting

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ABSTRACT

Printed-circuit-board (PCB) autorouters usually optimize geometric cost (e.g., wire length and via count) under design rules but seldom reason about signal integrity, such as crosstalk risk or return-path discontinuities, during routing. We propose SiRouteNet, a learning-assisted framework that predicts signal-integrity-risk heatmaps from multilayer PCB grids using a U-Net and injects these predictions as a differentiable cost term into a deterministic path search. Enabling training without proprietary data, we construct a synthetic dataset that procedurally generates boards with signal layers, ground-plane cutouts, differential-pair masks, and keep-outs, deriving SI-proxy labels from parallel-run proximity and return-path gaps. On held-out tests, SiRouteNet reduces the integral of predicted SI risk along routed paths relative to a geometric-only baseline with negligible change in path length; ablations show removing the ground-plane channel degrades SI performance by over an order of magnitude. Our results suggest that learned SI proxies + deterministic routing is a practical path to trustworthy SI-aware PCB automation, complementary to conventional autorouters, and amenable to real-tool integration.

Keywords: *PCB autorouting, signal integrity, crosstalk, return path, deep learning, U-Net, EDA automation*

Colorization of SAR Images Using Deep Learning: Balancing Perceptual Realism with Structural Fidelity

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ABSTRACT

In remote sensing, Synthetic Aperture Radar (SAR) imagery is essential because it provides reliable observations regardless of the lighting or weather. However, its grayscale representation limits intuitive human understanding. In order to close the visual gap between SAR and optical imagery and enable more approachable and instructive interpretation, this work investigates deep learning-driven colorization and compare U-Net and Pix2Pix frameworks for translating radar backscatter patterns into visually meaningful optical counterparts. While U-Net preserves fine structural fidelity, the adversarial approach of Pix2Pix enhances visual realism and perceptual clarity. Through extensive experiments across diverse terrain types—including urban, agricultural, and natural landscapes—our findings reveal a compelling balance between pixel-level accuracy and perceptual quality. The work highlights how customized deep learning algorithms can improve radar data interpretability, creating opportunities for more user-friendly and human-centered remote sensing applications.

Keywords: *Synthetic Aperture Radar, Image Colorization, Deep Learning, U-Net, Pix2Pix, Generative Adversarial Networks, Remote Sensing, Image-to-Image Translation, Computer Vision, SAR-to-Optical Translation*

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A Review on Event Management Systems

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ABSTRACT

Event management plays an important role in academic institutions where multiple events occur every year. However, the documentation and reporting process takes a lot of time but remains manual and non-centralized. A need for a centralized system which automates documents arises. The review focuses on understanding existing methods and technologies used by institutes to manage events conducted. It helps in identifying the gaps in existing systems, where the majority of these systems perform registration and scheduling, only a handful facilitate document storage and automation. The objective of this review paper is to study existing systems and their working in aspects of event management, proposing a framework that simplifies documentation through role-based access, automating and centralizing record management. The paper aims to connect the process of organizing events with a system that keeps official records, so that administrators can manage with clarity, and efficiency. Research mainly relied on the review of papers from 2023-2025, analyzing the limitations and gaps in existing systems. Papers were studied by comparing methodologies, features, objectives and their outcomes in relation to event management techniques within institutes. The study identified that most systems mastered scheduling, registration of participants and overall management, none focused on customization and documentation. Results showcase creating an intelligent documentation system could benefit institutions to customize and manage their records effectively and efficiently.

Keywords: *Web-based portal, Document-automation, Role-based access*

A Survey on AI-Driven Multi-Objective Optimization for Virtual Network Function Placement in Cloud-Edge Computing

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ABSTRACT

Cloud-edge computing has emerged as a key model supporting latency-sensitive and resource-hungry applications. Virtual Network Function (VNF) placement has been key for achieving efficient resource usage, low service latency, and maximum system availability for distributed cloud-edge platforms. The VNF placement problem itself has intrinsic NP-hard nature and includes balancing many competing factors such as cost, energy expenditure, latency, and load balancing. In recent years, AI-powered optimization solutions have attracted phenomenal interest for tackling these challenges. This survey thoroughly covers the state of the art of AI-powered multi-objective optimization techniques for VNF deployment on cloud-edge computing. We categorize existing methods as machine learning, deep learning, evolutionary, and game-theoretic hybrid ones and outline their design principles, computational complexity, and scalability. A comparative taxonomy has been developed for analyzing how different strategies compromise key performance indicators. Moreover, the survey takes into account benchmark datasets, simulation platforms, and evaluation metrics generally employed for model validation. Beyond describing current trends, we identify future areas of research that include handling dynamic user mobility, integrating energy-aware green computing, accommodating disparate edge devices, and delivering AI-informed decisions with trust, security, and fairness. Finally, we outline future areas of research, with emphasis on adaptive, explainable, and federated AI models that would allow for large-scale, real-time VNF control for next-generation networks. By incorporating recent advances and providing a structured long-term vision, our survey aspires to serve as a general reference for researchers and practitioners aiming at designing effective, intelligent, and robust VNF placement solutions for cloud-edge networks.

Keywords: Cloud-edge computing; virtual network function; AI optimization; multi objective optimization.

A SURVEY ON MACHINE LEARNING APPROACHES FOR REAL-TIME UPI FRAUD DETECTION: FROM STATIC MODELS TO SEQUENTIAL ENSEMBLES

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ABSTRACT

The Unified Payments Interface (UPI) has become the backbone of India's digital economy, offering unprecedented convenience¹¹. However, this rapid growth has been met with a surge in sophisticated fraudulent activities, including social engineering and phishing, which exploit the system's speed²². Traditional rule-based detection systems are proving to be slow, static, and insufficient to counter these dynamic threats³³. This has necessitated a shift towards advanced, adaptive machine learning (ML) solutions⁴⁴. This paper presents a comprehensive survey of the ML methodologies proposed for UPI fraud detection. The objective is to categorize and analyze these techniques, from baseline models like Decision Trees and Isolation Forests⁵⁵ to more advanced static feature analyzers like XGBoost⁶⁶ and sequential pattern detectors like Long Short-Term Memory (LSTM) networks⁷⁷. Our review of the current literature reveals a critical research gap: most existing models excel at analyzing either static tabular features or sequential temporal patterns, but rarely both in tandem⁸⁸. This survey concludes that the most promising and novel direction for future research is the development of hybrid ensemble models, which strategically combine the strengths of static and sequential analysis to provide a robust, adaptive, and real-time detection framework⁹⁹.

Keywords: *Ensemble Learning; LSTM; Machine Learning; Real-Time Detection; UPI Fraud Detection*¹⁰

A Comprehensive Survey on Machine Learning and AI for UPI Fraud Detection: Techniques, Challenges, and Future Directions

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ABSTRACT

The Unified Payments Interface (UPI) has revolutionized digital transactions in India, but its rapid adoption has triggered a significant surge in sophisticated fraudulent activities. Traditional rule-based fraud detection systems are often insufficient to counter these evolving threats. This paper presents a comprehensive survey of machine learning (ML) and artificial intelligence (AI) techniques proposed for detecting UPI fraud, based on a systematic review of contemporary research. We categorize and analyze a spectrum of methodologies, including supervised learning (e.g., Random Forest, XGBoost, SVM), unsupervised learning (e.g., K-Means, Isolation Forest), deep learning (e.g., CNN, RNN, LSTM), and advanced hybrid models incorporating federated learning, causal inference, and natural language processing (NLP). The paper synthesizes the performance of these models, discusses key evaluation metrics, and highlights the critical processes of data preprocessing and handling imbalanced datasets. We identify significant open challenges, including the lack of public datasets, the need for real-time adaptability (concept drift), and the demand for model explainability. Finally, we outline future research directions, emphasizing the potential of integrated frameworks that combine behavioral analytics, graph neural networks, and crowdsourced intelligence to build a more secure and trustworthy UPI ecosystem.

Keywords: *UPI, Fraud Detection, Machine Learning, Deep Learning, Ensemble Learning, Anomaly Detection, Survey Paper, Real-Time Systems, Imbalanced Data*

ENHANCING IMAGE-BASED MALWARE DETECTION USING TRANSFER LEARNING

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ABSTRACT

Conventional approaches for malware detection continue to face significant difficulties. They often perform poorly when dataset is unbalanced, require high resources, and struggle to adapt to the growing number of digital threats. This study aims to solve these issues by creating a powerful new system for detecting malware. The proposed solution uses a combined intelligent model that integrates a custom-built CNN (Convolutional Neural Network) designed to better recognize the visual patterns of malware with pre-trained ResNet50V2. The system automatically balances the dataset by changing how it samples different types of malware using weights. It also augments training data carefully that it preserves the critical features of each malware sample. When tested on well-known public datasets, including Malimg, Malevis, and a blend dataset, this framework achieved an accuracy of 99.80%. Better results have been seen with other well-known methods such as TL & kNN (Transfer Learning and K-Nearest Neighbour) as well as VBDN (Visualization, Balanced sampling, Data enhancement and Neural network techniques). The results show that the methodology is reliable and scalable using smart data handling with advanced pattern recognition. In conclusion, this study could be a foundation for innovative cybersecurity threat detection, which need to be very accurate, adaptable, and useful.

Keywords: *balanced data generation; deep learning malware detection; feature extraction; ResNet50V2; scalable cybersecurity framework*

FusionHeart AI Multimodal Clinical Integration for Angiographic Risk Prediction

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ABSTRACT

Angiographic disease detected via coronary angiography continues to pose a major global health burden, demanding accurate and timely predictive tools. This research proposes **MultiAngioML**, a new multimodal machine-learning framework that integrates diverse clinical features from the Cleveland heart-disease dataset into a prediction system. Five models—Logistic Regression, SVM, Random Forest, Gradient Boosting, and XGBoost—were trained and compared, followed by a stacked ensemble to boost reliability and generalization. Cross-validation shows Random Forest leading with **91.3% accuracy** and an **AUC of 0.91**, closely followed by XGBoost (89.2%) and SVM (87.6%). The ensemble delivered consistently stable performance across folds, highlighting its resilience to dataset variability. The key innovation is the fusion-based multimodal design, which enables richer risk assessment and greater diagnostic confidence. Overall, the framework provides a strong pathway toward improved computer-aided angiographic diagnosis and cardiovascular risk prediction.

Keywords: *Heart Disease, Ensemble Learning, Multimodal Learning, Angiographic Prediction, Ensemble Modelling, Cardiovascular Diagnostics*

Adaptive Hybrid Deep Learning Framework for Robust and Reversible Image Steganalysis

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ABSTRACT

Steganographic payloads are evolving in ways that prevent conventional steganalysis techniques from being effective, There by demanding adaptive and resilient steganalysis techniques. This paper describes a hybrid deep learning architecture that can be retrained across image domains with limited retraining to meet the challenge of a changing application workload. Architecture uses Convolutional Neural Networks (CNNs) to learn fine-grained texture features, Recurrent Neural Networks (RNNs) to capture structural dependencies, and an attention layer to focus on regions more likely to hold hidden information. An important novel property of the framework is reversibility, in which the algorithm can precisely reconstruct the original image after the payload removal, which is of high importance for domains in which fidelity needs to be preserved, such as medical imaging, forensics, and digital archiving. The model was trained and evaluated on heterogeneous data (DICOM radiology images and ultra-high-resolution multimedia samples) in order to illustrate its applicability to heterogeneous sources. Experimental evaluation demonstrates that the framework is robust to compression, noise, blurring, cropping, and scaling, and quantitative results on the PSNR and SSIM metrics confirm low perceptual distortion and preservation of structural detail. Further the modular design enables lightweight feature extractors to be deployed at the edge and for domain specific datasets to be adapted via targeted pretraining. These results suggest that the integration of convolutional, recurrent and attention-based components in a unified framework is both robust and reversible, presenting a feasible and domain specific approach for today's steganalysis challenges.

Keywords: *Steganalysis; Image Restoration; Data Hiding; Deep Learning; Reversible Watermarking.*

Explainable Federated machine learning for personalized recommendations system

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ABSTRACT

The use of digital platforms, e-commerce services, and entertainment services like Netflix is increasing in our daily lives. With this increasing use, concerns about user privacy have also increased significantly. This is because in traditional centralized recommendation systems, user data is stored on a central server, which exposes users to threats such as data breach, unauthorized access, and regulatory violations. Considering these issues, we have proposed to build a Federated Learning based Movie Recommendation System. In this system, users' data remains on their own devices and only encrypted model updates are sent to the server, which protects users' privacy. In this project, we have used TF-IDF method to extract features from movie descriptions and Cosine Similarity technique to measure similarity between movies. The model is trained locally on each user's mobile or device and send only encrypted learning updated to a central server which are combined updates from all users with the help of FedAvg algorithm. And we add Explainable Artificial Intelligence (XAI) tools such as SHAP, which help users understand why a particular movie was recommended to them. The quality of the recommendations was evaluated based on various performance indicators. Despite some difficulties such as non-IID data, the system provided accurate, consistent and reliable recommendations. Overall, the combined use of Federated Learning, Content-Based Filtering and XAI technologies can create a highly scalable, secure and privacy-preserving movie recommendation system.

Keywords: *Federated learning, Movie recommendation, Privacy preservation, Explainable AI*

Paper ID: 11122

A Deep Learning Perspective on Digital Image Forgery Detection and Localization

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ABSTRACT

The increasing sophistication of AI-driven image manipulation technologies, such as GANs and CNNs, has made it exceedingly difficult to distinguish between authentic and forged digital images. Traditional detection methods, reliant on pixel-level anomalies or metadata inconsistencies, are no longer effective in identifying subtle artifacts introduced by advanced generative models. This gap in detection capabilities poses a significant threat to digital security, public trust, and the authenticity of visual content. This survey explores the recent advancements in deep learning-driven methods for image forgery detection and localization. We provide a comprehensive review of the types of image forgeries, datasets, and evaluation metrics. The paper categorizes various deep learning architectures used in forgery detection, including Convolutional Neural Networks (CNNs), Generative Adversarial Networks (GANs), and Transformer-based models. We highlight challenges and future research directions in this evolving domain.

Keywords— Convolutional Neural Networks (CNNs), Generative Adversarial Networks (GANs)

Advances in RGB-Based Imaging Techniques for Early and Accurate Crop Disease Detection: A Comprehensive Review

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ABSTRACT

Image-based approaches have increasingly become the norm in crop disease detection as RGB cameras that are cost-effective and imaging systems that can be deployed in the field become increasingly accessible. In this review, the issue that has been explored is the development of RGB imaging to become a realistic and scalable modality in identifying visible symptoms of disease in many crops. The paper aims to bring to bear the seminal advances in standard computer-vision pipelines, machine-learners and current deep-learning systems used to analyse colour, texture and spatial structure of RGB images. The review outlines the evolution of methodological approaches of handcrafted feature extraction to end-to-end convolutional networks as an increasing use of data augmentation, multi-view imaging, and lightweight models adapted to on-device processing. One of the main novelties of this work is the systematic comparison of RGB-based methods with more sophisticated multispectral and hyperspectral systems, which thus proves the fact that RGB imaging contains a competitive level of performance and costs less and is operationally simpler. Studies reported show significant advancement in the accuracy of early-diagnosis, the ability to deal with field variability, and appropriateness to real-time decision support. It is concluded that RGB imaging will continue along a promising path of sustainable crop-health monitoring, especially with the inclusion of optimised learning models, curated datasets, and pragmatic field-integration approaches.

Keywords: *crop disease detection; deep learning; RGB imaging; precision agriculture; plant health monitoring*

Efficient and Explainable Deep Learning Methods for Skin Cancer Diagnosis: A Review

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ABSTRACT

Skin cancer remains a critical global health issue, where early and accurate diagnosis is essential to improving patient outcomes. However, clinical diagnosis is often challenged by the subtle visual variations in lesions and the need for expert interpretation. In recent years, the integration of deep learning (DL) and machine learning (ML) techniques has significantly advanced automated skin lesion analysis, offering new possibilities for enhanced diagnostic accuracy. This survey provides a comprehensive and critical review of state-of-the-art DL methodologies employed in skin cancer detection, with a focus on classification, segmentation, and diagnostic frameworks. We systematically examine and compare prominent deep learning architectures—including convolutional neural networks (CNNs), vision transformers, and hybrid models—evaluating their performance on widely used public datasets. Key components such as preprocessing, feature extraction, data augmentation, and ensemble learning are discussed in detail, along with emerging trends like multimodal data fusion, explainable AI, and the integration of patient metadata. Despite considerable progress, several challenges persist, including class imbalance, dataset bias, limited generalizability across diverse populations, and the lack of clinically interpretable models. This review also highlights underexplored opportunities, such as contextual integration of clinical data, improved interpretability frameworks, and the ethical deployment of AI systems in healthcare. By consolidating recent developments, this survey aims to serve as a valuable resource for researchers and practitioners seeking to develop robust, accurate, and clinically scalable AI-based diagnostic solutions for skin cancer.

Keywords: *Skin cancer detection, deep learning, convolutional neural networks, vision transformers, dermatology, Explainable AI, multimodal learning*

RELIABILITY ANALYSIS OF FREE VIBRATION OF SWCNT COMPOSITE PLATE

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ABSTRACT

The superior characteristics of single-walled carbon nanotube (SWCNT) fiber functionally graded material (FGM) plates are generally associated with uncertainty in their performance due to problems in customizing the gradients in their manufacturing processes. The responsiveness of the vibrational response of plates for uncertainties in their geometrical and material properties that can be effectively studied using a neural network-based approach. The purpose of the present research is to investigate the manner in which the fundamental frequency of SWCNT FGM plates responds to material variability employing a rigorously generated neural network and an isoparametric nine-noded Lagrangian element based on the hybrid hyperbolic shear deformation theory. The basic random variables include aspect ratio, thickness ratio, and the volume proportion of SWCNT fibers. The in-house MATLAB-based algorithm uses Monte Carlo simulation-based repeated random sampling data to train the neural network with calculated non-dimensional fundamental frequencies of the plate. The accuracy of the trained neural network is examined with the results of available literature, and thorough stochastic analysis is performed for attainment of the reliable fundamental frequencies of vibration. The results provide the holistic data for the material and geometric properties needed to prevent the structural frequency fall into resonance with desired safety values.

Keywords: *Structural mechanics, finite element method, free vibration analysis, artificial neural network, probability*

Paper ID: 11135

SMALL OBJECT DETECTION: A REVIEW OF CHALLENGES, ALGORITHMS, AND EVALUATION IN MODERN DEEP DETECTORS

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ABSTRACT

Nowadays, detection of small objects is considered as one of the biggest challenges in modern computer vision, which is crucial for safety-critical applications like autonomous driving, aerial surveillance, and industrial monitoring. Despite the rapid progress of deep learning-based detectors in recent years, finding objects that are only a few pixels in size in cluttered, distant, or low-contrast settings remains challenging. This often causes performance issues in traditional detection methods. This review looks closely at the main reasons behind these detection failures and evaluating the effectiveness of important algorithmic strategies developed in the last ten years. The discussion focuses on multi-scale feature aggregation methods such as FPN, PANet, and BiFPN along with evaluated transformer-based architectures like Deformable DETR and super-resolution-assisted pipelines to understand their benefits and limitations. In addition, this study investigates specialized benchmark datasets such as VisDrone, TinyPerson, and HardHat, to present various scenarios for a consistent and meaningful assessment of small object detection performance. By summarizing advancements in both methods and datasets, this review highlights existing performance gaps and suggests promising research opportunities. Moreover, it emphasizes the importance of lightweight high-resolution backbones, context-aware transformer mechanisms, and specific training strategies suited for tiny object detection. These insights aim to guide future developments that will lead to more accurate, efficient, and practical detection systems that can work well in complex real-world situations.

Keywords: *Anchor-free detection; deep learning; multi-scale feature fusion; small object detection; transformer architectures.*

Literature Review on Cognitive Stress Prediction Using EEG and Deep Learning

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ABSTRACT

Mental stress is a pervasive problem that has an impact on people's physical and mental health, job performance, and overall quality of life. Early detection of cognitive stress is crucial for avoiding health-related issues like anxiety, depression, and cardiovascular diseases. Modern lifestyle pressures have increased the prevalence of cognitive stress, which has an impact on mental health, decision-making, and total human performance. Traditional stress measurement tools, such as self-report questionnaires and subjective scales, fail to capture real-time cognitive oscillations and lack objectivity. Electroencephalography (EEG) is a non-invasive, low-cost, high-temporal-resolution device that measures brain activity to assess stress. Researchers have utilized deep learning's (DL) capabilities to extract complex patterns from EEG signals, significantly improving cognitive stress prediction. The article highlights the findings of 26 recent research publications (2017-2025) on cognitive stress prediction using EEG and deep learning, focusing on methodology, datasets, model architectures, performance measures, challenges, and the future directions encountered.

Keywords: *Cognitive stress, CNN, Deep learning, EEG signals, mental health, RNN*

Recent Advances in EEG-Based Epilepsy Detection: Introducing the Hybrid ADDIN Model for Enhanced Performance

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ABSTRACT

Millions of people worldwide are afflicted by the silent neurological disorder known as “Epilepsy” that manifests itself as recurrent unpredictable episodes called seizures. Automated seizure detection through electroencephalogram (EEG) is a major field of research to enhanced diagnostic accuracy, long-term monitoring and trigger timely intervention. Recent research on automated epileptic seizure detection has shifted from traditional feature-engineering methods to ML and deep learning models. These are yet facing some challenges such as poor generalization, limited interpretability, and computational complexity. To address these challenges here we proposed a hybrid model named Auxiliary deep dense inception network (ADDIN) which combine Inception modules, dense connectivity and auxiliary classifiers. With this novelty, enhancement in Epileptic Seizure detection using EEG may achieve by improving feature extraction mechanism, generalizing network and reducing overfitting concerns.

Keywords: *Auxiliary learning, ADDIN, deep learning, Epilepsy, EEG, Inception module, dense network*

CHANNEL SELECTION METHOD FOR EEG SIGNAL ANALYSIS: A REVIEW

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ABSTRACT

A Signal processing of electroencephalogram (EEG) signals is now widely used for various purposes like detection of alcoholism, classification of sleep disorder, seizure detection, emotion classification, depression level prediction and diagnosis of drug effects. The process becomes troublesome when more channels are involved. Selecting the channels more effectively is important for: reducing the computational complexity of the process, improving the performance by reducing overfitting caused due to use of unnecessary channels, decreasing the set up time in many applications. In EEG signal processing, various feature selection techniques are used like statistical parameters, fractal dimension, wavelet transform, power spectral dimension, etc. In this paper, a survey of recent developed techniques for EEG channel selection with its applications is discussed.

Keywords: *Channel Selection, Electroencephalogram (EEG), Seizure Detection, Sleep Disorder*

FEW-SHOT RELATIONAL AI FOR AUTOMATED FREIGHT DOCUMENT UNDERSTANDING

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ABSTRACT

This paper presents a novel approach to enable human-like machine comprehension of complex, visually rich freight and logistics documents, even with limited training data. We introduce a specialized deep learning framework that leverages spatial and relational insights to extract critical key-value pairs from documents such as bills of lading and consignment notes. By focusing on few-shot learning paradigms, our method addresses the challenges of data scarcity in the freight industry, demonstrating robust extraction capabilities for essential shipping attributes like sender, consignee, cargo details, and port information, paving the way for more automated and efficient freight operations.

Keywords: *Few-Shot Learning, Relational AI, Meta-Learning, Entity Recognition, Relation Extraction, Multimodal Document, Knowledge Graphs, Metric Learning*

DEEP SEQUENTIAL LEARNING FOR IMAGE FORGERY DETECTION USING METADATA CONSISTENCY ANALYSIS

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ABSTRACT

The proliferation of sophisticated image editing tools and generative AI has quantified the challenge of detecting digital image forgeries, which undermine trust in visual evidence across legal, journalistic, and social domains. There is a need for a robust image forgery detection mechanism, as traditional methods often fail to detect temporal inconsistencies in metadata. This paper proposes MetaSeqForensNet, a deep sequential learning framework that extends hybrid Long Short-Term Memory (LSTM) networks to analyze metadata streams, including EXIF timestamps, GPS coordinates, camera parameters, and edit histories, as time-series data. By modeling long-range dependencies and anomalies (e.g., non-monotonic sequences or device mismatches), it outperforms rule-based and Conventional Neural Network (CNN)-based approaches in granularity and interpretability. Evaluated on CASIA v2, Columbia, and synthetic EXIF datasets, MetaSeqForensNet attains 96.2% accuracy, 95.8% precision, and 96.0% F1-score, surpassing Error Level Analysis - Conventional Neural Network (ELA-CNN) hybrids by 8-12% in low-compression cases. This advances metadata forensics, providing defenses against deep-fakes, with potential for multi-modal extensions in real-time applications.

Keywords: *Digital Image Forgeries, Deep-fakes, Deep Sequential Learning, LSTM Networks, Metadata Consistency Analysis.*

AI-POWERED LEGAL ADVISOR FOR ACCESSIBLE LEGAL GUIDANCE

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ABSTRACT

In India, access to dependable legal information continues to be restricted because of the complicated nature of statutes, the abundance of case law, and the absence of accessible digital tools. This paper introduces Legal Genie.AI, an AI-powered legal assistance platform aimed at enhancing access to the body of Indian legal knowledge for citizens, students, and professionals. The main goal of the work is to create an explainable and citation-grounded legal intelligence system that can perform legal question answering, legal document understanding, drafting assistance, and judgment outcome analysis. The proposed system employs a Retrieval-Augmented Generation (RAG) framework integrating domain-specific embeddings derived from inLegalBERT and a FAISS vector index populated with the Indian Penal Code and judicial decisions spanning 1947–2025, enabling accurate statutes and case-level retrieval. Novel contributions are a document understanding and drafting module that supports OCR-based unstructured input and legal template structuring, as well as a neural judgment analysis component that offers probability-based insights with contextual explanations rather than black-box predictions. The platform is realized through a scalable web architecture with caching and fallback mechanisms to make the platform responsive and robust. Its experimental evaluation on real-world Indian legal queries shows evidence of high retrieval relevance, interpretability, and consistency in responses, as verified by experts. In conclusion, Legal Genie.AI shows that ethically designed citation-aware AI systems can improve legal transparency and accessibility, with future work focused on extending statutory coverage and supporting additional languages.

Keywords: *Artificial intelligence in law; legal document analysis; retrieval-augmented generation; Indian legal system; judgment prediction*

APTAPPO+ 2.0: Hierarchical Trust-Aware Multi-Agent Reinforcement Learning with Adaptive Topology Selection for Scalable IoT Networks

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ABSTRACT

The proliferation of Internet of Things (IoT) networks has introduced unprecedented challenges in trust management, scalability, and security, particularly in dynamic multi-agent environments where thousands of heterogeneous devices must collaborate under adversarial conditions. Existing trust-aware routing protocols struggle with computational complexity that scales poorly beyond 1,000 nodes, lack adaptive topology optimization, and provide insufficient resilience against sophisticated attacks such as collusion and Sybil attacks. This paper presents APTAPPO+ 2.0, a novel hierarchical trust-aware multi-agent reinforcement learning framework that addresses these limitations through three key innovations: (1) a hierarchical trust propagation mechanism achieving $O(n \log n)$ complexity with formal convergence guarantees, enabling scalability to 5,000+ nodes; (2) a multi-objective Proximal Policy Optimization (PPO) algorithm with Pareto-optimal convergence that simultaneously optimizes security, latency, and energy efficiency; and (3) practical integration of post-quantum cryptography (CRYSTALS-KYBER, CRYSTALS-Dilithium) with <30ms overhead on resource-constrained devices. We provide rigorous theoretical analysis including convergence proofs, complexity bounds, and security guarantees under Byzantine adversarial models. Extensive evaluation using NS-3 simulations across five network scales (100–5,000 nodes) and two real-world testbed deployments (healthcare IoT with 50 devices over 30 days, smart building with 75 devices over 45 days) demonstrates significant improvements over state-of-the-art approaches: 94.7% packet delivery ratio (vs. 87.3% baseline), 28.4% latency reduction, 35.2% energy savings, and 5× scalability improvement. Statistical validation confirms high significance ($p < 0.001$, Cohen's $d > 1.2$). Implementation on Raspberry Pi 4 achieves <100ms routing decisions with <50MB memory footprint, demonstrating practical feasibility for real-world deployment. Our framework provides a theoretically grounded, empirically validated, and practically deployable solution for secure, scalable IoT networks.

Keywords: *Internet of Things, Multi-Agent Reinforcement Learning, Trust Management, Hierarchical Networks, Post-Quantum Cryptography, Scalable Routing*

Multi-Core Processor Performance Enhancement with Cache Replacement Strategies: A Review

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ABSTRACT

Multi-core Processor or chip Multiprocessors (CMPs) have become inevitable to meet the increasing demand for advanced and complex functionalities in modern applications. Enhancement of overall performance, energy efficiency and scalability of Multi core processors can be achieved by utilizing the multiple cores and associated resources efficiently using State of art techniques. The significant areas for optimization are Task scheduling, core allocation, load balancing across cores, and cache memory management. The cache memory management impacts the throughput, energy efficiency greatly by enabling multiple cores to get their required data promptly and reducing memory stalls and core idle time. Existing Static, heuristic based and dynamic optimization strategies are simple but often not much flexible enough to be efficient and accurate across diverse workloads, machine learning based approaches provide better solutions by enabling adaptive, data-driven decisions for Cache Management and power management. Simulators are pivotal in evaluating and refining these design strategies to get optimum results. This study explores the advancements in Cache management strategies used in multi core processor design optimization, the role of machine learning, and the significance of simulators which offers a comprehensive overview of recent trends and future directions.

Keywords: *Multi Core Processor; Cache Replacement; Performance; Power management; Machine Learning.*

Early Diagnosis of Alzheimer's Disease Using AI-Based Analysis of Digital Voice Patterns

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ABSTRACT

Alzheimer's disease (AD), the most common progressive neurodegenerative disease and a major cause of dementia, requires the early identification of the disease in order to receive effective clinical treatment and maximize the quality of life associated with the disease. Unfortunately, commonly used diagnostic techniques for Alzheimer's disease are often reliant upon an invasive procedure, expensive to administer, and available only at a limited number of institutions. This paper presents the use of an artificial intelligence-based approach to diagnose AD at an early stage based upon the automated analysis of patients' digital voice patterns. The system extracts the following three types of digital voice characteristics during the patient's speech: acoustic, prosodic, and temporal. These types of speech characteristics include pitch variations, speech rate, articulation patterns, and pauses during each speaking segment, all of which have been found to be reliable indicators of cognitive decline. Machine Learning (ML) and Deep Learning (DL) algorithms, specifically Long Short-Term Memory (LSTM) Networks, were employed to analyze the digital voices of individuals with AD and healthy controls. Data was collected and the ML/DL algorithms were trained using the clinical record of patients' speaking characteristics. The results of the analyses indicate that the computerized voice analysis is capable of differentiating between the speech of healthy individuals and those who have cognitive impairment. Additionally, the framework developed through this research provides a non-invasive, inexpensive, and scalable method of screening for cognitive impairment in the form of a web-based system that can be utilized for early identification and large population-based monitoring of cognitive health through the use of the internet and telemedicine.

Keywords: *Alzheimer's disease; artificial intelligence; digital biomarkers; speech analysis; voice-based diagnosis*

Privacy-Preserving and Lightweight Phishing Detection via Browser-Based Machine Learning

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ABSTRACT

Phishing attacks remain a prevalent cybersecurity threat, deceiving users into revealing sensitive information through counterfeit websites. Traditional defense mechanisms, such as blacklists and server-side analysis, often suffer from update delays, network latency, and privacy concerns due to external data transmission. To address these limitations, this paper presents a real-time, privacy-preserving phishing detection system implemented as a client-side Google Chrome extension. The primary objective is to develop a lightweight solution that eliminates reliance on external servers while maintaining high detection accuracy. The methodology employs a Random Forest classifier trained on a comprehensive dataset comprising 11,055 samples from UCI and PhishTank sources. The system utilizes 17 distinct lexical, HTML, and behavioral features extracted directly within the browser environment to classify websites locally. Experimental results demonstrate that the developed prototype achieves a detection accuracy of 97.14% on the test dataset, validating its effectiveness in identifying malicious sites without compromising user privacy or browsing speed. The study concludes that client-side machine learning offers a robust, efficient alternative to server-dependent architectures, providing immediate protection against evolving phishing strategies while ensuring data sovereignty for end-users.

Keywords: *Client-side security; Machine learning; Phishing Detection; Random forest; Real-time protection.*

DESIGN AND IMPLEMENTATION OF NFC AND FACE RECOGNITION BASED LOCAL AUTOMATION SYSTEM USING RASPBERRY PI AND ESP32.

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ABSTRACT

Home automation in the recent years has been developing with great improvements that have included introduction of smart technologies in the quest to advance convenience, efficiency and control by the user. The traditional systems are usually based on specialized RFID modules or manual switching, which increases the cost of hardware as well as reduced flexibility. This work is aimed at creating and establishing an NFC-enabled automation system at home, which will avoid the use of the external RFID readers, utilizing the existing NFC scanner of smart phones. The suggested system enables the users to operate the appliances in the house by tapping their NFC-capable phones on the passive NFC tags attached to the outside of each room. The mobile application based on Flutter reads the tag data and sends it to a Firebase real-time database and communicates with a Raspberry Pi 3 microprocessor to provide the activation of similar devices with relays. The innovation is seen in substituting hardware RFID readers with the use of the NFC technology on a smartphone platform to be made cost-effective, portable and easy to use in automating processes. There are experimental outcomes proving stability of operation with real-time response and remote control through Firebase connection. Summing up, the created system offers a single and easy to use and scale solution to the smart home control that will improve user interaction and reduce the complexity of the system.

Keywords: *Home automation, NFC, Smart control system, Cloud integration.*

A Review on Multispectral Imaging Techniques for Citrus Crop Health Monitoring

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ABSTRACT

Monitoring crop health in relation to precision agriculture can result in higher yields and a more environmentally friendly way of growing food. Citrus plants are very responsive to changes in soil, water and other environmental factors, therefore, detecting stress early on is crucial. RGB (Red Green Blue) based traditional imaging cannot effectively capture the small amount of variation in light wavelengths that may indicate plant stress. This literature review examines the use of multispectral camera technology for monitoring citrus crop health. This literature review examines how multispectral cameras work, and how the most commonly used vegetation indices (NDVI & NDRE) are used to detect plant stress, nutrient deficiencies, and diseases, as well as current research on integrating multispectral imaging systems with ground-based and aerial (drone-based) data collection systems. Finally, this literature review identifies some of the major barriers to multispectral crop health monitoring, including costs, calibrating data, and lack of real-time validation in India. This review is intended to provide direction toward future advancements in developing effective, reliable, and affordable crop monitoring systems.

Keywords: *Citrus Disease, Multispectral Imaging, Crop Health Monitoring, Precision Farming, Real-Time Data Collection, Vegetation Indices (NDVI, NDRE).*

AI-DRIVEN ELECTRIC VEHICLE CHARGING SCHEDULER

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ABSTRACT

The growing popularity of electric vehicles (EVs) has introduced new challenges for modern power distribution systems, particularly due to uncontrolled charging patterns that increase energy demand, elevate operational costs, and cause significant peak load fluctuations. To address this issue, the present study proposes a smart EV charging scheduler developed in Python, capable of optimizing charging operations for multiple vehicles simultaneously. The scheduling algorithm operates on a rule-based artificial intelligence approach, considering essential parameters such as grid load, arrival and departure times, and the state of charge (SOC) of each EV. The method prioritizes vehicles with lower SOC and reallocates charging activities to off-peak periods, thereby achieving better load balance and energy efficiency. Simulations conducted using synthetic grid and EV data demonstrated notable reductions in peak demand while ensuring that all vehicles reached full charge within their required time frames. The framework is modular, scalable, and reinforcement-learning-ready, making it suitable for integration into smart grid ecosystems. This work highlights how Python-based scheduling can promote sustainable EV adoption while maintaining grid stability and operational reliability.

Keywords: *Electric Vehicles (EVs), Smart Charging, Artificial Intelligence, Energy Optimization, Peak Load Reduction, Scheduling Algorithm, Python Simulation.*

Analyzing the BER of OTFS Compared to OFDM in a Multipath Fading Channel

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ABSTRACT

To enable perfect communication in high-speed vehicular environments, the Orthogonal Time Frequency Space (OTFS) modulation technique has been introduced, utilizing a distinctive two-dimensional waveform in the delay-Doppler domain. Here we examine traditional techniques, such as Orthogonal Frequency Division Multiplexing (OFDM), particularly in high-mobility channels in wireless. This paper begins by examining the input-output relationship of OTFS signals in the domain known as delay-time, highlighting its resemblance to a combination of OFDM and Single-Carrier Frequency Division Multiple Access (SC-FDMA). Subsequently, the BER performance of OTFS systems is evaluated under varying channel tap conditions, with results compared to those of conventional OFDM waveforms. At a BER of 3×10^{-4} , the OTFS receiver achieves a 12 dB SNR gain compared to the OFDM-MMSE receiver. Through graphical representations illustrating OTFS performance at varying vehicle speeds, the analysis suggests that OTFS holds the potential for achieving lower BER than OFDM across a range of scenarios, encompassing both delay and Doppler domains. This advantage is particularly notable when employing a Minimum Mean Square Equalizer (MMSE), equalizer with perfect channel knowledge at the receiver.

Keywords: *OFDM; OTFS; MMSE, SC-FDMA.*

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SOLAR WIRELESS ELECTRIC VEHICLE CHARGING SYSTEM

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ABSTRACT

The increasing adoption of electric vehicles (EVs) has heightened the need for sustainable and user-friendly charging technologies. This research focuses on the design and development of a wireless solar charging system for EVs, aiming to overcome the constraints of traditional plug-in charging and reduce reliance on the electrical grid. The primary objective is to integrate photovoltaic (PV) power generation with an inductive power transfer mechanism to achieve efficient and contactless power transfer for EVs. The system utilizes a high-efficiency DC-DC converter with maximum power point tracking (MPPT) for optimal PV energy utilization, while a two-coil resonant inductive link ensures reliable wireless power transmission. Simulations and experimental analyses were conducted to evaluate performance under various illumination and load conditions. The results indicate an overall system efficiency exceeding 85%, demonstrating stable charging characteristics and reduced harmonics compared to conventional wired systems. This work contributes to sustainable transport by combining green energy production with intelligent wireless power transfer technology, paving the way for infrastructure-free EV charging solutions.

Keywords: *Electric vehicle charging; inductive power transfer; renewable energy integration; solar PV system; wireless charging efficiency.*

Design and Implementation of a MATLAB-Based Educational Interface for Analog and Digital Modulation Techniques

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ABSTRACT

The cost of the specialized laboratory equipment is too high which creates a significant challenge in providing practical communication engineering education to students, particularly the institutions with limited resources. This MATLAB based educational application designed to provide hands-on experience with both analog and digital modulation techniques. This application has introduced a virtual laboratory that allows the students to experiment various modulation techniques including AM, FM, PM, BPSK and QPSK. A distinctive aspect of this application is the integration of real-time audio signal processing, enabling users to employ real time audios, voice recordings or music files as input signals for analog modulation experiments while preserving standard digital modulation capabilities. This functionality facilitates visualization of how actual audio signals transform through modulation and enables observation of spectral characteristics in real-time. The implementation of this application among the undergraduate students helps to enhance their understanding the core subject and improve their practical examination performance. Results shows that this application brings an effective solution which act as a bridge between the theoretical knowledge and practical implementation, offering a perfect alternative to the expensive hardware laboratories. The implementation pf the real time audio signals as input provides an interactive platform to the students providing a real time examples of the communication system principles in action.

Keywords: *Audio signal processing; Engineering education; MATLAB simulation; Modulation techniques; Virtual laboratory*

OCCUPANCY ESTIMATION USING RSSI

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ABSTRACT

Any smart building system that requires real-time awareness must have occupancy estimation, but the majority of current methods fall short due to high deployment overhead, privacy issues, or cost.. The objective is to determine whether a usable occupancy model can be supported by a single ESP8266 transmitter–receiver configuration that uses only WiFi RSSI. LOS blocking and multipath scattering are two ways that human presence disrupts the channel. With Savitzky Golay smoothing, median filtering, and an adaptive baseline for signal processing, the approach models these effects as probabilistic models and assesses distribution using KL divergence, JS divergence, Bhattacharyya distance, and histogram based analysis. In this paper, we proposed a novel method that uses only WiFi power measurements between two stationary transmitter/receiver antennas to estimate the total number of people present in an area. For 300 seconds, data is gathered at 50 samples per second for different occupancy levels. Before every run, on-site calibration is necessary to account for environmental baseline drift. The results validate the theoretical framework's applicability by displaying consistent RSSI trends that correspond to the anticipated distributions.

Keywords: *adaptive baseline; indoor occupancy estimation; multipath modeling; RSSI-based sensing; statistical divergence metrics.*

Wireless Data Transmission using nRF24L01 and Arduino with OLED Display

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ABSTRACT

The low-cost wireless communication system for transmission, and visualization of a digitally produced sine wave using NRF24L01 transceiver module. The objective is to transmit digitally sampled sine-wave values from the transmitter to the receiver for monitoring a system. At the transmitter side, the sine wave is generated using lookup table which contains the amplitude values of one cycle of a sine wave. The receiver reconstructs the waveform by decoding incoming samples and displays the amplitude on an OLED screen for real-time observation. The results confirm stable wireless communication up to several meters with minimal data errors and consistent waveform reconstruction. In conclusion, this project validates that a simple microcontroller, such as an Arduino, paired with an nRF24L01 module, is sufficient for transmitting sampled digital signals, offering a simpler alternative to systems that are dependent on complex analog circuitry.

Keywords: nRF24L01, Arduino, wireless transmission, sine wave samples

IoT-Based Real-Time Embedded System for Performance Analysis and Fault Detection in Solar Photovoltaic Panels

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ABSTRACT

The increasing global demand for clean energy has enriched the utilization of solar photovoltaic (PV) systems. However, their performance and reliability are frequently affected by faults such as hotspots, dust accumulation, and electrical connection failures. This paper aims to develop a real-time fault detection and predictive maintenance framework to increase the power output and extend system lifespan. The proposed system continuously monitors the PV panels using a combination of sensors and infrared (IR) thermography to capture both electrical and thermal characteristics of the panels. A continuously moving IR camera capture accurate thermal maps which allow early localization of hotspots and other structural abnormalities, while voltage, current, temperature, from sensors (IoT) are transmitted to a cloud platform for remote access and analytics. To enhance decision-making and predictive maintenance, machine learning algorithms are integrated into the system. These algorithms analyze and combined historical and real-time datasets to predict the faults occurred on the panel. The proposed approach ensures the improvement in early fault identification accuracy, reduction in downtime, and enhanced operational safety. The system ensures improved energy yield, timely fault diagnosis, and intelligent maintenance scheduling, thereby offering a reliable and scalable solution for modern PV installations.

Keywords: Photovoltaic (PV) systems, Real-time fault detection, Infrared (IR) thermography, Predictive maintenance, Hotspots, Internet of Things (IoT), Machine learning

HARDWARE IMPLEMENTATION OF AN ECONOMICAL BLE DEVICE MONITORING SCHEME BASED ON SIGNAL SENSING AND ESTIMATION METHODS

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ABSTRACT

Unauthorized use of Bluetooth Low Energy (BLE) devices in restricted zones such as examination halls or R&D centers can compromise security and confidentiality. Hence, there is a demand for low-cost detection system to monitor BLE devices in restricted areas. We report an economical detection system based on three ESP32 BLE signal receivers to passively scan the Received Signal Strength Indicator (RSSI) from any active device. Since the RSSI values exhibit significant fluctuations, Kalman filtering is applied to obtain a smoothed RSSI estimate and compared it with the standard averaged RSSI to ensure consistent signal evaluation. To improve accuracy, the RSSI at 1-meter value (A) and the path-loss factor (M) were calibrated using the log-periodic path-loss model by collecting 50 samples per meter up to 5 meters. For localization, the system uses trilateration and the Min-Max algorithm to estimate coordinates based on the distance obtained using the path loss model. The results are displayed on a webpage hosted by a fourth ESP32 server, where a user can select a nearby device and view its tracked location on a graph after a two-minute scan. Experiments were conducted in a 5 m * 5 m room under both LOS and NLOS conditions. Based on the experimental results obtained, the system demonstrates high localization accuracy under LOS conditions. where the estimated coordinates are closely aligned with the actual device position. In contrast, under NLOS conditions, obstructions between an anchor and the target increased the distance estimate from that anchor, resulting in significant trilateration errors, whereas the Min-Max algorithm provides more stable and tolerable localization outputs.

Keywords: *Bluetooth Low Energy (BLE); ESP32; Indoor localization; Received Signal Strength Indicator (RSSI).*

PERFORMANCE ANALYSIS OF SOLAR CELL INTEGRATED MICROSTRIP DIPOLE ANTENNA FOR S BAND APPLICATION

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ABSTRACT

This paper presents the numerical simulation, fabrication and experimental analysis of microstrip dipole antenna integrated with a solar cell, for S band applications. The integration aims to create a multifunctional device that simultaneously works as an Antenna and Solar power harvester towards the Energy generation with electromagnetic radiator for communication system. The proposed antenna design is simulated using CST Software to evaluate its overall performance when combined with a solar cell. An experimental prototype is fabricated to validate the simulated results of antenna performance metrics, such as return loss, gain and radiation efficiency. Further, the impact of antenna integration on the solar cell's electrical performance including voltage, current and output power, is analyzed. The integration leads to reduction in the overall size and cost of the antenna with solar panel. The integrated antenna exhibits a return loss of -33.41dB around 2.45GHz, in the S band frequency spectrum. The solar cell maintains an optimum generated voltage of 4V with a power output of 3.5W, under standard illumination of 2500 lux intensity 25cm^2 of the area marginally compromised by antenna slots. The VSWR 1.02 of the microstrip antenna indicates an efficient impedance matching. Simulated and experimental results are found to align closely with performance competitive with typical standalone microstrip and dipole antennas. Integration of solar cell with dipole antenna for the S band frequencies is found feasible and successful for energy harvesting and wireless communications.

Keywords: *Solar cell Integrated Dipole Antenna; Microstrip antenna, S band Applications; Antenna gain and Solar cell performance.*

Advancements in Acoustic-Based Partial Discharge Detection and Localization in Power Transformers: A Review with Focus on Machine learning Applications

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ABSTRACT

Because of their strong immunity to electromagnetic interference, acoustic emission (AE)-based techniques have become a dependable solution for online partial discharge (PD) detection and localization in power transformers. Diagnostic accuracy is still constrained by issues like high ambient noise, complicated acoustic reflections, attenuation, and uncertainties in wave propagation. With an emphasis on machine learning (ML) and deep learning (DL) applications, this review explores recent developments in AE-based PD monitoring. Time of Arrival (TOA), Time Difference of Arrival (TDOA), and triangulation are examples of traditional localization techniques that provide quick estimation but perform poorly in noisy or structurally complex transformer environments. On the other hand, PD detection, identification, and localization accuracy are greatly improved by supervised machine learning models such as support vector machines (SVM), random forests, XGBoost, k-nearest neighbors (k-NN), decision trees, and convolutional neural networks (CNNs). CNNs and hybrid CNN-LSTM architectures show superior robustness in high-noise and multi-source scenarios. When labeled data are scarce or multiple PD sources coexist, unsupervised and self-supervised techniques like K-means clustering, bisecting K-means, blind source separation (BSS), and graph contrastive clustering offer efficient solutions. Further enhancing feature extraction, sensor placement, and localization reliability are optimization-driven techniques (GA, PSO, hybrid GA-PSO), multi-physics fusion frameworks, and sophisticated denoising models. Notwithstanding these developments, problems with data scarcity, model generalization, noise resilience, and deployment under real-time operating conditions still exist. To enable extremely dependable transformer health monitoring and fault prevention, future research should focus on creating interpretable, data-efficient, and integrated machine learning frameworks.

Systematic review of EMG signal acquisition, feature extraction and artificial intelligence in HGR

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ABSTRACT

In this era of technology, human computer communication plays a significant role in controlling various devices. To overcome the communication issues between human and machine/computers Human Computer Interaction (HCI) has been designed. One of the examples of HCI systems is Hand Gesture Recognition (HGR) that is used in number of applications where different tasks are performed by recognizing movements of hand. This task can be done by different input that can include images, real time videos, and surface electromyography (EMG). A number of approaches are available those are utilizing EMG as an input which records the electrical activity of the muscles. The main objective of this paper is to study different hand gesture recognition systems using EMG data. In addition to this, the study provides details of EMG based a hand gesture recognition system that covers various modules such as different methods of EMG signal acquisition, feature extraction and Artificial intelligence in HGR. Finally, a comparison between different techniques for various phases of HGR followed by an conclusion drawn out from the study to suggest new direction of work for future research in HGR systems using EMG.

Keywords: human computer interaction, Artificial intelligence, Application of electromyography, literature survey, etc.

BEYOND PERMANENT MAGNETS: COMPARATIVE ANALYSIS OF SWITCHED RELUCTANCE MOTORS FOR SUSTAINABLE TRANSPORTATION VEHICLE

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ABSTRACT

There is no denying that electric vehicles have emerged as a major mode of transportation and will likely be the preferred option in the future, as interest in electric traction has grown significantly in recent decades. One of the most important parts of creating an electric vehicle system is choosing the motor. Which motors are appropriate for electric vehicle applications? DC motors, permanent magnet synchronous motors (PMSM), brushless DC motors (BLDC), induction motors (IM), and switching reluctance motors (SRM). In order to provide a clear picture that enables selecting the best electrical motor for the intended application, this paper compares several electric motors used in the electric traction system based on a number of criteria, including efficiency, cost, reliability, power density, controllability, and technological maturity.

Keywords: *Switching Reluctance Motors (SRM); Transport Vehicle; DC Motors; Permanent Magnet Synchronous Motors (PMSM); Brushless DC Motors (BLDC); Induction Motors (IM).*

Comparative Analysis of Consensus Mechanisms for Internet of Vehicles: Performance, Security, and Implementation Considerations

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ABSTRACT

The Internet of Vehicles (IoV) signifies a pivotal development in intelligent transportation systems, necessitating resilient blockchain-based consensus methods to guarantee secure, efficient, and real-time communication between vehicles and infrastructure. This study offers a thorough comparative examination of four significant consensus mechanisms: Proof of Stake (PoS), Proof of Authority (PoA), Delegated Proof of Stake (DPoS), and Practical Byzantine Fault Tolerance (PBFT) in Internet of Vehicles (IoV). This paper analyzes these techniques across various dimensions, including speed, security assurances, energy efficiency, and appropriateness for vehicle network dynamics.

Keywords: *Internet of Vehicles, Blockchain, Consensus Mechanisms, Vehicle-to-Vehicle Communication, Intelligent Transportation Systems*

AI-Enhanced Macrobending Loss Prediction and Optimization in Self-Optimizing Optical Networks Using OTDR and Ensemble Learning

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ABSTRACT

Optical fiber networks support a wide range of services, including long-haul communication, space links, and undersea systems, and their reliability depends heavily on the stability of the physical layer. Faults such as fiber cuts, tapping, and especially macrobending can introduce noticeable attenuation and degrade signal quality. These issues become more difficult to manage as network size and traffic continue to increase, placing additional pressure on operations and maintenance resources. To study macrobending behaviour under controlled conditions, OTDR traces were synthetically generated using established empirical models. These traces were then used to train a Random Forest regression model capable of estimating macrobending loss and related parameters. The approach allows the system to identify and quantify bending-induced attenuation and to support fault localization at practical time scales, making it suitable for integration into a SOON-based monitoring framework. The model achieved a high prediction accuracy ($R^2 = 0.9856$), indicating strong potential for use in self-healing optical network environments.

Keywords: Optical Fiber, OTDR, Macrobending Loss, Machine Learning, Self-Optimizing Optical Networks (SOON), Random Forest.

Fish Monitoring Techniques Based on Acoustic Telemetry: A Review

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ABSTRACT

This review paper focuses on Internet of Things (IoT) based agricultural and environmental monitoring systems. Fish serves as an essential source of protein for everyone on earth. The demand for this food source keeps increasing in the modern world because it accounts for up to 40% of the protein. It finds occasional use as feed rather than food. The rate of fish consumption has shown gradual increase during prior years. Demand for fish in both developed and developing countries puts pressure on marine farms around the world. Fish processing operations move toward development of new products because of marketing extension. Human activities such as pollution, overfishing, and destructive fishing methods diminish tasks of marine farms. Climate change and chemical reactions in water adversely affect marine habitats. As a result, use of digital technologies in fish farming grows as a fascinating field of study for researchers. Internet of Fish (IoF) concept bases on LPWAN communication technology which addresses unique requirements of IoT devices and exploits unlicensed Industrial, Scientific, and Medical (ISM) radio bands. In general, this paper highlights the technological approaches propose to monitor fish farms. Low power consumption, wide area coverage, and inexpensive wireless connectivity incorporate in LPWAN. Most standards focus on MAC and physical layers. Non-cellular wireless technology fails to optimally connect low-power devices distributed across wide geographic areas. Dense deployment of devices and gateways linked by multi-hop mesh networking enhances scope of these technologies.

Keywords: *Internet of Things, LPWAN, Internet of Fish, Fish farm*

Survey on Speech Emotion Recognition- Evolving from Hand-crafted acoustic features to modern deep learning approaches

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ABSTRACT

Speech Emotion Recognition(SER) becomes a crucial research field for researchers since Humans starts interacting with computers & using it in real-life applications. Recently many SER systems studied by researchers based on the availability of emotional databases both for training & testing, whose occurrence is due to the variations in speakers, text, languages & recording environments between the training & testing datasets. Also applying suitable classifiers & using ML & DL proved to gain more accuracy for SER as compare to traditional methods used in earlier decades for extracting features. This survey mainly splits light on what is being done in previous studies to recognize emotions using audio speech in different aspects & review the present state of SER using Deep Learning. The current systematic review explores the different interpretability and explainability methods for speech emotion features. The current review paper aims to identify the progress in the area, identify potential research gaps, and motivate future research.

Keywords: *Speech Emotion Recognition; Deep learning; Speech features; Systematic review; Interpretability*

Performance Evaluation of Flame Guard 180 in High-Risk Industrial Fire Scenarios

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ABSTRACT

Industrial environments such as petrochemical plants, power generation units, manufacturing facilities, and hazardous material storage areas are highly vulnerable to rapid fire escalation, demanding fast-acting and reliable fire suppression solutions. Flame Guard 180 has emerged as an advanced fire suppression system designed to address such high-risk industrial fire scenarios. The objective of this study is to evaluate the performance, reliability, and suppression efficiency of Flame Guard 180 under representative industrial fire conditions. Experimental investigations were carried out using controlled fire scenarios involving Class A, Class B, and electrical fire simulations, with key performance parameters including activation time, flame knockdown rate, heat reduction, re-ignition probability, and system discharge characteristics. The novelty of this work lies in the comprehensive performance benchmarking of Flame Guard 180 across multiple industrial fire profiles and its comparison against conventional suppression approaches under identical conditions. The results demonstrate rapid fire suppression with significantly reduced flame spread, effective thermal control, and minimal residual impact on protected equipment. The system exhibited consistent performance across varying ambient temperatures and fire intensities, highlighting its suitability for critical industrial applications. In conclusion, Flame Guard 180 proves to be an efficient and reliable fire suppression solution for high-risk industrial environments, offering enhanced safety, reduced downtime, and improved protection of assets and personnel.

Keywords: *Advanced Fire Suppression; High-Risk Industrial Fires; Performance Evaluation; Rapid Flame Suppression*

Proposal of Cylindrical shaped Pipe Holding Mechanism Using buckling of Extension type Flexible Pneumatic Actuators

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ABSTRACT

Currently, the total length of Japanese water pipes reaches approximately 730,000 km. While the percentage of pipes exceeding their legal service life rose to 19.1% in 2019, the replacement rate per year remains at only 0.67%. It has led to a recent increase in water leak accidents. As fiberscopes are commonly used for inspection of leakage pipe and their ability to inspect in complex pipe is limited, it is also necessary to develop robots that can be operated in aquatic environments. In this paper, a pipe holding mechanism that can hold a pipe by using the buckling of Extension type Flexible Pneumatic Actuators ("EFPAs" for short) was proposed. The EFPA consists of a rubber tube covered by bellows type nylon sleeve. The mechanism consists of parallel arranged three and six EFPAs in cylindrical plastic cover. By pressurizing EFPAs, as they can extend until about double of the original length, they expand toward radial direction while buckling. The mechanism can hold a pipe from inside. The pipe holding performance of the mechanism inside the pipe according to supply pressure was investigated. As a result, we found low stability when buckling torsion is used for pipe holding. We confirmed that the mechanism could hold pipe surely according to increasing pressurized EFPAs. Based on these results, the traveling performance of the pipe inspection robot mounted the tested pipe holding mechanism was investigated.

Keywords: *Extension type Flexible Pneumatic Actuator, Piping retention mechanism, Buckling phenomenon*

Analytical Model of Delay Motion for Propulsion of Thin Pipe Inspection Robot

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ABSTRACT

Nuclear power plants use numerous complex pipes with inner diameters of 20 mm or less that are highly contaminated with radioactivity. Pipe inspection robots for these hazardous condition pipes must not only be flexible and slim due to be easily retrievable, but also inexpensive and easily disposable as nuclear waste. In this study, a pipe inspection robot using a thin Extension type Flexible Pneumatic Actuator (EFPA) with outer diameter of 10 mm using a rubber tube covered by a bellows type nylon mesh sleeve and was proposed and tested. A pipe traveling method using coil motion of EFPA with an axial fiber restraint on the rubber tube was also proposed and demonstrated. Furthermore, traveling condition of the robot that can generate a delay motion in series-connected coiling EFPA with simple orifice was investigated. In this report, an analytical model to determine the optimal inner diameter of orifices to get higher traveling speed in thin pipe was proposed. The calculation to get traveling distance when a supply and exhaust operation was given to the robot by using the proposed model and identified parameter was carried out. As a result, it could be confirmed that the tested robot can pass through curved thin pipes with an inner diameter of 20 mm simply by using calculated value of orifice for operating the on/off valves.

Keywords: *Analytical model, Thin pipe inspection robot, Delay motion using orifice, Inspection of curved thin pipes*

Progress of Ladder Climbing Robot with Bending Motion Using EFPAs

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ABSTRACT

As earthquakes occur frequently in Japan, aging infrastructure such as bridges, chimneys and tunnels has a high risk of collapse and is extremely hazardous. The nuclear plant in Fukushima met hazardous situation after Tsunami occurred. Therefore, it is necessary to develop the inspection robot that can climb ladder and traveling uneven floor in these hazardous buildings to prevent accident or radiation exposure. In the typical building that always requires maintenance, ladders and passages for inspectors are equipped. However, they can not use them safely after earthquakes. In addition, closed area prevents to use a drone controlled via wireless signal. In ideal, an inspection robot that can be used in wet and radiational condition is required. For these reasons, we had been developing various ladder climbing robots. This report introduces the constructions and operating principles of three ladder climbing robots driven by Extension type Flexible Pneumatic Actuator (EFPA). Their performances were also compared. First one is the robot that has three robotic arms on the side faces of a hexagonal prism, arranged radially with mutual angles of 60° . The second one is designed with horizontal gait in mind, that is the robot arranged four arms in four radial directions every 90° to achieve crawl-like locomotion. The third one was designed based on the second one configuration (four directions every 90°). The robot can realize an octopus inspired motion in horizontal movement. Compared with the conventional crawling gait, the moving speed is 4.4 times. In ladder climbing, the robot can transform so that two arms are parallel to each other. By using remaining two arms to grasp and support the ladder, the robot can climb more stably.

Keywords: *Extension type Flexible Pneumatic Actuator (EFPA), Ladder climbing robot using EFPAs, Horizontal traveling motion, Transformation function for climbing ladder*

Development Progress of Pipe Inspection Robots Using Extension type Flexible Pneumatic Actuators

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ABSTRACT

Many water pipes in Japan have exceeded their service life, and it makes pipe inspections urgently necessary. Pipe inspections are also required in hazardous environments, such as flammable and submerged environments and inside nuclear power plants. In ideal, as these inspection conditions often involve complex pipes, the required robot needs flexible and slim for easily traveling in these pipes. In our laboratory, we have been developing various pipe inspection robots for several years. In this paper, several robots using Extension type Flexible Pneumatic Actuator ("EFPA" for short) developed in five years are introduced. The construction and operating principle of these robots are also introduced. In addition, the traveling performance of these robots are compared and estimated. Mainly, three type pipe inspection robots are introduced. One is a robot using a single EFPA that can expand circumferentially inside the pipe and traveling in a pipe using an extension/bending unit composed of three EFPAs. The other is a simplified thin pipe inspection robot that an EFPA with axial fiber restraint can hold a pipe by using its coiling motion and travel by using extension of EFPA without restraint like a snake. The last one is cylindrical shaped pipe inspection robot that consists of parallel arranged six EFPAs to travel complex pipe with corner and can change the direction of propulsion in various branches such as T-shaped pipe. As a result of comparing performance using these robots, it was found that the suitable traveling performance of 50A to 150A standard pipes for each robot could be obtained.

Keywords: *Extension type Flexible Pneumatic Actuator(EFPA), Pipe inspection robot using EFPAs, Thin pipe inspection robot with axial fiber restraint, Cylindrical pipe inspection robot with parallel arranged EFPAs*

Humidity Based Sprinkler System

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ABSTRACT

The project addresses and solves the problem that many farmers have faced in the past and present time. The irrigation system that are currently in use are too expensive to install for the average income farmer. In this system we are using multiple types of sensors to adaptively control the humidity of the environment to improve the yield of the crops. Thus we are using the Arduino platform to create a humidity based sprinkler system that can solve these problems in a cost efficient manner. Using Arduino greatly reduces the costs in the prototype phase as the cost of it's modules is lower compared to Raspberry Pi or other alternative platforms. Our project utilizes the modularity of the Arduino platform to test a prototype of the system that demonstrate the feasibility of the project on a larger scale and keeping future room for further innovation.

Keywords : Arduino, adaptively, demonstrate, irrigation, humidity, modularity, feasibility.

Design and Development of Quadruped Robot for Industrial Application

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ABSTRACT

Background: The advancement of robotics has led to the development of quadruped robots capable of navigating complex environments, offering significant potential for industrial applications. This project focuses on the design and development of a quadruped robot that can perform tasks in industrial settings, including material handling, inspection, and surveillance in areas that may be hazardous or difficult for humans to access. The robot is designed with a four-legged locomotion system, enabling stability, agility, and adaptability over uneven terrain. The mechanical structure is integrated with sensors, actuators, and a control system to achieve coordinated movements and obstacle avoidance. **Objective:** The development process involves mechanical design, embedded electronics integration, and programming of motion algorithms, including gait planning and balance control. Experimental results demonstrate that the quadruped robot can successfully traverse varied surfaces, maintain stability under load, and respond to real-time sensor inputs for obstacle negotiation. The novelty of this work lies in combining robust hardware with intelligent control strategies to create a versatile robotic platform for industrial environments. This project highlights the potential of quadruped robots to enhance operational efficiency, reduce human risk in hazardous areas, and pave the way for autonomous industrial automation. **Result:** The quadruped robot successfully demonstrated stable locomotion across both flat and uneven surfaces, using pre-programmed gait patterns for smooth movement. Integrated sensors enabled effective obstacle detection and avoidance, allowing the robot to navigate complex industrial environments safely. It maintained balance while carrying small payloads, highlighting its potential for material handling tasks. The embedded control system efficiently coordinated leg movements, ensuring precise and reliable motion. Repeated trials confirmed the robot's durability and consistent performance, with no mechanical or software failures observed. Additionally, the robot operated autonomously for extended periods, reducing the need for human monitoring. Overall, these results validate that the designed quadruped robot can perform essential industrial tasks, maintain stability in challenging terrains, and enhance operational efficiency and safety in industrial settings. **Conclusion:** The developed quadruped robot demonstrates stable locomotion, obstacle avoidance, and autonomous operation in industrial environments. Its ability to carry loads, navigate uneven terrain, and operate reliably highlights its potential to improve efficiency, reduce human risk, and support automation in industrial applications.

Keywords: *Quadruped Robot; Industrial Automation; Robotics; Gait Planning; Obstacle Avoidance; Embedded Systems*

Design and Development of Automated De-Riveting and Disassembly System for Circuit Breakers

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ABSTRACT

In the manufacturing of Residual Current Circuit Breakers with Overload protection (RCBOs), a significant number of units are rejected after final testing. While these defective products cannot be used as complete devices, many of their internal components remain reusable. Traditionally, the process of disassembling in RCBOs is carried out manually using drilling methods in manufacturing industries, it is time-consuming, labor-intensive, and less efficient task. This research focuses on the design and development of an automated de-riveting system to overcome these manual challenges and improving the quality and quantity of work cycle. Author has tried designing and developing the new automated system for safely and efficiently remove rivets from defective RCBOs, enabling the recovery of reusable parts with minimal human efforts. By introducing system automation in the process, the research work aims to improve productivity, quality, ensure operator safety, and promote sustainable practices in manufacturing sector with affordable cost.

Keywords: *De-riveting, Residual Current Circuit Breakers , automation,*

Design and development of automated sorting system for warehouse products

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ABSTRACT

Now a days the significance of role of automation has been increasing day by day in many industries, time consumption is also one of the major important factors that affects productivity, quality and quantity of work. The other factors that should be considered are less human efforts, reducing lead time, minimizing the workforce from ideal jobs, accuracy and hassle-free operations. In many of the electronic commerce industries like Flipkart, Amazon and Mynta are sorting of various types of products based on the customers demand. Finding an item from big warehouse becomes a significant challenges. Warehouse operations require fast, error-free product handling to meet increasing customer demands. This research work presents the design and development of an automated sorting mechanism that utilizes a barcode scanner to identify and categorize products based on their predefined storage locations. When a product is placed on the conveyor, the barcode scanner reads its unique product code and sends the information to the programmable logic control or processing unit. The system then automatically activates actuators or diverter mechanisms to direct the product to its correct location bin or lane. This automated approach significantly reduces manual sorting errors, improves processing speed, and enhances overall warehouse efficiency. The system is designed to be scalable, cost-effective, and suitable for modern smart warehouse environments where accuracy and productivity are critical. So many sorting systems are available in most of the companies, but the main drawback is that the existing systems are not so efficient and appropriate in the sorting mechanism. In the research deals with improving the sorting mechanism through automation in a more appropriate and efficient approach. Design and development of automated sorting system consisting system design, hardware and software integration as well as testing. In automation system most important elements are conveyor, sensors, PLC, actuators, motors, diverters, and central control software integrated with warehouse management system.

Keywords: *Automation, warehouse, PLC, Sensors, Mechanis*

Automated System for Precision NVH Testing

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ABSTRACT

The increasing need for accurate and repeatable Noise, Vibration, and Harshness (NVH) assessment in industrial systems provides the background for this work, which aims to address the limitations of conventional manual testing. The objective of this study is to design an automated, intelligent NVH testing system capable of performing reliable diagnostics for rotating machinery. The proposed method integrates a worm-gear motor assembly, a 3-axis accelerometer, and a high-gain microphone to acquire real-time vibration and acoustic signals. A novel aspect of the system is the use of an ESP32-WROVER-E module to execute on-board Fast Fourier Transform processing, allowing rapid conversion of time-domain signals into frequency-domain features. These features are further evaluated by a machine-learning model trained to classify mechanical conditions such as imbalance and bearing wear. Experimental testing demonstrated consistent feature extraction, stable electrical operation, and accurate condition prediction, indicating the system's effectiveness for early fault identification. The study concludes that the developed platform offers a portable, scalable, and cost-efficient alternative for industrial NVH diagnostics, while also supporting future integration with IoT-based monitoring frameworks and Industry 4.0 environments.

Keywords: *Acoustic measurement; Condition monitoring; Machine learning; NVH testing; Vibration analysis .*

A Review of Advanced materials used in hip joint implants

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ABSTRACT

Hip replacement surgery involves replacing the damaged joint with an implant that can reestablish the joint's ability to articulate. This article aims to evaluate the current advancements in biomaterials for hip implants. Various combinations of materials, including metals, ceramics, and polymers, can be used to create hip implants. This review examines the unique qualities required for biomaterials used in hip joint arthroplasty, including biocompatibility; low wear rate, high strength, and low coefficient of friction, based on a comprehensive review of the global literature. A critique of the development and current state of hip prostheses is presented. We gathered data on material behaviour and how the human body reacts to it by analysing the scientific literature.

Keywords: *biomaterials, ceramic, hip implants, prosthesis, wear.*

MODELING, ANALYSIS, AND MANUFACTURING OF A PROSTHETIC KNEE JOINT (REVIEW STUDY)

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ABSTRACT

The prosthetic knee joint is a vital component of prosthetic limbs designed for individuals who have undergone above-knee limb amputations. This review study assesses the modeling, analysis, and manufacturing of knee prostheses. Addressing the urgent requirement for efficient prosthetic solutions in response to the rising number of amputations. The reviewed study examined various types of mechanical prosthetic knee joints, including single-axis, polycentric, pneumatic, and hydraulic knee joints. The inspection and comparison of a microprocessor-controlled knee joint were also carried out. To determine how much patient comfort improves while walking and performing other activities, and how the body stabilizes during activities or duties such as stair ascent and walking on an uneven surface. the review study also sought to understand the modeling, manufacturing, and how the prosthesis is fitted on human beings, and what the cost of the prosthesis is all about, the mechanical complexity involved, and how the weights are screwed together, the technologies involved in their making. Review studies a total of more than 40 previous studies that are similar or related to the objectives of this study, with the hope that this will help the reviewed study meet its goals. The study found that many studies have focused on the research and development of microprocessor-controlled and lightweight prosthetic knees. These studies demonstrated that the integration of high-technology materials and technology facilitated humans to become more stable while carrying out normal daily activities and mobility. More so, the FEA has been found to have assisted in designing while maintaining the strength and quality of the new product. Designing new knee joints that are modular and customizable has played a crucial role in promoting comfort for the end-user, enabling many individuals to become more independent. This review study recommends that further studies continue to develop various types of knee prostheses, aiming to design one that is less complex and more affordable for many clients, while also addressing the challenges that affect the development of prostheses.

Keywords:

Prosthetic knee joint, above-knee amputation, microprocessor-controlled knee joints, FEA (Finite Element Analysis)

A Comprehensive Review on the Influence of Hot Isostatic Pressing and Surface Finishing Sequences on the Surface Integrity of DMLS 316L Stainless Steel

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ABSTRACT

The review discusses how the processes of Hot Isostatic Pressing (HIP) and secondary finishing operations impact the surface characteristics and overall performance of DMLS 316L stainless steel. Surface characteristics of as-fabricated DMLS parts are very poor (i.e., surface roughness, unmelted particle and porosity), these surface characteristics greatly diminish both the fatigue life and corrosion resistance of fabricated parts. HIP has been shown to be an effective means to remove internal porosity and to improve fatigue performance by reducing variability in the fatigue response, however not removing surface defects, therefore fatigue initiation is still occurring at the surface. Secondary finishing processes either a single process (e.g., mechanical, electrochemical, laser, etc.) or multiple sequential processing steps can successfully remove surface defects, reduce surface roughness and improve corrosion resistance through the formation of passive film layers. The literature indicates that when HIP is performed prior to secondary finishing (i.e., HIP-finish), internal densification of the part (by HIP) can be combined with surface refinement (via secondary finishing) to produce parts exhibiting high fatigue lives and superior corrosion resistance. However, there are some areas that require additional investigation, including standardization of testing methodologies, establishment of quantitative relationships between surface characteristics and fatigue life, and evaluation of long-term performance under various complex or corrosive loadings. In addition to the need for additional investigations into optimizing HIP-finishing sequence, developing environmentally friendly surface treatment methods and development of multiscale modeling techniques to provide reliable and certifiable post-processing workflows for high performance DMLS 316L components.

Keywords: *DMLS 316L stainless steel; Hot Isostatic Pressing (HIP); surface finishing; fatigue life; corrosion resistance; porosity reduction; post-processing.*

SIMULATION OF MATERIAL FLOW IN FRICTION STIR PROCESSING OF AA7075

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ABSTRACT

Friction stir processing (FSP) is a friction stir based material processing method for enhancement of material and microstructural and surface properties. As FSP is a multi-physics problem coupled with severe plastic deformation, material flow and microstructural evolution. Modeling of the FSP process can be very complicated and challenging. Few research work has been reported on modeling and simulation of FSP for material modification. In FSP Arbitrary Lagrangian-Eulerian (ALE) and Coupled Eulerian-Lagrangian (CEL) are both methods are used to model material flow and deformation but they differ in how they handle the mesh and its movement relative to the material. ALE allow the mesh to move independently of the material, while CEL couples the material and mesh making the mesh movement dependent on the material's deformation. In this study a computation efficient process model is developed using ABAQUS/Explicit based on coupled Eulerian-Lagrangian formulation to simulate FSP of aluminum alloy 7075. The three dimensional (3D) finite element model simulates the entire process. The computational analysis attempts deformation and strain history throughout the friction stir processing of AA7075. The results are obtained at rotational speed 1000rpm, traverse speed of 10 mm/min and tilt angle 3° . The results of heat energy, frictional shear stress, nodal temperature and logarithmic strain are studied. This study shows that the CEL model can be a powerful numerical tool to simulate the complex process mechanics and optimize the FSP process parameters for industrial applications.

Keywords: Friction stir processing, CEL approach, Finite element model, Aluminum alloy

EXPERIMENTAL INVESTIGATION OF THERMAL CONDUCTIVITY OF BIO- BASED COMPOSITE MATERIAL MADE FROM JUTE, COTTON, COIR FIBER

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ABSTRACT

The present paper deals with the effect of volume fraction of fibers on the effective thermal conductivity (k_{eff}) for polymer composites. This work sees an opportunity of enhancement on insulation capability of a typical fiber reinforced polymer composite. A mathematical correlation for the effective thermal conductivity of polymer composites reinforced with fiber is developed using the law of minimal thermal resistance and equal law of the specific equivalent thermal conductivity. To validate this mathematical model, two sets of epoxy based composites, with fiber content ranging from 0 to 15.7 vol % have been prepared by simple hand lay-up technique. For one set of composite, natural fibers i.e. jute and cotton fibers are incorporated in epoxy matrix and for another set a well-known natural fiber i.e. coir fiber is taken as a filler material whereas matrix material remains the same. Thermal conductivities of these composite samples are measured as per ASTM standard E-1530 by using the UnithermTM Model 2022 tester, which operates on the double guarded heat flow principle. Further, finite element method (FEM) is implemented to determine the k_{eff} of such composites numerically using a commercially available finite element package ANSYS. Experimentally measured values are then compared with the values obtained from the proposed mathematical model, the numerical values and also with models established earlier, such as Rule-of-Mixture (ROM), Maxwell's model, Nielson-Lewis model and Bruggeman model. From the experimental and numerical output, it can be seen that with an increase in fiber content, there is gradual decrease in effective thermal conductivity value for both sets of composites. This comparison tells that while none of the established models are correctly predicting the effective thermal conductivity of the composites, the results obtained from the proposed model fits well with the experimental data. This study shows that the effective thermal conductivity reduces quite significantly as the fiber loading in the composite increases. A reduction of about 8 % in the value of thermal conductivity is recorded with addition of 15.7 vol % of Jute, Cotton fiber in epoxy resin whereas 12 % decrease is noticed when filler is Coir fiber. This study validates the proposed model and also proves that finite element analysis can be an excellent methodology for such investigations. With light weight and reduced heat conductivity, these insulative, fibers reinforced polymer composites finds their potential applications in insulation boards, food containers, thermo flask, building materials etc.

Keywords – *Fiber Reinforced Polymer Composites, Effective Thermal Conductivity, Epoxy Matrix, Natural Fibers, Volume Fraction of Fibers, Thermal Insulation, Mathematical Modeling, Finite Element Methods, ANSYS Simulation, Rule of Mixture, Hand-lay Technique*

Investigations on Tribological Performance of Nano-Alumina and Nano-Mica Filled PTFE Composites

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ABSTRACT

The present study focuses on investigating the wear performance of polytetrafluoroethylene (PTFE) nano-composites reinforced with nano-alumina and nano-mica separately. The PTFE polymer is widely used in engineering applications for its low friction and high temperature stability. However, PTFE's poor wear performance under highly abrasive conditions limits its use. The nano-alumina filler is extensively explored for fabricating PTFE nano-composites While, but nano-mica is relatively lesser explored. This study addresses this gap by incorporating varying amounts of nano-mica in PTFE and comparing their abrasive wear performance with highly explored nano-alumina PTFE nano-composites, both set of samples fabricated by compression moulding. The results show that optimum content on both the nano-fillers is necessary to achieve best wear performance. Thus, the aim of this study is to understand the role of nano-fillers in tailoring the wear performance of PTFE for wear prone applications like bearings, gears, sealants, and cookware.

Keywords: *PTFE ,nano-alumina, nano-mica, nano-composite, abrasive wear performance*

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REIMAGINING FACTORY MAINTENANCE THROUGH PREDICTIVE ANALYTICS AND GENERATIVE AI

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ABSTRACT

Predictive maintenance has become a critical requirement for modern industrial systems due to the limitations of reactive and preventive maintenance practices, which frequently result in costly downtime, energy losses, and reduced asset life. This paper aims to examine how predictive analytics combined with Generative Artificial Intelligence (AI) can significantly improve factory maintenance by enabling early fault detection, structured knowledge retention, and actionable decision support. The study employs a review-based analytical method, synthesizing advances in machine learning, time-series analysis, condition-based monitoring, and natural-language models to understand their integrated role in predictive maintenance. The novelty of this work lies in highlighting how Generative AI uniquely enhances traditional predictive maintenance by interpreting textual maintenance logs, supporting technicians through conversational guidance, and consolidating domain expertise into scalable virtual maintenance assistants. Reported outcomes from diverse industrial sectors demonstrate reductions in unplanned downtime, improved equipment reliability, better resource planning, and measurable energy savings. The study concludes that the convergence of predictive analytics and Generative AI represents a transformative shift in maintenance engineering, offering industries a pathway toward more efficient, sustainable, and resilient operations while preparing the workforce for data-driven decision-making in the era of Industry 4.0.

Keywords: *Generative Artificial Intelligence, Predictive Analytics, predictive maintenance, Asset reliability etc.*

Influence of Inclination and Power Input on Natural Convection Heat Transfer in Notched Aluminum Casted V-Shaped Fin Arrays

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ABSTRACT

Heat generation is unavoidable in many industrial systems, making effective thermal management essential for maintaining reliable operation. Passive cooling using fins is a widely adopted method for enhancing heat dissipation through natural convection, and its performance depends strongly on the material, geometry, and orientation of the fins. Previous studies have explored various fin shapes including rectangular, triangular, circular, V-shaped, and notched profiles to improve convective heat transfer. The present work investigates the natural convection performance of cast aluminum LM16 V-shaped fins by examining the effects of fin inclination, power input, and the use of notched and unnotched configurations. An experimental setup was developed to test V-shaped fin arrays with and without notch at different inclination angles while varying the applied heat input that allow the direct assessment of how fin geometry and orientation influence heat-transfer behaviour. The results show that the fin model incorporating a 20mm notch and positioned at a 60° inclination produces the highest heat-transfer coefficient and Nusselt number, indicating superior thermal performance compared to other tested configurations. Overall the study demonstrates that combining an optimally sized notch with an appropriate inclination angle can significantly enhance natural convection heat transfer in casted aluminum LM16 fin arrays, providing useful design guidance for improving passive cooling systems.

Keywords: *Natural convection, Aluminum casted fins, V- shape fins array, Passive cooling, Heat transfer coefficient*

Paper ID: 14017

A COMPREHENSIVE REVIEW OF TESTING & VALIDATION METHODOLOGIES FOR COMPOSITE MATERIALS

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ABSTRACT

Nowadays composite materials are used more and more in airplanes, automobiles, boats, military equipment and buildings. We need more accurate, better and standard way to test and check their quality. Compared to metals, composite materials have an anisotropic and heterogeneous structure, along with various failure modes such as matrix cracking, fiber breakage, delamination, and interface failure. These features make them more complex to analyze and test both mechanically and in terms of instrumentation. Toward understanding strength, stiffness, energy immersion, and fatigue in composite material, advanced mechanical evaluation methods have been developed recently, including tensile, compressive, flexural, fatigue, impact, and high strain-rate testing. In addition to temporal and environmental exertion styles, associated with humidity immersion, hygrothermal aging, hygrothermal aging gives an insight into long-term performance continuity and decline. Ultrasonic testing, thermal imaging, X-ray computed tomography, and digital image correlation (DIC) are also ultramodern forms of non-destructive evaluation (NDE), providing high-resolution detection of internal damage.

Keywords: *Composite materials, Mechanical testing, Failure mechanisms, Structural integrity, ASTM Standards, Non-destructive evaluation (NDE).*

A HYBRID PELICAN-PARTICLE SWARM OPTIMIZATION ALGORITHM FOR THE JOB SHOP SCHEDULING PROBLEM

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ABSTRACT

This paper introduces a metaheuristic, hybrid Pelican-Particle Swarm Optimization Algorithm (PPSO), to solve the Job Shop Scheduling Problem (JSSP). The JSSP in the manufacturing and service sector is a well-known NP-hard problem. The objective function of JSSP is to minimize the total completion time of all tasks using available resources (makespan). In the proposed metaheuristic, the exploratory ability of the Pelican Optimization Algorithm (POA) is used to improve the performance of the Particle Swarm Optimization Algorithm (PSO). The exploration phase, based on POA, uses pelican foraging behavior to concentrate the search around promising regions of the solution space. After this focused search, PSO enables broader movement across the entire space, allowing the algorithm to examine new regions and refine the quality of the solutions. A combination of POA and PSO allows the metaheuristic to efficiently explore and find better areas in the search space. In addition to combining the algorithms, this method is incorporated with other features to improve metaheuristic performance. These include an initial solution generation method that ensures all initial schedules are valid; an active schedule generation method to avoid unnecessary computations during decoding; and an adaptive inertia factor in the PSO portion of the algorithm, which allows the swarm to dynamically modify their movements as the search continues. Performance evaluation is done using the 20 Lawrence benchmark instances. This hybrid strategy shows that it yields reliable and competitive solutions for JSSP applications.

Keywords: *job shop scheduling problem; pelican optimization algorithm; particle swarm optimization algorithm; active schedule.*

Paper ID: 14020

AN INVESTIGATION OF ADVANCES OF HIGH PERFORMANCE COMPOSITE MATERIALS IN DIFFERENT APPLICATIONS: A SYSTEMATIC REVIEW

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ABSTRACT

Composites are used to gain better performance in every sector as well as the vehicle industry. Due to its high strength, corrosion resistance, lightweight, ballistic performance, and durability this materials are used in different applications. Features like fire, heat and lightning protection behaviour it can be inflicted simple and cost effective fabrication process. This paper emphasizes the convenience of compound accouterments used in manufacturing of different components in various applications rather than conventional metallic accouterments. Numerous factors like chassis, wind turbine blades, steering systems, batteries, braking-related components, differential suspension systems depend adequately on composites. Composite materials structure may look complicated, but their overall significant performance is gainful for launching new types of products. Composite material is a new turning point of material science and very shortly it will provide a greater reach in many applications. Considerable hindrances of using composites are characterized in particularly automobile components. Overall use is consistently developing latest technology and safety for environment and humanity. The manufacturing cost is quite high for different components and different features of metal. But, composite reduces overall cost than other conventional materials; improving opportunities available to vehicle manufacturers. The new perspective to use of high performance composites in automobile, marine, piezoelectricity, magnetostrictive property, power generation equipments, wind turbine, self-healing electromagnetic shielding, and many more sectors is accelerating this field in long term future which is briefly discussed in this paper. The findings discussed in this paper are expected to assist early-stage researchers in advancing their understanding of composite materials.

Keywords: *High Performance; Composite Materials; Automobile Sector; Fender Component.*

Mechanical Investigation of Metal-Matrix Composites Al-Tic and Al-Sic Manufactured through centrifugal casting

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ABSTRACT

The purpose of this research work is to manufacture and characterize the aluminum metal matrix composite reinforced with titanium carbide (Tic) and silicon carbide (Sic) through centrifugal casting technique. Advanced metal matrix composite materials is one of the potential and advanced category of industrial engineering materials, Composite material exhibits step by step transitions in the microstructure as well as reinforced composition in a specific direction increasing variable changes in the functional performance of a new element. The objective of the present research work is to fabricate, investigate and characterize combined Tic and Sic hybrid particles reinforced with commercial graded aluminum composite for brake pad applications. Centrifugal casting technique is applied for making functional performance graded hybrid composite. It consists reinforcing aluminum metal with small grits size of Tic and Sic silicon carbide through centrifugal casting were adopted to manufacture the experimental samples. The samples were further tested and analyzed for specific (mechanical) characteristics of composite materials. The results showed the movement of Tic and Sic particles towards the inner region in centrifugal cast. Centrifugal cast technique settle reinforced particles on periphery of element. The combination of these two materials and the centrifugal casting technique creates a brake pad with improved mechanical properties like compressive strength, hardness with less porosity compared to a standard aluminum alloy without reinforcements. As well as maintained density of hybrid composite materials.

Keywords: Centrifugal casting, Hybrid composite, Reinforcement, Aluminum matrix composite

Performance optimization of Fiber Reinforced PEEK Composites with Solid Lubricants under Dry Sliding Conditions

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ABSTRACT

This study focuses on formulating and optimizing a high-performance PEEK-based composite strengthened with 20% Glass Fiber (GF) and lubricated with 10% PTFE ,10% Graphite and 4% MoS₂ to improve its wear behavior under dry sliding conditions. Tribological evaluations were carried out using a Linear Reciprocating Tribometer (ASTM G133 standard), in which temperature, stroke length, load, and sliding frequency were systematically varied. A Taguchi L16 experimental layout was employed to minimize testing requirements, and Response Surface Methodology (RSM) was utilized to develop regression models and determine the parameters that most significantly affect the Specific Wear Rate (SWR). The quadratic RSM model exhibited strong statistical performance with $R^2 = 99\%$, Adjusted $R^2 = 98\%$, and Predicted $R^2 = 96.7\%$, confirming its high predictive capability. Multi-response optimization using the desirability function ($D = 1.000$) identified the optimum operating conditions as 160°C, 16 mm stroke, 120 N load, and 9 Hz frequency, achieving a minimum SWR of 1.2×10^{-7} mm³/N·m. The optimized composite demonstrated markedly improved wear resistance, making the GF/PEEK–PTFE–MoS₂ system a promising candidate for automotive, aerospace, and biomedical components where lightweight materials with superior tribological performance are essential.

Keywords: *PEEK Composite, Glass Fiber Reinforcement, PTFE, MoS₂, Dry Sliding Wear, Tribology, Response Surface Methodology*

DESIGN AND MANUFACTURING OF GFRP MONO COMPOSITE LEAF SPRING

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ABSTRACT

The development of suspension composite leaf springs has emerged as a practical approach to reduce vehicle weight while maintaining the strength and durability required in suspension systems. Leaf spring made by Glass fiber reinforced polymer (GFRP) is best replacement for metallic leaf spring which enables the high weight savings and increases the efficiency of vehicles. The composite leaf spring provides additional benefits such as high strength to weight ratio and high elastic strain energy storage capacity. This study focuses on the design, material optimization and fabrication of a composite mono-leaf spring using Glass fiber-reinforced polymer materials as a replacement for traditional steel. The objective is to achieve substantial mass reduction while preserving or exceeding the static and fatigue performance of a conventional steel leaf spring. The design process involves determining the appropriate laminate structure, material properties, and geometric profile to achieve the desired stiffness and load-carrying capacity. For manufacturing, a controlled hand lay-up is employed to ensure proper fiber alignment and consistent material quality. The prototype leaf spring is tested for static strength, stiffness to validate the design. Results indicate that the composite leaf spring achieves a weight reduction of 60–70% compared to high-carbon steel springs, with improved specific stiffness, enhanced damping characteristics. The outcomes confirm that composite materials can effectively enhance suspension efficiency, reduce unsprung mass, and contribute to overall vehicle light weighting without compromising structural reliability.

Keywords: *Glass fiber reinforced polymer; Composite; Leaf spring; Design*

Tribological Characterization of Hybrid PTFE Composites Reinforced with fillers for sliding Applications

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ABSTRACT

Today hybrid polymeric polytetrafluoroethylene composites are widely popular because of their excellent properties, high resistance to chemical reactions, a very low coefficient of friction surface, and stability at elevated temperatures with a low weight-to-strength ratio. Polymer-based sliding has emerged as a replacement for metal-based sliding components in various applications in process industries. Polymer composite material has a low weight-to-strength ratio, self-lubrication properties, and a noncorrosive nature. During the study it is observed that PTFE has poor mechanical strength and poor resistance to wear and abrasion. To avoid this, suitable filler materials like glass fibres, MoS₂, graphite, carbon, and bronze are added to increase its durability and reliability. This study focuses on using self-lubricating PTFE hybrid composite sliding action as a replacement for the traditional hydrostatically lubricated gun metal components used in sugar mill processing industries. In this experimental work bronze-filled PTFE composites are applied because they have an effective, strong, and even transfer layer of PTFE and bronze, which helps reduce wear and increase the strength of hybrid composites. The experimental tests were performed under different loads (110 N, 120 N, and 130 N) at a sliding speed of 0.2 m/s, while keeping other tribometer conditions unchanged. To analyse the performance of hybrid PTFE composite samples, they were rubbed against an EN8 steel disc in dry conditions using a pin-on-disc tribometer.

Keywords: *Hybrid composite, Steel disc, Filler materials.*

Experimental investigation on the effect of tool geometry and machining conditions on Micro-hardness of chips in turning

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ABSTRACT

Due to the widespread use of highly automated machine tools in the metal cutting industry, manufacturing requires highly reliable models and methods for the prediction of output performance of machining processes. The prediction of optimal manufacturing conditions for good chip micro-hardness and dimensional accuracy plays a very important role in process planning and tool life. In the metal cutting process, the tool geometry and cutting conditions determine the time and cost of production, which ultimately affect the quality of the final product. In the present work, experimental investigations have been conducted to see the effect of the tool geometry (effective tool nose radius) and machining conditions (cutting speed, feed rate, and depth of cut) on the chip micro-hardness during the turning of EN-31 steel with tungsten carbide inserts. First- and second-order mathematical models are developed in terms of machining parameters by using the response surface methodology on the basis of the experimental work. The results obtained from the application of response surface methodology can predict the effect of machining parameters on chip micro-hardness. The second-order response surface was found suitable for the present work. A factorial design with the added centre point technique has been used to plan the experiment. Optimum machining conditions for minimizing the chip micro hardness are determined using the desirability function approach. Results obtained showed that chip micro-hardness increases with increasing feed rate and depth of cut, while it increases with decreasing tool nose radius. It also increases with increasing cutting speed and feed rate up to a certain level, beyond which further increases cause a drop in chip micro-hardness.

Keywords: *Chip micro-hardness, Machining parameters, Response surface methodology*

Assessing Healthcare Waste Variability and Operational Barriers to Effective HCWM Systems: Evidence from Waste Profiling and Industry 4.0 Readiness

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ABSTRACT

The study estimated numerous types of waste produced by Health Care Units (HCU) and examined the existence of significant differences if any among waste produced by different wards of the HCUs. The study involves an opinion-based survey of Health Care Waste Management (HCWM) practices among practitioners and problems encountered by the HCWM team during implementation of industry 4.0. It was observed that there is a significant difference in wastages produced by different wards in the HCUs. Through ANOVA, it can be interpreted that the Causality, Emergency, Burn's ward, Male orthopaedic, Maternity, ANC Ward, Post-operative, Female surgical, Cardiac ICU and Paediatric wards produce a high number of wastages. It was found that there is a significant difference exists in the type and quantity of wastages produced by the different HCUs. The study also revealed that Biodegradable waste, Plastic wrappers and non-recyclable is produced in high amount. Then the measurement model of this work developed using EFA and CFA has validated 19 items from 25 items. The study also revealed that the HCWM teams are facing several challenges while implementing an effective HCWM system due to existing policy & laws, lack of training, as well as lack of fund and infrastructure. The scales are validated from the perspectives of developing countries such as India. Finally, this study can facilitate managers and decision-makers to monitor systematically the waste management systems in the healthcare industry.

Keywords: *Health Care Waste (HCW), Industry 4.0, HCWM, Exploratory factor analysis (EFA), Confirmatory factor analysis (CFA)*

Enhancing Natural Fiber Composites through Surface Treatments: A State-of-the-Art Review

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ABSTRACT

Natural fibers are perfect for industries like aviation, automobile sectors like car production that require robust, lightweight components because they are more biodegradable, reusable, and sustainable than synthetic materials. Additionally, they are less expensive than synthetics. However, surface treatments are necessary to improve adhesion and performance since natural fibers frequently exhibit poor compatibility with polymer matrices. Fiber surfaces can be altered chemically, physically, or biologically to improve their qualities; however, chemical treatments are more expensive even though they increase mechanical strength and enable the use of less fiber. Hydrophilic compounds are eliminated by biological treatments using fungi or enzymes. The benefits, drawbacks, and potential of various surface treatments in polymer composites are reviewed in this research. It gives researchers knowledge to choose appropriate treatment approaches or investigate novel subjects. Future studies might concentrate on employing nanoparticles, integrating treated fillers, investigating biological approaches, and improving composite performance for more extensive, environmentally friendly uses.

Keywords: *Natural fibers, Composites, Surface treatment, Chemical treatment, Chemical modifications, Fiber-reinforced composites*

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Tribological Characterization of PA66 Reinforced with fillers and fibers

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ABSTRACT

Persistent Organic Pollutants (POPs) are a major global concern due to their toxicity, bioaccumulation potential, and long- range environmental transport. Sediments act as long-term sinks for these pollutants, making their extraction and quantification essential for evaluating ecological risks and supporting environmental management. The present study focuses on the systematic extraction, identification, and quantification of selected POPs from sediment samples collected from identified aquatic environments. Standardized analytical techniques, including soxhlet extraction and solid-phase extraction (SPE), were employed to ensure efficient isolation of target pollutants. Quantitative analysis was conducted using Gas Chromatography–Mass Spectrometry (GC-MS), providing high sensitivity and accuracy. Results indicate notable spatial variations in POP concentrations across sampling locations, reflecting the impact of anthropogenic activities and local hydrodynamic conditions. This study offers critical insights into the environmental fate and distribution of POPs and underscores the necessity of continuous monitoring to protect aquatic ecosystems. The outcomes are expected to aid policymakers and environmental agencies in designing effective pollution control and sustainable water resource management strategies.

Keywords: *Persistent Organic Pollutants, Sediments, Extraction, Quantification, GC-MS, Environmental Monitoring*

SOUND ABSORPTION PERFORMANCE OF BIO-COMPOSITE MATERIALS: A CASE STUDY

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ABSTRACT

In the recent years, to substitute the conventional synthetic sound absorption material by bio-composite material their sound absorption properties have been increasingly studied. Owing to the fact that conventional synthetic fiber use as an acoustic material has potential health risks for human beings and significant environmental impact. In this study, existing and newly emerging bio-composite sound absorbers are summarized. The comparison of sound absorption properties between bio-composite materials like cork, hemp and fiberboard and conventional materials, mineral wool, propylene and polyurethane foam are done. It is found that many natural fibers have comparable sound absorption performance, some of them such as hemp and fiberboard can be the ideal alternatives to conventional synthetic sound absorption material. Use of agricultural waste even can solve the problem of agricultural waste management and environmental pollution due to burning of agricultural waste in a field. Present case study can serve as a database for designers who are increasingly emphasizing the use of environmentally friendly materials.

Keywords: *sound absorption material; bio-composite material; agricultural waste; natural fibers; pollution; synthetic fiber.*

Effect of Chemical Treatments on the Structural, Thermal, and Mechanical Properties of Vetiver Fibers

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ABSTRACT

Natural fibers, like vetiver provide a renewable alternative to synthetic materials but face the problem of excessive moisture absorption, low adhesion to surfaces and amorphous constituents which reduce their performance in engineering applications. In a bid to overcome these shortcomings, this paper aims at enhancing the physicochemical characteristics of vetiver fibers, in a systematic manner, by using specific chemical procedures. It is done to increase their structural integrity, thermal resistance, and mechanical behavior through a change in their surface and internal composition. Vetiver fibers gathered in the local areas of Odisha, India were cleansed, dried, separated by mechanical processes and subjected to different chemical treatments. The originality of the work is that it offers an all-encompassing and treatment-focused analysis of vetiver fibers as an under-explored natural fiber. XRD, FTIR, SEM, TGA, and moisture absorption tests were used to examine the treated and the untreated fibers to understand the change in crystallinity, functional groups, morphology, thermal behavior, and hydrophilicity. Findings indicated that alkali treatment enhanced considerably tensile strength change by 15.90 percent and crystallinity because of elimination of hemicellulose and other amorphous substances. FTIR supported increased molecular reorganization and ordering. Thermal analyses indicated increased thermal stability of all chemically treated samples. The absorption of moisture was significantly low and this implied enhanced dimensional stability. On the whole, this paper shows that the chemical modification especially the alkali treatment significantly improves the properties of vetiver fiber, making it viable in the use of fibers as composite reinforcement in a sustainable fiber-reinforced polymer.

Keywords: *Vetiver fibers, Chemical treatment, Alkali modification, Thermal stability, Fiber characterization*

Chemical Treatment and Characterization of Rattan Fibers for Enhanced Material Performance

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ABSTRACT

Rattan fiber is a lightweight and renewable material produced by using climbing palm of Calamoideae subfamily, however, it is characterized by high moisture absorption, surface impurities, and low compatibility with the matrix. In this study, the extract, chemical treatment and characterization of the rattan fibers harvested in Odisha will be carried out in order to improve its structural, mechanical, and thermal behavior. The raw fibers were washed, dried, and treated by different chemical procedures, and mainly, the alkali modification was focused upon. The uniqueness of this work is the fact that treatment-specific changes are correlated in detail with the properties of fibers in the context of developed techniques. XRD, FTIR, SEM, TGA, and moisture absorption tests were performed to verify the treatment results, and they revealed substantial improvements. Alkali-treated fibers showed a 53.20% increase in tensile strength, higher crystallinity, and improved surface morphology. Thermal analysis indicated that it showed an increase in stability and low weight loss during decomposition. The FTIR confirmed the decrease of amorphous components and the enhancement of the molecular organization. Overall, the rattan fibers subjected to alkali treatment have the best properties that can be used in composite applications that are sustainable.

Keywords: *Rattan fibers, Chemical treatment, Alkali modification, Thermal stability, Fiber characterization*

Identifying and Mitigating Major Maintenance Issues in Sugarcane Rolling Mills: A Review

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ABSTRACT

In monsoon season, due to sugar cane harvesting problem, the production of sugar is stopped. During this period the plant machinery and equipment are planned for major scheduled preventive, predictive and breakdown repair work. It has been reported by many sugar industries in India that huge material, man power and money are required for up keeping of machinery and equipment's. The objective of this paper is to understand and highlight various mechanical maintenance problems related to tribology in sugar cane rolling mill and discuss the methods to mitigate them. Due to the large amount of forces involved in crushing the sugarcane in rolling mill, friction and wear occurs. To understand the major maintenance issues in sugar industry, visits were made to two renowned sugar industries in Ahmednagar district, Maharashtra. Information regarding the Manufacturing Process, Plant Layout, maintenance was collected and recorded for further study. Investigators have addressed the wear problems occurred in the rolling mill section with regard to Shaft, Shell and Bearing and suggested remedies to improve the wear behavior mainly changing the Surface Topography. As high cost and downtime is involved in maintenance of rolling mill it attracts the attention for research.

Keywords: *Mechanical Maintenance; Sugarcane Rolling Mill; Surface Topography; Wear Behavior.*

Grade Classification of Non-edible Vegetable Oil Base Stocks Using WASPAS and COPRAS Multi-Criteria Decision-Making Methods

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ABSTRACT

Rising interest in sustainable lubricants has led to research on renewable, biodegradable vegetable oil base stocks. In this research, suitability of vegetable oil base stock for lubricant formulation was assessed considering its rheological, tribological, physicochemical and environmental properties by referring multi-attribute decision making tools. Eight alternative oils have been studied in terms of their density, coefficient of friction, viscosity, oil film strength, cost, flash point, pour point, oxidation stability and thermal stability. To ensure methodological consistency and comparability, the data were weighted and standardised. The COPRAS model confirmed that Jatropha oil constituted the best alternative, while Jatropha oil was ranked the highest respectively by WASPAS approach. The stability and accuracy of the method are confirmed by the close match of results from both models. These results indicate that jatropha oil had higher environmental superiority, less acidity and better thermal resistance, which makes them a technically feasible lubricant base stock from the ecological standpoint. The combination of the two approaches provides a data centric structured process for sustainable environmentally acceptable lubricant selection. An in-depth investigation into lubricant formulation using various additives tailored for specific metalworking applications, using Jatropha oil as the base stock, is recommended.

Keywords: *Vegetable oil; WASPAS; COPRAS; MADM; biodegradability.*

Effect of MoS₂ Nano-additives on Oil Film Strength of Jatropha Oil under Boundary Lubrication

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ABSTRACT

Due to increasing environmental concerns, many countries are limiting the use of mineral-based lubricants. There is a need for a biodegradable, non-edible oil as a viable alternative to mineral-based lubricants. This study explores the potential of crude Jatropha oil as a lubricant by enhancing its tribological performance through the addition of MoS₂ nanoparticles with varying sizes and concentrations to improve oil film strength. Nanoparticles sized 20–30 nm, 50–60 nm, and 80–90 nm were blended at concentrations of 0.5%, 1.0%, and 1.5%, and tested using a four-ball tribotester. A Taguchi L9 orthogonal array was used to assess the influence of additive size, concentration, load, and speed. EP tests were conducted specifically with the 80–90 nm formulation, and wear scar morphology was examined via SEM. Results indicate that additive size is the most significant factor, followed by load, concentration, and speed. Crude Jatropha oil showed the lowest performance, while 1.5% MoS₂ delivered the best results with LNSL of 1569 N, weld load of 3089 N, and LWI of 2200 N, indicating excellent extreme pressure performance. Overall, MoS₂ nanoparticles markedly boost the performance of Jatropha oil, making it a viable, eco-friendly option for specialized metalworking lubrication.

Keywords: *Oil film strength; MoS₂; jatropha oil; anti-wear; extreme pressure.*

AUTOMATIC LIQUID PURIFICATION METHODS: REVIEW

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ABSTRACT

Conventional industrial purification methods often encounter challenges such as frequent downtime, equipment-related process failures, and increased operational costs, all of which compromise overall plant efficiency. In response to these limitations, automatic purification filters have been developed to offer more reliable and sustainable alternatives. The objective of this paper is to review the evolution and performance of various modern liquid purification methods, with a particular focus on self-cleaning mechanisms that aim to reduce human intervention. The study employs a comparative literature review methodology to assess the design, functionality, and economic impact of these purification methods. A key novelty of this work lies in its emphasis on evaluating the degree of automation and the potential for achieving maintenance-free operation. The findings indicate that while some automatic filters demonstrate rapid return on investment and improved operational continuity, others still require periodic supervision, limiting their autonomy. The review concludes that although significant progress has been made in enhancing filtration efficiency and reducing manual maintenance, further innovation is needed to achieve fully autonomous, cost-effective solutions for industrial liquid purification.

Keywords: *Contamination Cleaning, Purification, Filtrations, Scrapping Mechanism, Ultrasonic Sound, Backwash, Spark Discharge.*

Investigation of Flow-induced Oscillation of Multiple Flexible Foils

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ABSTRACT

The study of flow-induced flutter or flapping in thin, flexible foils subjected to axial flow is critical for various engineering applications, including energy harvesting from wind and tidal currents, enhancing flow mixing, and mitigating undesirable structural vibrations. A flexible foil or plate placed in a moving fluid can become unstable at certain flow speeds, triggering large-scale flutter or flapping motions due to flow instabilities. Once initiated, the foil captures energy from the flow, sustaining its oscillations. As a result, self-sustained, flow-induced flapping has garnered significant interest as a method for harvesting wind and tidal energy. In scenarios involving multiple flexible foils arranged in various configurations, the spacing between them, in addition to their geometry and flexibility, becomes an important factor. However, this aspect remains underexplored. This study presents an experimental investigation into the flutter dynamics and energy harvesting potential of flexible sheets in axial flow. The experiments are conducted in a low-speed wind tunnel at the Aerodynamics Lab, UPES. Observations reveal that a thin, flexible sheet attached to a rigid support begins to flutter at a critical wind speed, with both its amplitude and frequency increasing as the wind speed rises. Flutter characteristics are analyzed using a stroboscope and high-speed imaging. One of the primary objectives is to explore the mutual interactions between multiple sheets and identify optimal configurations for energy harvesting. In the case of parallel sheets, minimal interaction occurs when the spacing between them exceeds twice the sheet length. However, when the spacing is reduced to the length of the sheet, significant mutual interaction is observed, which affects their flutter behavior.

Keywords: *Flow-induced flutter, Wind energy harvesting, Wind tunnel Testing*

Structure–Property–Wear Correlations in Thermal-Sprayed and Laser-Remelted High-Entropy Alloy Coatings: A Comprehensive Review

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ABSTRACT

High-entropy alloys (HEAs) have attracted intense interest because of their unusual combination of high hardness, exceptional thermal stability, and promising tribological properties, making them attractive candidates for wear-resistant surface coatings. Despite increasing literature on HVOF/HVAF HEA coatings and separate studies on laser remelting of thermal-sprayed coatings, a focused, quantitative assessment of how a remelted lamellar structure can be transformed into a more homogenous, fine-grained or partially re-solidified network, reduce porosity, and promote formation or redistribution of hard phases and oxide dispersoids that impede material removal during abrasion. This research progress report presents the experiments completed to date, microstructure by SEM/EBSD/XRD, hardness mapping, and preliminary wear data, and situates those findings within the context of existing literature.

Keywords: *High-entropy alloy coatings; Thermal spraying; HVOF/HVAF; Laser remelting; Microstructural evolution; Tribological performance; Wear resistance; Structure–property relationships*

Control of the Flutter Characteristics of a Flexible Thin Sheet Using Boundary Layer Trip Wire

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ABSTRACT

The flutter of plates or sheets is a classic example of fluid-structure interaction, which is undesirable and a crucial design consideration in many engineering applications. The flutter of the flexible foil is usually flow-induced, and the flow perturbation in the incoming flow can trigger a large amplitude oscillation. The flutter instability of the sheet depends on several parameters, such as flow speed, turbulence level in the flow, flexibility of the sheet and its aspect ratio. In the present study, the flutter characteristics of a rectangular thin sheet made of PET material, was studied experimentally in a wind tunnel. The sheet was clamped vertically to the trailing edge of a streamline mast to minimise the interference. The primary objectives of the present work are to study the flutter behaviour of the sheet and to control it using boundary layer trip wires. The boundary layer trip wires were attached to the surface of the streamline support (airfoil shape), which controls the incoming flow characteristics over the sheet. Different diameters and different locations of the tripwire were tested, and their effect on the flutter instability of the sheet was observed. The flutter motion of the sheet was investigated using a hotwire and a high-speed camera, whereas the flow-field was studied using PIV measurements. The tripwires placed before the mid-chord of the airfoil were found to be more effective in controlling flow and, hence the flutter instability of the sheet.

Keywords: *Flow-induced flutter, Flow control, Boundary layer control, Wind tunnel Testing*

Optimizing High Energy Multi-Stage Coilgun for Projectile Velocity

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ABSTRACT

Electromagnetic technology provides a promising alternative to conventional firearm systems by enabling projectile acceleration without chemical propellants. This project studies how to design and improve a multi-stage coil gun in order to shoot a projectile since a single-stage coilgun is easy to make but cannot provide very high velocity, while a multi-stage coilgun uses many coils to actuate the projectile multiple times as it moves forward making it much faster. We examine how coil shape, stored energy and pulse timing affect the projectile's motion, since wrong timing can slow it down instead of speeding it up. In this research approach we are combining the structural approach along with Numerical integration, Finite Element Analysis and integration of theoretical modeling to achieve an optimized coil gun design. We will also use high-end sensors and speed switching devices to maintain an accurate positioning of the projectile and current control. There are multiple simulation tools which help in the analysis of magnetic behavior along with the optimization of the system parameters before we move onto the physical implementation of the project. The main aim of this study is to maximize projectile velocity through development of systemic design, accurate simulation and validation through experimental analysis which contributes in the advancement of classic electromagnetic launch systems. The results show that when everything is set properly, a multi-stage coilgun can achieve much higher speed than a single-stage one using the same energy, making it useful for experiments and research that need fast, contact-free launching.

SUSTAINABLE MANUFACTURING OF COMPACT H-TYPE FIN HEAT EXCHANGERS USING CuCrZr ELECTRODES IN RESISTANCE WELDING

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ABSTRACT

The increasing demand for compact and energy-efficient thermal systems has intensified the need for advanced manufacturing solutions in heat exchanger design, particularly for reducing fin pitch in H-type fin-to-tube heat exchangers. Conventional projection resistance welding (PRW) using electrolytic copper electrodes is limited to fin pitches above 12.7 mm due to rapid electrode wear, deformation, and loss of dimensional accuracy, restricting further compactness and productivity. The objective of this study is to overcome this limitation by developing a durable, high-performance electrode material capable of enabling stable welding at reduced fin pitches while improving electrode life and manufacturing efficiency. A Copper–Chromium–Zirconium (CuCrZr) alloy electrode is developed through controlled smelting, forging, solution treatment, and precipitation hardening to achieve an optimal balance of mechanical strength, electrical conductivity, and wear resistance. Projection resistance welding trials were conducted on H-type fin-to-tube assemblies, and the performance of the developed electrode is systematically compared with that of conventional pure copper electrodes under identical process conditions. The CuCrZr electrode enabled stable and repeatable welding at fin pitches as low as 9.0 mm while maintaining weld integrity and dimensional accuracy, demonstrating nearly a 20-fold increase in service life and a 26 % improvement in production rate. The reduced fin pitch resulted in higher fin density, increased effective heat transfer area, reduced heat exchanger volume, and material savings in pressure-grade tubing. The results confirm that CuCrZr electrodes provide a scalable and sustainable manufacturing solution for compact heat exchangers and establish their suitability for high-cycle industrial PRW applications aligned with Industry 4.0 and sustainable manufacturing.

Keywords: *Compact heat exchanger; CuCrZr electrode; H fin; Projection resistance welding; Sustainable manufacturing*

Statistical Modelling and analysis of experimental performance of Aluminium hybrid composites Using Taguchi based Response Surface Methodology

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ABSTRACT

The purpose of this research work is to manufacture and characterize the aluminum metal matrix composite reinforced with titanium carbide (Tic) and silicon carbide (Sic) through centrifugal casting technique. Advanced metal matrix composite materials is one of the potential and advanced category of industrial engineering materials, Composite material exhibits step by step transitions in the microstructure as well as reinforced composition in a specific direction increasing variable changes in the functional performance of a new element. The objective of the present research work is to fabricate, investigate and characterize combined Tic and Sic hybrid particles reinforced with commercial graded aluminum composite for brake pad applications. Centrifugal casting technique is applied for making functional performance graded hybrid composite. It consists reinforcing aluminum metal with small grits size of Tic and Sic silicon carbide through centrifugal casting were adopted to manufacture the experimental samples. The samples were further tested and analyzed for specific (mechanical) characteristics of composite materials. The results showed the movement of Tic and Sic particles towards the inner region in centrifugal cast. Centrifugal cast technique settle reinforced particles on periphery of element. The combination of these two materials and the centrifugal casting technique creates a brake pad with improved mechanical properties like compressive strength, hardness with less porosity compared to a standard aluminum alloy without reinforcements. As well as maintained density of hybrid composite materials.

Keywords- Response surface methodology, wear, coefficient of friction, RSM, Taguchi

Numerical Investigation of Syngas Combustion Considering Effect of Inlet Air Temperatures

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ABSTRACT

Two-dimensional detailed numerical combustion analysis is performed to investigate syngas combustion in a non-premixed combustion chamber. The study adopts a detailed chemical kinetic mechanism and transport model to examine the combustion phenomenon. Syngas, a mixture of H_2 , CO, and N_2 , is subjected to variations in the molar proportions of H_2 and CO, while maintaining a constant N_2 content, and is introduced into the combustion chamber. The temperature of the inlet air, supplied via a co-flow, is varied, and its influence on the chemical reaction rates is examined. The structure of the ignition zone and the adiabatic flame temperature under different H_2 /CO molar ratios are investigated. An optimization of the H_2 /CO ratio in syngas, coupled with the inlet air temperature, can provide a better trade-off between the reaction rates of CO and H_2 . These simulations provide insights into the temperature distribution, reaction rates, and flame topologies, which are critical for optimizing combustion performance.

Keywords: *Syngas, H_2 /CO ratio, Inlet air temperature, non-premixed combustion.*

EFFECT OF SUSPENSION SUPPORT NUMBER ON THE DYNAMIC PROPERTIES OF A VENTILATION DUCT SYSTEM

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ABSTRACT

Ventilation ducts are sensitive to vibration and noise due to their thin-walled structures, which may lead to resonance-related performance reduction and structural integrity concerns. In practice, ventilation systems are often designed with a large number of suspension elements for safety, whereas systems designed for ease of installation and cost efficiency commonly employ fewer suspension elements. However, the influence of suspension number on the dynamic behaviour of ventilation systems is not always sufficiently evaluated. In this study, a multi-segment ventilation duct system is numerically modelled to investigate the effect of suspension number on its dynamic response. A frequency response function-based approach is used to compare the reference configuration with modified system. This approach allows the dynamic response of the ventilation duct system to be evaluated directly as a function of suspension number, without relying on local modal shape interpretations. The results show that changing the number of suspensions produces noticeable changes on the dynamic responses within specific frequency ranges, particularly near regions where the suspension layout is modified. These results indicate the critical role of suspension number in the dynamic behaviour of ventilation duct systems in practical ventilation system design.

Keywords: *Vibration; Finite element modelling; Frequency response function; Structural modification method; Ventilation duct system*

A HYBRID STATISTICAL APPROACH FOR PERFORMANCE OPTIMIZATION OF MICRO-SCALE WIND ENERGY SYSTEM

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ABSTRACT

Micro wind turbines (MWTs) are becoming the promising source of electricity generation for decentralised electricity generation especially in the rural areas. The efficiency of MWTs depends on some design and operational factors including number of blades, blade radius and wind speed. This paper seeks to establish the effects of these parameters on the performance of the turbine and determine the best configuration that will yield the highest power and efficiency. The experimental design was done systematically using the Taguchi method with an L16 orthogonal array to reduce the number of experiments required for the analysis. Two dependent variables, namely power output and coefficient of performance (C_p) were recorded for each configuration tested. The results of the experiments were analyzed using Analysis of Variance (ANOVA) to test the significance of each input factor and Weighted Sum Model (WSM) for multi-objective optimization. As for the WSM method, unequal weights were assigned to power (0.35) and C_p (0.65) because efficiency takes precedence over other factors. The optimization studies revealed that the highest performing turbine was the three-bladed turbine with a radius of 0.26m and the wind speed of 12m/s. Confirmation experiments under these conditions also showed the same results with little variability thus confirming the experimental results. The present work offers a systematic and quantitative approach to improve the MWT performance, which is useful for the design and implementation of small-scale wind energy systems in distributed energy applications.

Keywords: *Micro wind turbine; Performance evaluation; Taguchi method; ANOVA; WSM optimization.*

AN ANALYTICAL STUDY OF INDIA'S ENERGY FLOWS (2014-2024)

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ABSTRACT

Energy availability is a decisive aspect affecting the economic and social development of a nation. Recognizing national energy flows is important for policy-making and long-term energy planning. It helps to evaluate the progress toward sustainability goals. This study explores India's energy supply and consumption patterns using commodity balance, energy balance, and Sankey diagram techniques. The analysis uses data from FY 2012-13 to FY 2023-24. It points on Total Primary Energy Supply (TPES), Total Final Consumption (TFC), sector-wise consumption, and transformation losses. The results show rising dependence on imported coal and crude oil. They also show a growing gap between domestic production and supply. Incompetence in energy conversion remain huge. In FY 2023-24, TPES reached 9,03,158 KToE, with coal contributing 59.14% and crude oil 29.83%. The Sankey diagram highlights major losses in power generation and increasing energy use in the transport sector. This study offers a useful reference for policy review and planning India's future energy transition.

Keywords: *Energy Availability; Energy Balance; Sankey Diagram; Total Primary Energy Supply (TPES)*

Piezo-Stair: A smart staircase for sustainable energy generation

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ABSTRACT

The growing demand for sustainable and decentralized energy sources has encouraged the exploration of small-scale energy harvesting systems suitable for smart infrastructure. This work presents a staircase-based piezoelectric energy harvester designed to capture mechanical energy from human footsteps and convert it into usable electrical power. The main objective is to develop a cost-effective and practical mechanism capable of generating sufficient energy to charge low power electronic devices. Twenty -five piezoelectric sensors were arranged in a series-parallel configuration and mounted beneath spring supported tile to ensure uniform force distribution. The AC output generated from the stacked piezo elements is rectified using Schottky diode bridge rectifier And filtered with high-value capacitor to reduce fluctuation caused by intermittent foot pressure. This stabilized DC signal is conditioned using DC - DC boost converter and safety stored in a lithium-ion battery via dedicated charging module. Experimental trials demonstrated consistent voltage generation under varying loads, confirming the feasibility of harvesting micro-level energy in real-world environment. Overall, the system offers a simple mechanical structure, low component cost, and strong potential for smart-city application where continuous human motion is available as an energy source.

Keywords: *energy harvesting; piezoelectric staircase; power conditioning.; smart infrastructure; micro-energy storage*

Paper ID: 15013

SUSTAINABLE DESALINATION APPLICATIONS THROUGH A PENTAGONAL- PYRAMID SOLAR STILL: INTEGRATED MODELING AND EXPERIMENTAL EVALUATION

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ABSTRACT

This study presents an experimental and theoretical investigation of the Pentagonal Pyramid Solar Still (PPSS) in comparison with the Square Pyramid Solar Still (SPSS) under identical summer climatic conditions in Nagpur, India. The evaluation was performed for key parameters, including basin water temperature, glass cover temperature, productivity, thermal efficiency, and exergy efficiency. Results demonstrate that the PPSS consistently achieved higher performance due to its multi-angled geometry, which enhances solar trapping and uniform heat distribution. The average distillate yield of the PPSS was 12–15% higher than the SPSS, producing 4.8 L/m²/day compared to 4.2 L/m²/day. Similarly, the thermal efficiency of the PPSS ranged from 58% to 65%, while that of the SPSS was limited to 50%–56%. Exergy efficiency was also comparatively higher for the PPSS (6.2%) relative to the SPSS (5.4%). These comparative findings confirm that the pentagonal pyramid geometry offers superior freshwater productivity and improved energy utilization, making it a more effective design for decentralised desalination systems in water-scarce regions. Experimental findings indicate higher freshwater productivity with an error of less than 10% between predicted and actual values. The research indicates that the design is low-cost, scalable, and environmentally sustainable and thus ideal for rural and urban areas.

Keywords: *Solar Desalination, Pentagonal Solar still, Thermal efficiency, Mathematical Modeling.*

Comparative Evaluation of Passive and Active Cooling Strategies for Battery Thermal Management Using PCM, Air, and Fin-Based Systems

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ABSTRACT

This paper is an experimental comparison of passive, active and hybrid thermal management of a battery through the phase change material (PCM) composed of paraffins, aluminium fins, and forced draught under air convection. A model cell assembly of a lithium-ion cell was constructed to simulate the thermal behavior of 18650 cells in a simulated 2C discharge. Five cooling modes which were natural convection, forced convection, PCM-assisted natural convection, PCM with fins and PCM-assisted forced convection were tested at the same conditions. The findings indicate there are significant variations in peak temperature control as natural convection attained 71.5 °C. The highest thermal suppression was obtained through forced convection where the highest temperature was 41.86 °C, which was a 41.45 % improvement. Passive PCM-based configurations also showed large improvements with PCM + FC, PCM + NC, and PCM + Fin + NC giving 25.99 %, 24.14 % and 22.64 % respectively. Interestingly, the use of fins did not help in improving performance, since the accelerated heat conduction diminished the usefulness of latent heat usage. The results indicate that PCM has a good buffering behavior, but it is more effective to combine forced airflow that offers the most reliable performance in the case of high-heat-generation conditions. In general, there is a very promising future in the development of hybrid PCM forced convection systems about safety, uniformity and stability in the operations of battery thermal management systems.

Keywords: Battery thermal management, Phase change material, Natural convection, Forced cooling, Fins, Passive cooling.

Paper ID: 15015

ELECTRIC VEHICLE CHARGING STATION LOCATION OPTIMIZATION

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ABSTRACT

The increasing adoption of electric Vehicles in India further necessitates well-planned charging infrastructure for maintaining sustainable transportation with a view to combat climate change. Delhi, The Capital is facing challenges to establish efficient charging infrastructure to meet the increasing demands of Electric Vehicle users. This paper presents a study on identifying optimal locations for installing electric charging stations across the Delhi. A Geographic Information System (GIS)-based approach is used to map Traffic density and current Charging infrastructure across Delhi. A genetic algorithmic Optimization technique has been applied to identify high demand points. These locations will help determine the efficiency level of the present charging infrastructure it must address regions where charging demands remain unmet. High-resolution traffic data was processed to calculate a Congestion Index representing potential charging demand. A uniform grid of candidate sites was generated, and demand values were spatially joined to these locations. The genetic algorithm maximized coverage by selecting exactly 15 optimal sites through iterative optimization. Scenario evaluation across different station counts validated this as the optimal balance between cost and coverage. The results indicate that the identified locations are concentrated in Delhi(NCR), particularly along the major roads. The proposed framework ensures that the infrastructure and tariffs are strategically placed in order to minimize the waiting times and facilitate the transition to electric vehicles in Delhi.

Keywords: electric vehicle; electric vehicle charging station; genetic algorithm; gis-based optimization; traffic congestion

Paper ID: 16001

Exploring Thermoelectric Phenomena in Semiconductor Materials: A Path Towards Efficient Energy Conversion

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ABSTRACT

Thermoelectric phenomena in semiconductor so new materials have risen up as a promising area for sustainable energy preservation and waste heat recovery. With the rising global energy demand and the urgent need to reduce carbon emissions, There has been a lot of interest in thermoelectric materials' capacity to directly convert heat into electrical energy. This study examines the Seebeck, Peltier, and Thomson effects the fundamental ideas of thermoelectric effects in semiconductors as well as the connection between thermal and electrical conductivity in different semiconductor materials. The figure of merit (ZT), material optimization methods, and developments in nanostructured semiconductors are covered in detail. The paper also highlights how group engineering, confinement of quantum particles, and material doping can improve thermoelectric efficiency. Additionally, a study is conducted of contemporary applications in renewable power generation, automotive waste heat recovery, and microelectronics cooling.. The findings indicate that semiconductor-based thermoelectric devices can are essential to the creation of upcoming renewable energy technologies.

Keywords: *Thermoelectric Effect , Seebeck Effect, Peltier effect, Semiconductor Materials, Energy Conversion, Nanostructures, Figure Of Merit, Waste Heat Recovery.*

Microstructure and Pit Statistics of 316L (As-received / Annealed / Quenched) Before and After 65 Hours of Neutral Salt Spray Exposure

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ABSTRACT

Austenitic stainless steel 316L is extensively used in chloride-laden environments where wet-dry cycles promote pit formation and initial microcracking; however, effective microstructure-sensitive screening instruments for early-life damage are still scarce. We provide salt-spray exposure as a swift QA/QC proxy to connect heat-treatment condition with pit stability and repassivation, using portable microscopy and straight forward measurements. Examining how the microstructural state of AISI 316L (as-received, solution-annealed, quenched) influences early-life surface damage after 65 hours of neutral salt-spray exposure, utilizing plan-view SEM/EDS metrics that are directly applicable to QA/QC. Approaches. Coupons in every state were subjected to ASTM B117 neutral salt-spray testing (35 °C, 5 wt% NaCl). Post-exposure surfaces were photographed using a fixed magnification ladder; we assessed pit areal density, maximum equivalent diameter, and projected crack length per region, and mapped damage to microstructural heterogeneities (δ -ferrite traces, MnS/oxide inclusions, grain boundaries/twins). EDS validated matrix chemistry and examined deposits/products. Outcomes. In comparison to the baseline, annealed 316L exhibits a reduced number of sustained metastable pits and a shorter projected crack length per area, which aligns with improved repassivation associated with clean boundaries and a high $\Sigma 3$ twin fraction; the quenched material inhibits sensitization pathways and restricts grain boundary-anchored pit strings, yet pit nucleation transitions towards inclusion- and slip-emergence sites. Chloride-rich residues are found at machining flaws and inclusions in various circumstances. Fracture-fresh planes seldom contain Cl, highlighting the necessity for plan-view chemistry analysis. Effect. The paper provides a replicable procedure (field-of-view selection, thresholds, uncertainty budget) and microstructure-informed acceptance criteria for 316L, facilitating the prediction of mechanical penalties without the need for further tensile testing. Contribution. We offer standardized descriptors for pits and cracks and demonstrate how heat treatment influences pit stability vs repassivation in molybdenum-bearing austenitic steel applicable to coastal hardware, process piping, and energy systems.

Keywords: *Microstructure, Pits, saltspray, SS316L*

Extraction and quantification of persistent organic pollutants in sediments

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ABSTRACT

Persistent Organic Pollutants (POPs) are a major global concern due to their toxicity, bioaccumulation potential, and long-range environmental transport. Sediments act as long-term sinks for these pollutants, making their extraction and quantification essential for evaluating ecological risks and supporting environmental management. The present study focuses on the systematic extraction, identification, and quantification of selected POPs from sediment samples collected from identified aquatic environments. Standardized analytical techniques, including Soxhlet extraction and solid-phase extraction (SPE), were employed to ensure efficient isolation of target pollutants. Quantitative analysis was conducted using Gas Chromatography–Mass Spectrometry (GC-MS), providing high sensitivity and accuracy. Results indicate notable spatial variations in POP concentrations across sampling locations, reflecting the impact of anthropogenic activities and local hydrodynamic conditions. This study offers critical insights into the environmental fate and distribution of POPs and underscores the necessity of continuous monitoring to protect aquatic ecosystems. The outcomes are expected to aid policymakers and environmental agencies in designing effective pollution control and sustainable water resource management strategies.

Keywords: *Persistent Organic Pollutants, Sediments, Extraction, Quantification, GC-MS, Environmental Monitoring*

Machine Learning Driven Temperature Control: Advancing Automation in Modern Chemical Plants

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ABSTRACT

Temperature control is a critical operational requirement in chemical plants, directly influencing reaction selectivity, product quality, equipment safety, and energy efficiency. Conventional PID based control often struggles to maintain stable operation under strong nonlinearities, time-varying conditions, and unmeasured disturbances. This paper presents a data-driven framework applying machine learning (ML) techniques including gradient boosting regression (GBR), long short-term memory (LSTM) networks, and reinforcement learning (RL) to temperature control in representative chemical-process units. A validated CSTR simulation and historical plant data (reactor and heat-exchanger loops) are used to train predictive models and evaluate ML augmented control strategies. Results show that LSTM based predictive control and RL policies offer significant reductions in error indices and energy usage compared with classical tuning. Practical aspects such as data quality, integration into DCS/PLC platforms, and safe deployment are also discussed.

Keywords: *machine learning, temperature control, CSTR, heat exchanger, MPC, reinforcement learning, process control*

INDUSTRIAL WASTE AS AN ALTERNATIVE FOR CLAY BRICKS- A FEASIBILITY STUDY

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ABSTRACT

Conventional burnt clay brick is the most widely used building material. Since ancient times, these bricks have been used for the construction of buildings and other civil engineering structures. The main issue associated with the burnt clay bricks is their production process. Burnt clay bricks are produced from clay, which is normally obtained from agricultural fields. The extensive use of this clay for brick manufacture causes erosion of the top layer of fields. The manufacturing process of clay bricks involves molding the bricks, followed by their burning in a kiln. For burning bricks in a kiln, coal is typically used as the fuel. This burning produces harmful greenhouse gases, leading to environmental pollution. On the other hand, due to industrial growth, a huge amount of waste is generated. If this waste material is disposed of improperly, it causes land pollution, water pollution, and even a decline in air quality. The proposed study aims to develop an eco-friendly and sustainable alternative to burnt clay bricks, thereby reducing pollution associated with burnt clay bricks and industrial waste. In this work, sugarcane bagasse ash (SCBA) a byproduct from the sugar industry is employed as a replacement for clay, along with cement, sand, and Gypsum, a byproduct of the fertilizer industry, as binding and filler materials. Experimental investigations were conducted to assess the physical and mechanical properties of the waste mix developed, including compressive strength, water absorption, durability, and density. The results indicate that the material has the potential to be used as a replacement for conventional bricks.

Keywords: Clay bricks; Industrial waste; Bagasse ash; Gypsum; Eco-friendly bricks

AI IN ARCHITECTURE

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ABSTRACT

Artificial Intelligence (AI) is transforming the architecture, engineering, and construction (AEC) industry by redefining how projects are conceived, executed, and maintained. In the design stage, AI-based generative systems enable architects and engineers to explore optimized design alternatives by simultaneously evaluating structural integrity, material efficiency, energy performance, and cost factors. Machine learning techniques further enhance design intelligence by analyzing historical project data to anticipate performance outcomes and minimize design conflicts. The integration of AI with Building Information Modelling (BIM) facilitates automation, clash detection, and iterative design improvement, allowing professionals to focus on strategic and creative problem-solving. During construction, AI contributes to more efficient project management through predictive analytics that identify potential schedule deviations, budget constraints, and safety concerns. Computer vision systems enable continuous site surveillance, ensuring quality assurance and compliance with regulations. The adoption of autonomous and semi-autonomous machinery, guided by AI algorithms, enhances precision, reduces operational errors, and improves resource utilization. AI-driven logistics and supply chain optimization further support sustainable construction practices. In the operational phase, AI-based building management systems dynamically regulate energy consumption, indoor environmental quality, and occupant comfort through adaptive control algorithms. Predictive maintenance models and digital twins, supported by real-time sensor data, enable proactive facility management and extend the lifespan of infrastructure assets. While issues such as data integration, implementation cost, and workforce adaptation persist, AI is emerging as a central collaborator in advancing sustainable, efficient, and intelligent built environments.

Keywords: *Artificial Intelligence, Digital Transformation, Design Optimization Building Information Modelling, AI-assisted Design Tools.*

FUNCTIONALLY GRADED MATERIALS (FGMs)- A MINOR REVIEW ON FABRICATION METHODS, CLASSIFICATIONS, AND ITS APPLICATIONS

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ABSTRACT

Functionally Graded Materials (FGMs) is one of the advanced composite materials whose composition and properties vary gradually along one or more directions, most preferably through the thickness. FGM was used for the first time in Japan in 1983; FGMs exhibit superior mechanical strength, thermal resistance, and structural reliability compared to conventional composites. These properties make FGM more ideal for high-performance engineering applications such as aerospace, nuclear, and marine structures. The primary objective of this paper is to review and summarize the fundamental aspects of FGMs, focusing on their fabrication techniques, classifications, and diverse engineering applications. A comprehensive literature review approach is adopted, analyzing and comparing various fabrication processes, material gradation models, and performance characteristics. The novelty of this review lies in presenting a concise yet holistic understanding of the evolution, development, and technological relevance of FGMs in modern engineering design. The review highlights that different fabrication methods significantly influence the structural and thermal behavior of FG. It also identifies critical challenges in achieving precise gradation control and suggests directions for improving fabrication efficiency and reliability. FGMs demonstrate immense potential for advanced structural applications due to their tailored material properties. Continued research and innovation in processing techniques can further enhance their performance, sustainability, and adaptability across diverse engineering domains.

Keywords: *functionally graded materials; fabrication; classifications; applications.*

UTILIZATION OF WASTE PLASTICS AS PHASE CHANGE MATERIALS (PCM's): STRUCTURAL AND THERMAL PERFORMANCE EVALUATION

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ABSTRACT

The growing demand for sustainable construction materials has prompted the exploration of alternative solutions that reduce environmental impact while enhancing energy efficiency. This study investigates incorporation of waste plastics as Phase Change Materials (PCMs) in M30-grade concrete to assess their influence on both structural and thermal performance. By re-purposing plastic waste in concrete, the research aims to contribute to resource-efficient and thermally optimized infrastructure. Four concrete mixes were prepared and tested: a control mix (N), and three modified mixes viz. M (melted and crushed plastic mix), P (melted plastic), and C (crushed plastic). Samples were evaluated on Days 3, 7, and 14 for water absorption, rebound number (surface hardness), thermal conductivity, and compressive strength. Results showed that Mix M (melted + crushed plastic) outperformed others with the highest compressive strength of 31 MPa, compared to 26 MPa for the control (N). It also exhibited the highest surface hardness (rebound number 47) and lowest thermal conductivity highlighting superior durability and insulation. Mix C showed the highest water absorption (4.5%) and moderate thermal insulation, but its compressive strength was lower (25–26 MPa). Mix P, composed of only melted plastic, recorded the lowest strength (21 MPa) and the lowest hardness (rebound number 35), indicating poor structural integrity despite some insulation gains. The study concludes that integrating waste plastics into concrete can yield significant structural and thermal advantages when optimally formulated. The combined plastic mix (M) offers the best balance of strength and energy efficiency, while unblended forms (P or C) demonstrate limitations. These findings show the importance of plastic type and mix design in developing sustainable, PCM-enhanced concrete for future infrastructure.

Keywords: Waste plastics, phase change materials, sustainable concrete, thermal conductivity, surface hardness, energy-efficient infrastructure.

Paper ID: 17012

Experimental Investigation on Mechanical Properties of Coconut Shells for Flexible Pavement

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ABSTRACT

The present scientific study experimentally investigated the mechanical characteristics of the coconut shells (CS). The main objective of the present study is to evaluate the performance of the coconut shells for the design of flexible pavement. This study includes the different test conducted on CS to check aforesaid materials is used as a sustainable partial substitute for coarse aggregate in flexible pavement. It includes the aggregate impact value, crushing strength, water absorption, specific gravity, and flakiness index were conducted to assess the mechanical and physical properties. It is found that coconut shell having good compressive strength. The shells are replacing with coarser aggregate materials of fineness modulus is less than 4.75 mm IS sieve. The water absorption and specific gravity of shells is found to be less than 2.0 % & 0.945 respectively, and these materials are best suited for road construction with partial replacement. Therefore, this study validates that coconut shells are more feasible to replace some of the coarse aggregate in the optimize range for sustainable flexible pavement.

Keywords: Coconut shells; flexible pavement; sustainable; coarse aggregate.

Paper ID: 17013

Sustainable Building Block Using Eco-friendly Natural Materials

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ABSTRACT

The main objective of the present study is to develop sustainable building blocks using eco-friendly natural materials such as sand, cement, and bagasse ash. The conventional building blocks primarily rely on cement and sand, which contribute to environmental degradation through high energy use and carbon emissions. To address this issue, bagasse ash an agricultural by product of the sugar industry is used as a partial replacement for cement. In this study, casting of the sustainable block were prepared with varying proportions of bagasse ash at 10%, 15%, and 20%, with three blocks for each mix ratio. The one block from each proportion was tested after 7 days of curing, while the remaining blocks were tested after 14 days. The test were evaluated for compressive strength and water absorption to assess their structural performance and durability. The results indicated that bagasse ash can effectively replace a portion of cement without significantly reducing strength. It enhancing sustainability and reducing environmental impact using sustainable building blocks. This study examines that by incorporating bagasse ash in building block production offers a viable and eco-friendly alternative for sustainable construction.

Keywords: *Building blocks; bagasse; sustainable; performance; eco-friendly.*

Investigating the Use of Treated Water in Concrete as a Part of Green Infrastructure

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ABSTRACT

The main focus of the present study is to treat wastewater from various sources. The increasing scarcity of freshwater resources has prompted the construction industry to explore sustainable alternatives for concrete production. This study investigates the feasibility of using treated water as a partial replacement for potable water in concrete mixing and curing, contributing to green infrastructure development. The research examines the physical and chemical properties of concrete prepared with treated water, investigated on workability, compressive strength, durability, and potential long-term environmental impacts. It ensures that treated water meets quality standards prescribed by relevant codes such as IS 456:2000 and IS 3025. The comparative study indicates that, the treated water can produce concrete with performance characteristics comparable to or even exceeding those of conventional mixes, depending on the level of treatment and the presence of dissolved solids or contaminants. It utilizes treated water not only conserves natural resources but also supports sustainable urban water management practices and reduces environmental pollution. The percentage of the removal efficiency of treating the water is achieved up-to 92%. The findings of current investigation highlight the potential of integrating treated water in concrete as a viable component of green infrastructure and circular construction systems, promoting environmental sustainability without compromising structural integrity.

Keywords: *treated water; sustainable concrete; green infrastructure; water reuse.*

Performance Evaluation of Cement Mortar with Sugarcane Bagasse ash and Coconut Shell Waste as Alternative Construction Material

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ABSTRACT

The construction industry is one of the major consumers of non-renewable resources, which leads to extensive use of natural resources and exponentially causes challenges to sustainability and waste management. The primary resources used in any construction include cement, sand and aggregate, which contribute towards the deterioration of the environment and natural resources. Many studies have been conducted to find the replacement of these resources via agricultural waste such as sugarcane bagasse, bricks and recycled concrete aggregate, leading to the utilisation of waste materials, which can be used as a replacement for cement, sand and aggregates. This study focuses on the mechanical performance and fresh properties of cement mortar with the partial replacement of cement with sugarcane bagasse ash (SCBA) and sand with coconut shell waste (CSW) in cement paste in the proportion of 5%, 10%, and 15% with SCBA and 50 % replacement of sand with CSW in the interval of 3rd, 7th and 28th day hydration period. The initial and final setting times of the mortar lead to a delay in the setting time, suggesting morphological changes in the cement mortar, and the compressive strength overall increased till the 10% replacement and decreased with further replacement of the cement due to decreased pozzolanic properties in the replacement of sugarcane bagasse. Overall, the study highlights the potential of combining SCBA and CSW as sustainable alternatives in cement mortar, contributing to waste utilisation and environmental conservation.

Keywords: Sugarcane Bagasse Ash, Coconut Shell Waste, Fine Aggregate Replacement, Compressive Strength

Mechanical and Hydrological Performance of LC3-Based M25 Pervious Concrete Incorporating Polypropylene Fibres

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ABSTRACT

Pervious concrete has a sustainable pavement material due to its high permeability and ability to reduce surface runoff. However, its relatively low strength limits broader structural applications. Recent research on Limestone Calcined Clay Cement (LC³) offers potential improvements because of its enhanced packing density, reduced clinker demand, and superior long-term performance. This study investigates the feasibility of using LC³ as a binder in M25-grade pervious concrete and compares its behaviour with conventional OPC. The primary objective of this work is to evaluate the influence of LC³ on key engineering properties water absorption, compressive strength, and infiltration rate along with the effect of polypropylene fibres at various dosages. The methodology involves preparing pervious concrete mixes using OPC and LC³, testing water absorption, 7- and 28-day compressive strength, and conducting infiltration testing. The novelty lies in generating combined mechanical and hydrological performance data for LC³-based pervious concrete, which is scarcely reported in literature. Results show that LC³ mixes exhibit higher compressive strengths compared with OPC indicating better binder performance. Water absorption of LC3 mixes remains comparable but slightly lower than OPC at fibre dosages above 0.2%. Infiltration rates remain high (>740 mm/hr), confirming that LC³ does not compromise permeability.

Keywords: LC3 concrete; Pervious concrete; Infiltration rate; Compressive strength

Experimental Study on Partial Replacement of Coarse Aggregate with Mangalore Tiles in Concrete

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ABSTRACT

The conventional production of concrete relies heavily on natural aggregates, contributing significantly to resource depletion, high energy consumption, and environmental degradation. Simultaneously, the improper disposal of large volumes of construction and demolition waste, such as Mangalore tiles prevalent in South India, creates substantial environmental hazards. This paper focuses on addressing these sustainability challenges by investigating the potential of substituting natural coarse aggregate with crushed Mangalore tiles, which are lightweight and possess suitable physical properties. The main objective is to assess the impact of this replacement on the fresh and hardened properties of concrete. The experimental methodology involves testing concrete mixes with coarse aggregate replacement levels of 0%, 10%, 20%, and 30% by weight. Performance is evaluated using slump and compacting factor tests for workability, and compressive strength is measured at 7, 14, and 28 days, alongside monitoring of durability parameters like water absorption and density. The study aims to establish an optimal replacement level that maintains comparable quality and workability to conventional concrete, thereby achieving the dual benefits of waste mitigation and material cost reduction, ultimately advancing eco-friendly and economic development practices.

Keywords: *Mangalore tile aggregate; Coarse aggregate replacement; Compressive strength; Sustainable concrete.*

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Torsional Behaviour of Reinforced Concrete Beam Retrofitted with Externally Bonded Basalt Fiber Reinforced Polymer

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ABSTRACT:

Externally bonded fiber-reinforced polymers (FRP) are becoming increasingly popular for strengthening reinforced concrete (RC) beams due to their excellent strength-to-weight ratio, corrosion resistance, and ease of installation. This research investigates the effectiveness of externally bonded basalt fiber-reinforced polymer (BFRP) in increasing the structural performance of RC beams. BFRP is a novel material that has superior mechanical properties, environmental resistance, and cost-effectiveness compared to standard carbon and glass FRPs. The work comprises experimental tests on the torsional behavior of RC beams modified with BFRP sheets. The effectiveness of BFRP retrofitting is evaluated using essential parameters such as bond strength, load-carrying capacity, deflection behavior, and failure modes. The wrapping is done for single layer using bi-directional fiber sheet. The experimental study involves the confinement of reinforced concrete beams of M40 using basalt fiber reinforced polymer to check its adequacy for its torsional behavior. An experimental research was conducted for fifteen small scaled beams. The beam is 1500mm in total length and 300mm by 150mm in dimension.

Keywords: *Externally bonded fiber, basalt Fiber, Torsional behavior, Retrofitting, Angle of twist*

Comparative Study of Infiltration Using Horton's Model

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ABSTRACT

The hydrological cycle depends heavily on infiltration, which has a direct impact on surface runoff production, groundwater recharge, and the general effectiveness of water resource management systems. Understanding infiltration behavior is particularly crucial in dry and water-stressed areas like India, where soil characteristics have a significant impact on agricultural productivity and irrigation planning. In order to demonstrate how soil texture, structure, and permeability affect infiltration dynamics, this study compares the infiltration properties of murum and black cotton soil using Horton's infiltration model. The Double-Ring Infiltrometer method was used in a controlled field experiment in the Kopargaon area of Maharashtra to measure the temporal variation in infiltration rates. Regression analysis was used to determine the parameters of Horton's empirical model, which allowed for an accurate depiction of infiltration decay over time for both types of soil. Comparative analysis showed clear variations in infiltration behavior, with black cotton soil showing slower rates because of its fine-grained, swelling nature and murum showing a comparatively higher infiltration potential because of its coarser texture. In addition to offering helpful insights for enhancing irrigation efficiency, soil management techniques, and sustainable water resource planning, the results validate the applicability of Horton's model for forecasting infiltration processes in contrasting soil types. All things considered, the study backs the creation of hydrological models tailored to a given area, which improves agricultural and environmental decision-making.

Keywords: *water resource management, murum soil, infiltration properties, Horton's model, and black cotton soil.*

PLANNING AND FABRICATION OF RAINFALL SIMULATOR TO STUDY RUNOFF CHARACTERISTICS

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ABSTRACT

Rainfall is a key factor in hydrological processes such as infiltration, runoff, and soil erosion, but its uneven and unpredictable nature develops conditions unfavorable for controlled experiments. The lack of regular rainfall events is a limiting factor for conducting repeatable, accurate hydrological research. The subject of this study was to design and develop an inexpensive rainfall simulator able to realistically reproduce natural rainfall characteristics inside both the laboratory and the field. The next stage in the methodology consists of reviewing models of available simulators, selecting acceptable materials like PVC pipes, pumps, and nozzles, and fabricating a portable prototype. Calibration and tests of the rainfall simulator were performed to measure rainfall intensity, drop size, and spatial uniformity to ensure realistic performance. Results show that the simulator achieves high uniformity, adjustable rainfall intensity, and controlled drop distribution to effectively reproduce natural rainfall patterns. Experimental validation showed that simulated rainfall is close to natural parameters, and therefore it can be applied in studies related to soil erosion, infiltration, and surface runoff. Finally, a portable, scalable, and economic solution for hydrological research has been developed with the simulator described here, contributing to sustainable water and soil management practices (SDG 6: Clean Water and Sanitation, SDG 13: Climate Action, and SDG 15: Life on Land).

Keywords: hydrological studies; infiltration analysis; rainfall simulator; soil erosion; sustainable design

EVAPOTRANSPIRATION MONITORING AND IRRIGATION WATER ACCOUNTING SYSTEM FOR COMMAND AREAS

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ABSTRACT

Efficient and equitable irrigation water management is increasingly vital in the face of growing water scarcity, climate change, and agricultural demand. In canal command areas, where large-scale irrigation systems serve diverse cropping patterns, understanding actual crop water consumption is essential for sustainable planning and operations. This study introduces a comprehensive Evapotranspiration Monitoring and Irrigation Water Accounting System (ETIWAS), which integrates satellite-based remote sensing, hydrological modelling, and ground-based measurements to provide real-time insights into water use dynamics. The system estimates actual evapotranspiration (ETa) a key indicator of crop water uses by applying surface energy balance models such as SEBAL (Surface Energy Balance Algorithm for Land) or METRIC (Mapping Evapotranspiration at high Resolution with Internalized Calibration), using imagery from satellites like Landsat-8, Sentinel-2, and MODIS. Meteorological inputs such as solar radiation, wind speed, humidity, and temperature are obtained from automated weather stations to improve model accuracy. These ETa estimates are then integrated with irrigation water delivery data from canal flow records or SCADA systems to evaluate water use efficiency, detect mismatches between supply and demand, and identify operational inefficiencies. A case study was conducted in a representative canal command area to demonstrate the system's effectiveness in guiding irrigation scheduling and detecting spatial heterogeneity in crop water use. Results revealed significant variation in water use patterns across the command area, highlighting opportunities for better targeting of water resources and improved equity in water distribution. The system also facilitated performance benchmarking of distributary canals and informed real-time decision-making for irrigation managers. By providing actionable insights through user-friendly dashboards and GIS-based visualizations, the ETIWAS contributes to data-driven irrigation management, promotes water conservation, and supports policy development for climate-smart agriculture. The study underscores the potential of remote sensing and integrated monitoring systems in transforming traditional irrigation governance into a transparent, accountable, and adaptive water management framework.

Keywords: *Estimates crop water requirements (ETa), irrigation scheduling, canal operation planning, equity in water distribution, data-driven irrigation management, climate-smart agriculture.*

Application of Oyster Shell Powder in partial replacement of cement in concrete

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ABSTRACT

The oyster shell is a residue rich in calcium carbonate, which can be reused as a raw material for preparation of building materials. So this study focuses on the partial replacement of cement by oyster shell powder in concrete. The objective of this study is to reduce environmental impacts caused during preparation of cement, to reduce carbon footprints and also to minimize pollution caused by shell waste and promote eco-friendly construction practices. In this experiment concrete mixes were prepared with varying proportions of OSP of 10%, 20% and 30%, replacing by weight by maintaining constant w/c ratio and mix proportions. The concrete cubes were tested for 7, 14, 28-day compressive strength, and the results were compared with the conventional mix. The findings indicated that the compressive strength decreases gradually with an increase in the percentage of oyster shell powder. The optimum result was observed at 10% replacement, where the compressive strength was found to be 20.25 MPa, which is satisfactory for light construction applications. The study concludes that the use of oyster shell powder as a partial replacement of cement provides an effective solution for waste management, resource conservation, and sustainable development in the construction industry. It also demonstrates the potential of converting marine waste into useful construction material, thereby contributing to green and economical concrete production.

Keywords: *oyster shell powder; reduce carbon footprints; partial replacement; compressive strength.*

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CLIMATE RESPONSIVENESS AND VĀSTUŚĀSTRA: A CRITICAL SYNTHESIS AND SYSTEMATIC LITERATURE REVIEW FOR CONTEMPORARY RESIDENTIAL ARCHITECTURE

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ABSTRACT

Literature review of fifty academic studies done by scholars are studied and analysed to find out the relationship between modern sustainable, climate responsive design and Vāstuśāstra principles, the ancient Indian science of designing a built environment, in a hybrid systematic way, is presented in this paper. The research papers that are identified for this study are published between 2006 to 2024. The main body to review the research paper is divided into five main thematic domains that are - orientation of the built environment and sun-path, thermal comfort and passive cooling techniques, ecological and material balance, psychological well-being and technological adaptations. With the limitations of getting empirical confirmation of contemporary architectural practices, the study shows that Vāstuśāstra symbolizes fundamental ecological intelligence with climate responsive design. This study shows a growth in academic thinking away from psychological perspective and towards evidence supported assessment of environmental and spatial based outcomes. On the basis of these observations this paper gives a conceptual framework combining Vāstuśāstra principles and quantifiable sustainability indicators, reinterpreting Vāstuśāstra as a culturally relevant but scientifically flexible structure for contemporary architectural designing.

Keywords: *Vāstuśāstra, Indian traditional knowledge, Sustainability, bioclimatic design, thermal comfort, residence designing and ecological harmony.*

Paper ID: 17044

Design of Flexible Pavement Mixes using Waste Plastic, Fly Ash and Bakelite

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ABSTRACT

Flexible pavements are most commonly used type of pavement in India. Rapid urbanization and industrial growth led to have significant environmental challenges including non-biodegradable waste which is plastic. Bakelite, a durable and strong material commonly sourced from item like cooker handles possesses properties like aggregate which is used in flexible pavement. Fly ash is a fine, powdery byproduct resulting from combustion of coal from thermal power plant. In this investigation, an attempt has been made to solve the problem of environmental pollution and preparing sustainable flexible pavement mixes. In this work, a pavement mix solution is developed to modify the properties of flexible pavement mixes by adding high-density polyethylene in 0%, 5%, 10%, 15 %, and 20% by weight, replacing the bitumen quantity, adding fly ash in 0%, 2%, 4%, 6 %, and 8% by weight and partially replacing aggregate by Bakelite in 0%, 5%, 10%, 15 %, and 20%. Till today, many researchers have worked to enhance the quality of pavement mixes by using these three materials separately. In this research we have added all these three materials together to form sustainable and strong flexible pavement mixes. In this work, innovative solutions are developed and tested to determine its suitability for the pavement. We have obtained desirable result at plastic at 5%, fly ash at 2% and Bakelite at 10%. From this investigation, it is found that the prepared mix is very good for design of flexible pavement. Detailed investigations and results are presented in this research paper.

Keywords: *Flexible pavement; sustainable; Bakelite aggregate; fly ash; High Density Polyethylene.*

Paper ID: 17046

VEHICLE DENSITY ANALYSIS FOR AHILAYNAGER MAMNAD HIGHWAY

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ABSTRACT

Transportation infrastructure serves as the backbone of socio-economic development, influencing trade, mobility, and regional growth. In India, highways play a vital role in connecting rural and urban cankers, carrying nearly 80% of passenger traffic and 65% of freight movement. The Ahilaynager–Manmad Highway is one such crucial corridor supporting agricultural, commercial, and residential connectivity in the region. However, the rapid increase in mixed traffic—comprising two-wheelers, light motor vehicles, buses, trucks, and multi-axle vehicles—has led to congestion, road safety challenges, and accelerated pavement deterioration. This study aims to analyse the vehicle density patterns, axle load distribution, and traffic composition on selected stretches of the Ahilaynager–Manmad Highway. Traffic data were collected through continuous CCTV surveillance and manual field observations over a period of three months. The collected data were processed and classified according to vehicle type and time intervals to evaluate hourly variations in traffic flow. The analysis revealed that during peak hours (6:00–9:00 AM and 5:00–8:00 PM), traffic volume exceeds the design capacity recommended in IRC:64-1990 and IRC:106-1990, resulting in severe congestion and reduced service levels. The dominance of two-wheelers and light motor vehicles during morning hours and heavy commercial vehicles in the evening hours contributes to fluctuating axle loads and uneven pavement stresses. The findings emphasize the urgent need for traffic management improvements, lane widening, pavement strengthening, and segregation of slow-moving and heavy vehicles. Implementation of Intelligent Transportation Systems (ITS) and real-time monitoring could further enhance operational efficiency and road safety. This study demonstrates that a data-driven, IRC-compliant approach provides a reliable framework for sustainable highway capacity planning and long-term performance enhancement of the Ahilaynager–Manmad Highway.

Keywords: *Vehicle Density, Mixed Traffic Flow, Axle Load Analysis, Highway Capacity, Pavement Deterioration,*

Integrated Water Audit for Sustainable Development in Vaijapur and Gangapur region

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ABSTRACT

The growing requirement for water alongside dwindling supplies necessitates implementation of sustainable management practices for water, especially in fast-developing cities such as Vaijapur . This work presents an integrated water audit across the Vaijapur Municipal Council's audit covers both quantitative and qualitative studies, such as source sustainability, distribution efficiency, patterns of consumer demand, and wastewater recycling potential. Field surveys, meter readings, inspections of infrastructure, and stakeholder consultations provided the data. The results show high inefficiencies in the existing system, such as high levels of non-revenue water, leakages, and poor wastewater treatment. Recommendations are the installation of smart metering, leakage control schemes, rainwater harvesting, greywater reuse, and community outreach programs. This holistic approach not only guarantees more efficient and equitable utilization of water resources but also contributes to the long-term sustainability and resilience of water infrastructure in Vaijapur.

USE OF HIGH-STRENGTH RMC CONCRETE WASTE SLURRY AS A REPLACEMENT TO CEMENT SLURRY IN NORMAL-STRENGTH CONCRETE

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ABSTRACT

The rapid expansion of the construction industry has led to an increase in demand for concrete, resulting in higher production at ready-mix concrete (RMC) plants. Consequently, a significant amount of waste slurry is generated. This slurry, primarily composed of fine cementitious particles and inert materials, poses serious environmental hazards if improperly managed, including water contamination, soil degradation, and material wastage. This study examines the feasibility of recycling RMC waste slurry as a partial substitute for cement slurry in M20-grade concrete.

In this experimental work, an attempt has been made to collect high-grade (M40) RMC slurry, characterising its physical properties, and incorporating it into concrete mixes at different replacement levels (5% to 20%). Compressive strength tests were conducted on both waste slurry and modified concrete cubes to evaluate the performance. The results are benchmarked against conventional M20 concrete designed as per IS 10262:2019. The findings of this study aim to identify the optimal replacement ratio that maintains structural integrity while promoting sustainable construction practices.

Keywords: Ready-mix concrete (RMC) waste slurry, Material Testing, Conventional M20 concrete design, Cube casting, Compressive strength tests

Keywords: Ready-mix concrete (RMC) waste slurry, Material Testing, Conventional M20 concrete design, Cube casting, Compressive strength tests

Experimental Study of Yield Line Patterns of Slab with Different Shapes and End Conditions

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ABSTRACT

Designing two-way slabs under uniformly distributed load is one of the challenges in designing the structures. However plastic method can be the best method for designing such cases. The paper mainly focused on the experimental study of different slab conditions to check the yield lines under uniformly distributed load. To verify the analytical results experimentally, RC slab subjected to uniformly distributed load with six panels having dimensions 1200 x 1000 x 70 mm and other six having dimensions 1000 x 1000 x 70 mm by changing support conditions. Experimental test setup is made, load is applied with the help of jack and point load is converted into uniformly distributed load by using arrangement as shown below. Actual and theoretical moment of resistance for different slab conditions is related along with Margin of safety and Margin of Serviceability. Also yield line patterns for different slab conditions are observed. Experimental results are discussed and compared with theoretical.

Keywords: *Uniformly distributed load, Plastic method, Yield lines, RC slab, Moment of Resistance,*

Margin of safety and Margin of serviceability.

Suitable Matrix for Pothole Solution

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ABSTRACT

Potholes are the current issue on the highway roads which leads to inconvenience and safety concerns related to the drivers. The traditional repair methods using regular concrete or bituminous materials can be slow and will not be efficient for long lasting. The use of geopolymer concrete offers a faster and more durable solution than that of conventional one. It is made by combining fly-ash with alkaline solutions like sodium hydroxide (NaOH) and sodium silicate (Na₂SiO₃). This mixture reacts to form a strong, quick-setting material that can fill potholes effectively. In addition to the aforesaid solution with coconut fiber, which are natural and biodegradable, further enhances the geopolymer concrete's compressive strength and flexural strength. These fiber help to prevent cracks and improve the overall durability of the repaired portion. Using geopolymer concrete reinforced with coconut fiber not only speeds up road repairs but also recycles industrial and agricultural waste, making it an eco-friendly material in forthcoming days.

Keywords-*Fly ash, Geopolymer concrete, Alkaline solutions, Coconut fiber, Mechanical Strength.*

A REVIEW OF COMPUTATIONAL MODELS AND DESIGN STRATEGIES FOR ENHANCING BLAST RESISTANCE IN MEDIUM- RISE BUILDINGS

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ABSTRACT

The increasing vulnerability of medium-rise buildings to blast-induced threats has become a pressing concern in urban safety, especially in densely populated areas. These buildings, typically ranging from four to twelve stories, are exposed to unique challenges due to their structural complexity and urban setting. This review explores the importance of blast-resistant design strategies and the role of computational models, particularly Finite Element Modeling (FEM) and hydrocode simulations, in predicting the building's response to explosive forces. These advanced techniques allow for a detailed analysis of stress distribution, material deformation, and failure points, providing a cost-effective alternative to physical testing. Additionally, the integration of emerging technologies such as machine learning (ML) and artificial intelligence (AI) is transforming blast-resistant design by enabling real-time simulations and dynamic optimization of structural configurations. The paper also highlights the significance of material innovations, including high-performance concrete (HPC), ultra-high-performance concrete (UHPC), and smart materials, which contribute to improved energy dissipation and durability without adding excessive mass. Furthermore, the review discusses the evolving trends toward sustainable and hybrid structural systems that optimize energy absorption while reducing environmental impact. As urban areas grow, it is essential to incorporate these advancements into medium-rise buildings to ensure enhanced resilience against blast events. By adopting these innovative strategies, the safety and sustainability of buildings in blast-prone urban environments can be significantly improved.

Keywords: *Blast resistance, medium-rise buildings, finite element modeling, hydrocode simulations, smart materials, sustainable design.*

A REVIEW ON TRANSPARENT LIGHTWEIGHT CONCRETE BLOCKS INCORPORATING PLASTIC OPTICAL FIBRES AND GRAPHENE

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ABSTRACT

The growing emphasis on sustainable, energy-efficient, and multifunctional construction materials has driven significant interest in transparent lightweight concrete blocks (TLWBs). This review paper comprehensively examines the development and performance of lightweight concrete incorporating plastic optical fibres (POFs) and graphene as advanced reinforcing components. Transparent concrete enables the transmission of natural and artificial light through cementitious matrices, thereby reducing dependence on artificial lighting and enhancing architectural aesthetics. The use of POFs, as opposed to conventional glass fibres, offers advantages such as flexibility, ease of handling, reduced brittleness, and cost-effectiveness while maintaining adequate light transmittance and mechanical integrity. In parallel, graphene, a high-performance nanomaterial, acts as an effective nano-reinforcement by refining the microstructure, enhancing hydration, improving interfacial bonding, and significantly increasing compressive and flexural strength, durability, and crack resistance. This review synthesizes existing research on material composition, fabrication techniques, optical and mechanical performance, and sustainability benefits of TLWBs integrating POFs and graphene. Key challenges, including uniform fibre distribution, optimal graphene dosage, fabrication complexity, and cost constraints, are critically discussed. Overall, the synergistic integration of POFs and graphene presents TLWBs as promising candidates for smart, lightweight, and energy-efficient construction applications in modern and sustainable architecture.

Keywords: *Occupational Health, Occupational Safety, Employee Wellbeing, IT Industry, India, Workplace Stress, Ergonomics.*

AI-DRIVEN RESOURCE ALLOCATION AND SCHEDULING FOR SMART CONSTRUCTION PROJECTS

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ABSTRACT

The construction industry faces persistent challenges, including low productivity and high rates of project delays and cost overruns, largely due to its manual processes and resistance to digital transformation. Traditional scheduling and resource allocation methods (like CPM and PERT) are often inadequate for managing the dynamic uncertainties of modern projects. This review addresses the critical need for more adaptive solutions by investigating the paradigm shift towards AI-driven resource management. This paper systematically reviews the integration of Artificial Intelligence (AI) and Machine Learning (ML) techniques—including predictive analytics, optimization algorithms, and hybrid frameworks—to enhance project efficiency. Researcher analyze the applications of AI in improving scheduling accuracy, forecasting resource demands (labor, materials), and mitigating risks in real-time. The review highlights the crucial synergy between AI and enabling technologies like BIM, IoT, and Digital Twins, which establish the foundational ecosystem for smart construction. While affirming the transformative potential of these technologies in promoting sustainability and project performance, we also consolidate the major barriers to adoption, such as data quality and integration challenges. The study concludes by identifying key research gaps and proposing future directions toward developing highly resilient and automated construction management systems.

Keywords: *Artificial Intelligence, Resource Allocation, Smart Construction, BIM, Optimization.*

A-STATE-OF-THE REVIEW ON BEHAVIOUR OF STEEL MEMBERS SUBJECTED TO COMBINED ACTIONS

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ABSTRACT

In recent construction, steel structures are used in almost every type of structure. e.g. Multi-storeyed frames, Gantry Girders etc. Due to transverse and lateral loads, members in a structure are subjected to various actions simultaneously. For example, column in a ground storey of a multi – storeyed frame or member in an unsymmetrical frame may be subjected to combined actions of M-P (Moment – Axial Thrust), M-V (Moment – Shear), M-V-P (Moment – Shear – Axial Thrust), and M-V-P-T (Moment – Shear – Axial Thrust – Torsion). Many researchers have studied combined effect of M-P and M-V. It is also included in IS Codal provisions. Few research is available on M-V-P and it is available in some of the International Codal provisions. However, very less research is available for the structures subjected to combined action of M-V-P-T. The present study considers behavior of member subjected to M-V, V-P, P-T and M-T and its comparison from Indian, British, American, Australian and Euro Codal provisions.

Keywords: *combined actions, moment – axial thrust, moment – shear, moment – shear – axial thrust, moment-shear-axial thrust - torsion*

ENVIRONMENTAL AND TRAFFIC DISRUPTIONS DURING METRO CONSTRUCTION: EFFECTS ON ROAD USERS

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ABSTRACT

The construction of metro rail systems, while essential for improving urban transportation, significantly contributes to roadside environmental pollution. This study examines the impact of metro rail construction on air quality and traffic congestion, focusing on pollutants such as particulate matter (PM_{2.5} and PM₁₀), nitrogen oxides (NO_x), sulfur oxides (SO_x), carbon monoxide (CO), and the Air Quality Index (AQI). During construction activities like excavation, tunneling, and heavy vehicle movement, pollutant concentrations rise significantly in nearby areas, exacerbating roadside pollution. The study utilizes field measurements and traffic flow analysis to quantify the direct and indirect environmental impacts of metro construction, revealing elevated levels of PM and gaseous emissions that worsen air quality. Furthermore, traffic congestion, caused by construction-induced lane closures and diversions, intensifies vehicular emissions, leading to higher pollution levels in affected zones. The findings underscore the importance of implementing effective mitigation strategies such as dust suppression, traffic management, and waste handling to reduce pollution during construction. The study highlights the need for balancing the long-term environmental benefits of metro systems with the short-term challenges posed by their construction, providing recommendations that align with Environmental Protection Agency (EPA) standards for air quality management.

Keywords: *Metro rail construction, Roadside pollution, Air quality, Noise pollution, Carbon emissions, Sustainable urban development.*

STUDY ON PARTIAL REPLACEMENT OF FINE AGGREGATE IN CONCRETE WITH LOW DENSITY POLYPROPYLENE AND CEMENT WITH FLY ASH

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ABSTRACT

These days, there's a growing interest in the creation of environmentally friendly products. Burning older, harder anthracite and bituminous coal to produce fly ash is known as the basic industrial waste, and the result is usually Class F fly ash. There is less than 10% lime (CaO) in this pozzolanic fly ash. The primary causes of the startling rise in plastic pollution are careless design, inappropriate disposal, and unsustainable throwaway behaviors. Thus, it becomes necessary to direct the used plastic bottles toward their best use. Low-Density Polypropylene Plastic (LDPP) is a thermoplastic polymer composed of long chains of ethylene monomers. For the next generation of environmentally sustainable concrete constructions, a partial replacement of aggregates is required. The depletion of the natural resources gets exhausted. In the current project, LDPP plastic is used to partially replace the fine aggregates and fly ash with cement. The ideal strength values for compression, split tensile, and flexure were achieved at 16% fly ash replacements of the fly ash with cement and 12% LDPP with partially replacing the fine aggregates. When we raise the percentage of fly ash and LDPP, the mixture's workability first rises and then falls in the concrete's workability. The results showed that the compressive strength, split tensile strength and flexural strength increases with the adding of the fly ash and LDPP.

Keywords: LDPP (Low-Density Polypropylene plastic), FA (Fly ash), workability, compressive strength, Split Tensile strength, Flexural strength.

Predictive Analysis of Construction Project Delays Using Machine Learning Integration with Building Information Modelling

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ABSTRACT

By integrating machine intelligence with Building Information Modeling (BIM) software, this research introduces an innovative approach to proactively identify and mitigate delays in construction projects. The proposed methodology entails leveraging AI algorithms to analyze discrepancies between real-time progress captured through photos or videos and the planned activities outlined in a 4D BIM model. This process enables project managers to swiftly detect potential delays and make informed decisions to optimize project timelines. The utilization of AI in this context represents a paradigm shift in construction project management, offering a proactive strategy to address challenges and enhance overall efficiency. By harnessing machine learning algorithms, the study aims to enhance the accuracy of project timetable forecasts, empowering stakeholders to preemptively address issues before they escalate into significant delays. The implications of this research extend beyond individual construction projects, potentially revolutionizing the field of building information modeling (BIM) and project management practices within the construction industry. By providing a data-driven approach to anticipate and mitigate delays, the findings of this study have the potential to streamline project execution, minimize cost overruns, and enhance overall project success rates. The integration of machine intelligence with BIM software represents a promising avenue for improving construction project management methodologies. By leveraging AI-driven insights to proactively address delays, this research contributes to the ongoing evolution of BIM practices and has the capacity to significantly impact the efficiency and productivity of construction projects in the industry.

Keywords: *Construction Project Delays, Machine Learning, Building Information Modeling, Predictive Analytics*

AN INVESTIGATIVE ANALYSIS OF CEMENT PARTIAL REPLACEMENT IN CONCRETE BY COMBINING PERLITE AND SUGAR CANE BAGASSE ASH

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ABSTRACT

Cement has the largest steps when it comes to energy consumption and carbon dioxide emissions of all the concrete ingredients (water, fine aggregates, additives that make up cement), so reducing the content of cement concrete is one of the ongoing issues of 21st-century global sustainability. Sugarcane, the greatest sugar crop in the world, is a hot, humid plant. Powdered perlite is a porous, light substance that is derived from volcanic glass. It's made by rapidly heating raw perlite ore to about 1600°F (870°C), which causes the ore to expand and release a lot of tiny bubbles. Perlite's characteristic lightweight and porous structure are attributed to these bubbles, which also make it a very adaptable material. The waste generated by the industry has accumulated over the years, and it's been dumped immorally leading to environmental problem. The research work here deals with the partial replacement of cement by mass with SCBA and Perlite Powder together. After mixing, casting and curing the characteristic strength of this new concrete are compared with standard concrete of M35 grade. The experimental investigations are administered for compressive strength Split Strength and flexural strength for curing period of 7, 14 and 28 days. The experimental results show that the for a combined replacement percentage of replacement of Perlite Powder 6% & SCBA 12% in cement concrete mix, is show positive results. Workability reduces with increasing % age of SCBA and Perlite Powder. The maximum proportion of replacement has been found by conducting the following strength tests: Compressive strength test, Flexural strength test and Split Tensile Strength Test.

Keywords: *Sugarcane Bagasse Ash (SCBA), Perlite Powder (PP), Pozzolan material, Compressive strength, Flexural strength and Split tensile strength.*

EXPERIMENTAL STUDY ON RAW SUGARCANE BAGASSE ASH FOR ITS UTILIZATION IN MORTAR AS A PARTIAL REPLACEMENT TO CEMENT

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ABSTRACT

Rapid urbanization and increasing construction activities causes growing need to identify alternative and sustainable materials for cement production. Cement manufacturing contributes significantly to CO₂ emissions and depletion of natural resources. Sugarcane bagasse ash (SBA), an agro industrial by product obtained from burning sugarcane waste in sugar mills, has shown pozzolanic properties that make it suitable as a partial replacement for cement in mortar. The study investigate the mechanical and physical properties of mortar using processed SBA as a partial replacement for cement at varying proportions of 0% 10% 20% and 30% by weight. Test such as specific gravity, wet sieve analysis, standard consistency and compressive strength were conducted. The utilization of SBA not only improves sustainability but also reduces environmental pollution caused by the disposal of Bagasse ash. These research supports the feasibility of using sugarcane bagasse as a supplementary cementitious material in mortar production, promoting eco-friendly and cost effective construction practices

Keywords: Sugarcane bagasse ash; sustainable; compressive strength; supplementary cementitious material.

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CHAMOMILE AROMATHERAPY FOR ANXIETY: AN EEG-BASED REVIEW

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ABSTRACT

Over 359 million people in the world have an anxiety disorder. Anxiety is a state of psychological anticipatory dread, characterized by physiological arousal, emotional uneasiness, and behavioral dysregulation. Conventional treatment methods for anxiety, like benzodiazepines, may lead to psychomotor impairment, and Selective Serotonin Reuptake Inhibitors (SSRIs) have been shown to cause sexual dysfunction in some cases. This has led to interest in complementary approaches, such as aromatherapy with essential oils, such as lavender, rosemary, and chamomile. While the studies on lavender's aromatic link with EEG have been prominent, chamomile is relatively underexplored in the realm of aromatherapy, as most of the studies only focus on chamomile with respect to oral consumption. PubMed, Scopus, and Google Scholar were surfed through for a systematic literature search using keywords, such as "chamomile", "aromatherapy", "anxiety", "EEG". Relevant clinical and experimental studies were taken under consideration to assess the efficacy of chamomile as aromatherapy and its subsequent changes in EEG waves. The reviewed studies indicated significant objective and subjective reduction in anxiety, largely attributed to its anxiolytic components like apigenin. However, with neurophysiological findings fundamentally focusing on other essential oils, the EEG-based studies on chamomile aromatherapy have been sparse. The brain waves associated with calmness, such as alpha waves (8-13 Hz) and theta waves (4-8 Hz), show potential decrement in amplitude after chamomile aromatherapy. This is a major area to emphasize when assessing the efficacy of chamomile aromatherapy. This highlights the need for proper neurophysiological analyses on chamomile aromatherapy for future studies.

Keywords: *Anxiety; chamomile aromatherapy; apigenin, neurophysiological analyses; alpha waves; beta waves*

AI-Integrated Biphasic Bioresorbable Fracture Fixation Device

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ABSTRACT

This biphasic biodegradable internal fixation device, intended to increase biological compatibility and mechanical stability for bone repair, is composed of Nanocellulose, hydroxyapatite (HA), and 45S5 bioactive glass. Early, the inner phase forms a strong load-bearing core that keeps the fracture stable throughout the healing process even as the outside permeable layer supports angiogenesis. Natural bone healing coincided with controlled biodegradability and osteogenesis. HA improves osteoconductivity and mineralisation; nanocellulose provides excellent mechanical strength and biocompatibility; and 45S5 bioactive glass promotes ion-mediated bone formation. Apart from physical development, the gadget provides Artificial Intelligence (AI)-assisted solutions for preoperative planning and postoperative recovery evaluation. CNN and Grad Cam is used to classify the fracture type ,the Vision Transformer is used to size and position the implant .Finding the ideal implant shape, placement, and bone- implant contact as well as monitoring of absorption profile using deep learning algorithms on medical pictures. This approach raises precision and thus enhances healing efficiency by allowing patients to get personalized self- resorbing implants that removes superfluous operations. Orthopedic forward: utilizing creative biomaterials together with AI-driven diagnostics.

Keywords: *nanocellulose; hydroxyapatite; magnesium calcium alloy; CNN; Grad Cam; Vision transformer;*

PTSD SUPPORTING DEVICE

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ABSTRACT

A person develops Post Traumatic Stress Disorder (PTSD). If this is left untreated, it may affect all aspects of the person's life. Most of the people who are affected by this disorder donot realise the presence of it as there is lack of devices to detect precisely and diagnose the patients. Also, a supportive device for PTSD is currently not available widely at a feasible cost to people. The main objective of this research is to develop a non-invasive device which detects the disorder as well as helps the patients with interaction and rehabilitation. The method involved is an integration of hardware and software. The hardware contains an EEG band to detect brain signals. A mobile app is developed for this and the brain signals are taken as input and the initial classification of person into normal or PTSD affected is done. Then, a few questions are asked to the patients which help in diagnosing the type of trauma the patient is affected with. Personalized VR simulations are integrated with the app, which generates scenes similar to the traumatic incident to normalize the condition. When the stress levels seem to get increased, the app generates scenes accordingly like meditation, calming music and visuals. Artificial Intelligence will play a major role in asking questions and for generating healing responses. Therefore, this supportive device is designed to support doctors and psychologists who treat patients from far distances and this device will also remove the social stigma of the patients who need to visit therapists often as it can be accessed right at home.

Keywords: *Post Traumatic Stress Disorder; supporting device; rehabilitation*

Exploration of Silicon Wafer Patterning Techniques for MEMS Sensor Fabrication in Healthcare

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ABSTRACT

The evolution of Micro-Electro-Mechanical Systems (MEMS) technology is heavily dependent on precise patterning techniques used for silicon wafers. Silicon wafer patterning is a critical process in the design and development of Micro-Electro-Mechanical Systems (MEMS) sensors. This paper delves into the cutting-edge wafer patterning technologies utilized in MEMS sensor design and manufacture, including photolithography, deep reactive ion etching (DRIE), laser micromachining, and nanoimprint lithography, electron beam lithography (EBL), and galvanic micro contact imprinting lithography (GMIL). Also the paper discusses how key parameters such as feature size, pattern fidelity, alignment, accuracy, and etch depth control affect the functional performance of MEMS devices, particularly in high-sensitivity applications like biomedical sensing. The paper discusses the application of these techniques in creating precise and efficient MEMS sensors, highlighting the advantages and challenges associated with each method. This study explores the intricate process of silicon wafer patterning, a critical step in the design and development of Micro-Electro-Mechanical Systems (MEMS) sensors. The study delves into various patterning techniques, their applications, and the advancements that have propelled MEMS technology to the forefront of modern engineering.

Keywords: *Micro-Electro-Mechanical Systems (MEMS), deep reactive ion etching (DRIE), nanoimprint lithography, electron beam lithography (EBL), galvanic micro contact imprinting lithography (GMIL).*

Occupational Health, Safety and Wellbeing challenges among IT/ITES industry, India

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ABSTRACT

The rapid growth of the Information Technology (IT) industry in India has created immense opportunities but has also introduced significant challenges concerning occupational health, safety, and employee wellbeing. This study explores the main workplace issues that face IT professionals: the risks to their physical health, ergonomics, excessive hours at work, stress related to the job and work-life balance. Primary data was captured through a structured survey with employees at major IT locations, as well as semi-structured interviews with appropriate employees and HR managers to better capture depth of experience. The findings indicate that many IT organizations place nearly exclusive emphasis on productivity and technological change, adding little to the actions and attention they give to occupational health and safety, resulting in significant issues such as musculoskeletal disorders, eyestrain, mental fatigue and burnout. In addition to absent organizational policies or organization awareness of policies to support safety contribute to the stress and lack of wellbeing of employees. Overall, this study indicates the strong need for a developed level of occupational health and safety strategy, support for employees, and proactive initiatives related to wellbeing of their employee population in the IT industry within India. Organizational health and safety approach in the IT industry in India could lead to better healthier workplaces, retention and productivity.

Keywords: *Occupational Health, Occupational Safety, Employee Wellbeing, IT Industry, India, Workplace Stress, Ergonomics.*

Degradation of methylene blue by indium oxide (In_2O_3) nano catalyst

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ABSTRACT

The current study aims to create environmentally friendly indium oxide (In_2O_3) nanoparticles and assess how well they work for the degradation of methylene blue dye. A hydrothermal method was used to synthesize the indium oxide (In_2O_3). The In_2O_3 nanoparticles were characterized using FT-IR, EDS, SEM, TEM, and XRD to determine the catalyst's crystal structure. Data analysis verified the catalyst's crystalline phase formation. The potential of the green synthesized indium oxide (In_2O_3) nanocatalyst for the degradation of dangerous organic dyes, such as methylene blue was examined. The rapid (within 1 to 1.5 h) and nearly total degradation ($\sim 90\text{-}95\%$) was attained because of the small size and high dispersion of nanoparticles. Even after the photocatalyst was used three times, there was no discernible change in the indium oxide (In_2O_3) nanocatalyst photocatalytic activity. All things considered, the green-synthesized indium oxide (In_2O_3) nanocatalyst showed a great deal of promise for the quick and environmentally safe removal of hazardous organic dyes.

KEYWORDS: *Indium oxide (In_2O_3) nanocatalyst, hydrothermal process, degradation, methylene blue dye.*

COMPARATIVE STUDY OF CLASSICAL COMPUTING AND QUANTUM COMPUTING

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ABSTRACT

This paper presents a systematic comparison between classical computing and quantum computing, focusing on their physical principles, computational models, and limits of efficiency. Classical computing is based on classical physics and Boolean logic, representing information in definite binary states and processing it through probabilistic algorithms. Quantum computing is based on quantum mechanics and employs qubits that can exist in superposition and become entangled, enabling computational processes that have no classical analogue. We examine how these differing foundations give rise to distinct computational paradigms, particularly with respect to parallelism, information encoding, and algorithmic complexity. Well-known quantum algorithms illustrate how quantum resources can yield exponential or polynomial speedups for specific problem classes, while also highlighting the constraints imposed by measurement, decoherence, and error correction. Rather than viewing quantum computing as a straightforward extension of classical computing, the analysis emphasizes their conceptual discontinuities as well as their formal connections, such as classical simulation of quantum systems and hybrid computational architectures. The comparison clarifies both the promise and the limitations of quantum computing, showing that quantum advantage is problem-dependent and grounded in physical structure rather than abstract computation alone. This perspective contributes to ongoing debates about the nature of computation, physical realizability, and the role of quantum theory in redefining computational limits.

Keywords: Algorithmic Complexity, *Classical Computing*, *Computational paradigm*, *Entanglement*, *Quantum Computing*, *Qubits*, *Superposition*.

Investigation of Minimum Phase System Response under Pole Motion

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ABSTRACT

Step input signals and their responses are used in control systems analysis and design. The frequency response methods are most powerful in conventional control system. In this paper we discuss the pole motion in Minimum Phase system and Mat-lab based evaluation of corresponding step responses and frequency responses. The different characters of the step response and frequency response are shown in numerical examples. The numbers of figures are presented to explain the concepts. A few illustrated figures are presented to validate the concepts.

KEYWORDS: *Laplace transform, Transfer Function, Step response, Frequency response, Mat-lab*

Paper ID: 20005

Mathematical Modeling of Humidity Transportation and Gravitational Effects in Porous Material

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ABSTRACT

This article deals with study of numerical analysis and simulation of moisture and gravitational effects near the latitude of maximum concentration. This task to comprehend the complex interfaces among atmospheric moisture, gravity and latitude dependent phenomenon. A comprehensive mathematical model is established to simulate the dealings with concerning humidity and gravity. The outcomes are investigated to deliver perceptions into the mechanism dynamic concentration designs. The results demonstrates a gravitational forces and accelerate descendant moisture migration.

Keywords: *Numerical Techniques, Moisture Transport, Gravitational, Gravitational formula*

Paper ID: 20006

Scientific Clarification of Partial Differential Equations by Physics-Informed- Neural Networks (PINNs)

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ABSTRACT

This article study scientific clarification consuming PINNs techniques to resolving partial differential equations. Comparing with traditional numerical method. PINNs leveraging AI knowledge to learn the essential physics of PDEs. Partial differential equations is vital in several fields such as physics, engineering, finance and cognitive sciences. This present task to developing design a neural network and to find out the approximate the solution by PDEs. Consuming current technology to developed model with emerging efficiency and precision using partial differential equation. The majority of researchers and students employ these methods, which are useful for future model development and prediction accuracy.

Keywords: PDEs, Neural Networks, physics, AI, PINNs,

Paper ID: 21002

Review On Web Penetration Testing And Malware Detection

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ABSTRACT

Penetration testing plays a crucial role in identifying security breaches in web applications, while malware detection focuses on recognizing and mitigating malicious software threats. Both are essential areas in cybersecurity. This review examines common web application vulnerabilities, such as SQL injection and cross-site scripting, and highlights key penetration testing tools, including Metasploit, Burp Suite, and Nmap. In malware detection, we discuss traditional signature-based methods alongside modern behaviour-based strategies, emphasizing the growing role of artificial intelligence in enhancing detection capabilities. The paper explores methodologies used in both fields, recent advancements, and future research directions. Key findings indicate a shift towards automation in penetration testing and malware detection, with AI and machine learning significantly improving efficiency and detection rates. Additionally, considerable work on penetration testing and malware detection, clear comparisons of their automation, tool effectiveness, and future directions are still limited. This review addresses these gaps and offers a structured overview of current methods.

Keywords: *Web Penetration, Malware Detection, Web Vulnerability ,Effectiveness and Performance of Tools.*

Paper ID: 21006

VEHICLE THEFT DETECTION AND REMOTE ENGINE LOCKING

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ABSTRACT

Vehicle theft has become a major concern in urban and rural areas, with rising incidents reported across India. Traditional alarm-based systems and GSM-based solutions often fail due to network issues, delays, or lack of instant user response. This project proposes an innovative IoT-based vehicle security system that utilizes the ESP32 microcontroller and the Telegram messaging platform to detect theft attempts, notify the vehicle owner in real-time, and allow remote engine locking through Telegram commands. The system uses a sensor (such as a door or ignition switch) to detect unauthorized vehicle access. Upon detecting suspicious activity, the ESP32 connects to a Wi-Fi network and sends an instant alert via Telegram using a pre-configured bot. The owner can then respond with a command (e.g., "LOCK") to remotely disable the engine through a relay module. A DC motor simulates the engine in the prototype. For enhanced security, a GPS module can be integrated to share the vehicle's real-time location via a clickable Google Maps link. This project offers a cost-effective, internet-enabled, and user-friendly solution to prevent vehicle theft, with the potential for further development such as camera integration, app interface, and voice control.

AI-ENHANCED WEARABLE HEALTH ASSISTANT WITH BIOMETRIC FEEDBACK

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ABSTRACT

Stress, fatigue, and unnoticed health changes often lead to late detection of serious conditions. To address this, we developed an AI-Powered Wearable Health Monitoring System capable of continuously measuring heart rate, SpO₂, body temperature, and motion activity. The system integrates MAX30102, MCP9808, and LIS3DH sensors with a compact XIAO ESP32-S3 microcontroller. Real-time data is uploaded to the Firebase Realtime Database and visualized through a custom Android application that displays live vitals, graphs, and alerts. An integrated AI Chatbot Assistant provides speech- and text-based guidance by analyzing current health readings, especially stress indicators. Testing in resting, walking, and stress-induced conditions showed accurate readings and reliable stress detection. The proposed system offers a low-cost, portable, and user-interactive solution that supports continuous personal health monitoring and early detection of abnormalities.

Keywords: *AI wearable, IoT health monitoring, ESP32-S3, MAX30102, Firebase, SpO₂, stress detection, mobile health application, biosensors, chatbot assistant*

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