THAPAR INSTITUTE OF ENGINEERING & TECHNOLOGY

Thapar International Conference for Student Research (TICSR-2026)

17-18 April 2026 | Hybrid Mode

Book of Abstracts

Organized by:

Student-Led Research Societies

Thapar Institute of Engineering and Technology

Patiala, Punjab, India

MANY PATHS
ONE PURPOSE

Seeking Excellence Together

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Thapar Institute of Engineering and Technology, Patiala, India

Preface

Thapar International Conference for Student Research 2026 (TICSR-2026) is conceived as a dynamic platform to nurture a culture of inquiry, inculcate a strong sense of research, innovation, and enthusiasm for academic excellence among students. In an era defined by rapid knowledge expansion and interdisciplinary engagement, it becomes imperative to equip learners with the skills and perspectives necessary to meaningfully engage with contemporary research trends.

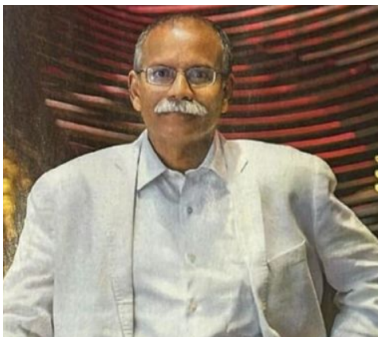
This initiative aims to provide undergraduate students with the opportunity to explore and understand the essentials of research methodology, academic writing, critical thinking, and ethical scholarship, and to express these learnings effectively in their academic papers. By fostering a robust research culture enabled through mentorship, collaboration, and exposure to diverse domains, TICSR-2026 seeks to go beyond classroom learning and encourage engagement with real-world research practices.

Aligned with the principles of the United Nations Sustainable Development Goals (SDGs), TICSR-2026 also emphasizes inclusivity, gender equity, and equal access to academic opportunities. Special attention is given to the integration of Social Sciences, Humanities, Liberal Arts, and Management Studies alongside STEM disciplines, addressing pressing societal challenges such as mental health, environment, and social justice. As an initiative, it aspires to cultivate a generation of responsible researchers and informed citizens. It not only enhances academic competence but also contributes to building a socially conscious and research-oriented academic community.

It is hoped that this pure-intentioned initiative will serve as a springboard for intellectual growth and innovation, enabling young minds to contribute meaningfully to society.

- Team TICSR-2026

From the Desk of the Vice-Chancellor



I am delighted to present the Book of Abstracts for the Thapar International Conference for Student Research 2026 (TICSR-2026). This volume captures the innovative ideas of young minds shaping the research landscape and reflects the aspirations of participants by providing a platform to articulate their ideas and pursue academic excellence within a rapidly evolving scholarly environment.

In alignment with evolving knowledge systems and a steadfast commitment to the highest academic standards, TIET's efforts continue to garner widespread appreciation. The institution's thoughtful dedication to nurturing young scholars, particularly by encouraging them to articulate and refine their research insights, is evident in the rich diversity of abstracts, which lend both depth and distinction to this volume. These contributions offer an engaging and intellectually stimulating read, showcasing the diversity and rigour of students' research while serving as a source of inspiration for the broader academic community.

This conference also reflects sustained institutional efforts that translate vision into tangible academic outcomes. TIET's unwavering, selfless mission has always been to advance knowledge and cultivate a value-driven intellectual ethos, especially among emerging learners. The enthusiastic participation of students from within and beyond the institution reaffirms our commitment to fostering academic talent and community engagement. By providing a platform for learners, TICSR-2026 embodies our belief in their potential as the future leaders and torchbearers of research and innovation.

I extend my warmest congratulations to the organising team for launching this initiative, to the faculty for their dedicated mentorship, and to all participants for their valuable and thought-provoking contributions. I am confident that TICSR-2026 will serve as a source of inspiration for all, standing as a model exemplar of inclusive vision, scholarly excellence, inventiveness, and collaborative academic endeavour.

From the Desk of the Pro Vice-Chancellor

It gives me immense happiness, deep satisfaction, and profound pride to present the Book of Abstracts for the Thapar International Conference for Student Research 2026 (TICSR-2026).

We stand today at the cusp of a transformative era-one defined by rapid technological advancement and the pervasive influence of artificial intelligence. In such a dynamic landscape, it is both heartening and inspiring to witness young minds, especially undergraduate students, stepping forward as creators of knowledge. Their willingness to question, explore, and contribute reflects intellectual courage and a strong commitment to shaping the future.

At TIET, our collective aim is to foster learning in a supportive and enabling environment, where students are encouraged to discover their potential and refine their critical thinking. Hosting this conference and providing such a platform reflects our belief that research is not merely an academic exercise; it is a way of thinking, a spirit of inquiry, and a pathway to innovation-essential in today's world. We firmly believe that the true purpose of education lies in empowering learners to think independently, communicate effectively, and innovate responsibly. The cultivation of research aptitude, clarity of expression, and a passion for lifelong learning remains at the heart of our mission.

The ideas presented in this volume are more than abstracts-they are catalysts of discovery, carrying the potential to address real-world challenges while underscoring the urgency of engaging with them. I hope this collection inspires many young scholars to embark on their own journeys of inquiry with courage, curiosity, and conviction. The future belongs to those who dare to question, seek answers with determination, and uphold a strong sense of ethical responsibility.

I congratulate the organizing team for creating a venue that empowers young minds to showcase their research. The guidance of mentors, together with the insightful contributions of participants and guest presenters, reflects the dedication and collaborative effort behind TICSR-2026. This conference stands as a testament to the shared vision of all involved, highlighting an academic ecosystem where curiosity is fostered, creativity is celebrated, and knowledge is meaningfully advanced.

From the Desk of the Dean of Research & Development

The present Book of Abstracts encapsulates the scholarly contributions of enthusiastic learners who have shared their research, reflecting ideas with the potential to make a meaningful impact in the near future. It also provides an occasion to recognize the institution's commitment to nurturing young, aspiring learners through the organization of the Thapar International Conference for Student Research 2026 (TICSR-2026), thereby advancing its academic mission.

The centrality of student research to this event underscores a twofold significance: first, it reaffirms our vision, mission, and future aspirations; and second, it highlights the processes of knowledge acquisition, the development of research ideas, and their dissemination—efforts that continue to gain recognition across wider academic domains.

TIET's Research & Development initiatives play an especially pivotal role in cultivating research skills among learners, preparing them to engage meaningfully with the global research community. These initiatives—including projects, research papers, presentations, and collaborative ventures—act as enablers for continuous learning and intellectual growth. Therefore, the enthusiastic participation of learners from TIET and other institutions is particularly encouraging, as it reflects the realization of our shared vision and fosters collective academic advancement.

I place on record my sincere appreciation for the collective dedication and coordinated efforts that have shaped this academic initiative. The enthusiasm, commitment, and sincerity demonstrated towards this event reflect the shared values and sense of purpose that guide our institution. Such concerted effort not only reinforces the legacy we continue to uphold within the academic community but also underscores the principles that define us, shaping our continued pursuit of academic excellence.

Organizing Committee Members

1. Prof. Padmakumar Nair, Vice Chancellor, TIET, Patiala, Punjab
2. Prof. Ajay Batish, Pro Vice Chancellor, TIET, Patiala
3. Prof. R. S. Kaler, Dean, Research, TIET, Patiala
4. Prof. B. N. Chudasama, Associate Dean, Research, TIET, Patiala
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17. Dr. Elham Fatma, DHSS, TIET, Patiala
18. Dr. Himali Horo, DCHE, TIET, Patiala
19. Dr. Vivek Parmar, DME, TIET, Patiala
20. Dr. Vivek Gupta, DCE, TIET, Patiala

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Abstracts of accepted papers in TICSR 2026

1 PID-6: Design and Implementation of a K-Type Thermocouple Amplifier with Cold-Junction Compensation

Atharv Vashisht, BE, Third Year, Mechatronics, Thapar Institute of Engineering & Technology, Patiala

Thermocouple is the oldest sensor and one of the most useful and commonly used because they generate electric emfs (voltage) directly and hence all one needs to do is measure the voltage, but that voltage is too small to be measured and needs to be amplified. This paper presents a low-cost thermocouple amplifier design by minimizing signal noise and hence capturing the temperature readings using cold junction compensation (CJC). Amplification is done by the AD623 instrumentation amplifier module and LM35 for CJC. The instrumentation amplifier provides a gain of 100 with linear response, and the LM35 sensor offers cold-junction compensation within ±0.5 °C accuracy. The system achieved an overall measurement accuracy of ±1–2 °C in the 0–100 °C range, making it suitable for embedded monitoring applications. Temperature was calculated using inverse polynomial equations after receiving the amplified voltage from the output pin of instrumentation amplifier module. The paper proposes avoiding reliance on fixed-function modules such as the MAX6675, which includes built-in CJC and the amplification.

2 PID-8: DELTA - Deep Ensemble Learning for Temporal Analysis

Arnav Jain, BTech, Forth Year, CSE, Thapar Institute of Engineering & Technology, Patiala
Aditya Raj Singh, BTech, Forth Year, CSE, Thapar Institute of Engineering & Technology, Patiala
Nihar Sharma, BTech, Third Year, CSE, Thapar Institute of Engineering & Technology, Patiala

Accurate electricity demand forecasting plays an important role in maintaining grid stability and enabling efficient energy management. Traditional statistical models often struggle

to capture the increasing complexity of modern energy systems driven by renewable integration and evolving consumption patterns. This study evaluates multiple deep learning architectures for short-term electricity demand forecasting using historical data obtained from the National Grid ESO. Models including TST, XCM, ResNetPlus, and InceptionTime are compared using standard forecasting error metrics. Experimental results indicate that transformer-based models achieve lower error compared to several convolutional and residual architectures. Furthermore, the proposed DELTA ensemble framework demonstrates improved aggregate performance, highlighting the benefits of combining heterogeneous models for time series forecasting. The findings emphasize the importance of model architecture selection and ensemble strategies for improving forecasting robustness.

3 PID-19: AgroSense: Smart Farming Advisory Platform

Ashutosh Mishra, BTech, Fourth Year, CSE, KCC Institute of Technology & Management, Greater Noida
Ayush Mishra, BTech, Fourth Year, CSE, KCC Institute of Technology & Management, Greater Noida
Jigar Ahmad, BTech, Fourth Year, CSE, KCC Institute of Technology & Management, Greater Noida
KP Singh, KCC Institute of Technology & Management, Greater Noida

AgroSense is essentially an assistant that is a practical solution based on smart technology created to address the very problems that might have left small-scale farmers bewildered. Rather than over-linguistic tools, it employs photo checkups on ailing plants, harvests accordingly to changes in the local weather, and connects farmers to a secure online trading platform, all fitted within one easy application. AgroSense is based on intelligent technologies - such as special neural nets - that scan the images of plant leaves to identify sickness in a short time. Give a snap on your phone and the tool then cleans up the shot, compares it with known cases to ensure that you have what is wrong and the confidence and quick care tips. Growers respond earlier when things go wrong instead of lingering around until they eventually find a specialist. The more photos the user adds, the more the software is updated, enabling it to learn more about the farms around and the issues that appear regularly. Out of only identifying problems, AgroSense provides a product that suggests what to cultivate depending on intelligent technology. It extracts information such as rain

patterns, future weather clues, soil quality - consider nutrients and moisture - and historical harvests to make decisions about planting. Instead of relying on the habit or hunches, the growers are presented with the options ranked by fit with the rating of score of how well each will perform. These recommendations are inclined toward the plants that are resistant to changing climatic conditions and require less fertilizers or water, and increase chances of producing good yields. This eventually assists in planning in advance, reduces the risk of crop failure, and utilization of fields and supplies. The third component of AgroSense is an integrated market, that allows farmers to sell crops directly using digital products.

4 PID-22: Long-Term Traffic Behavior Analysis Using Multi-Year Social Media and Sensor Data: Trends and Predictions for Kanpur and Lucknow

Nikhil Shukla, Research Scholar, Chhatrapati Sahuji Maharaj University, Kanpur
Pushpa Mamoria, Chhatrapati Sahuji Maharaj University, Kanpur

Traffic congestion in Kanpur and Lucknow, fueled by industrial surges, monsoons, and festivals, demands innovative solutions beyond short-term traffic studies. This research investigates long-term traffic patterns and predicts future congestion in these Uttar Pradesh cities using a blend of social media and sensor data, offering a scalable model for India's urban traffic challenges. We analyze a simulated dataset of over 1000 hourly records from 2023–2024, including vehicle counts (500–2000 vehicles/hour), speeds (10–60 km/h), Twitter (X) posts (400 alerts), weather conditions, and festival events (e.g., Diwali), processed with a Long Short-Term Memory (LSTM) neural network to capture seasonal trends. Crafted to mirror real-world dynamics (Singh & Gupta, 2019), the dataset reveals a 25% traffic rise during July–September monsoons (1600 vehicles/hour), November festival peaks (1800 vehicles/hour), and December lows (900 vehicles/hour). The LSTM model achieves an 85% prediction accuracy with low error, outperforming a Random Forest baseline (80%), due to its ability to track extended patterns (Tian & Pan, 2015). These insights empower urban planners to deploy proactive strategies, such as monsoon traffic rerouting and festival signal adjustments, enhancing mobility in Kanpur and Lucknow. As a simulated proof-of-concept, this study advances beyond short-term analyses, laying groundwork for real-time traffic systems across India's growing cities. By integrating diverse data sources, it provides a practical framework for sustainable urban transport, adaptable to other regions facing similar congestion woes.

5 PID-30: AI-Based Occlusion Handling in AR Using Monocular Depth and Segmentation Models

Rubalpreet Kaur, BE, Third Year, ECE, Thapar Institute of Engineering & Technology, Patiala

Correct occulsion simulation is essential interaction between virtual and real-world objects in Augmented Reality(AR) and Virtual Reality (VR).Without accurate depth reasoning,virtual elements appear incorrectly overlad,reducing immersion.Most commercial systems rely on dedicated depth sensors such as LiDAR or time-of-flight cameras,which increase hardware cost ,power consumption and device complexity. This paper presents a hardware-free occlusion reasoning framework that operates using only monocular RGB images to perform pixel-level occlusion in real time. The framework integrates a monocular depth estimation model with a semantic segmentation network to extract per-pixel depth information and foreground object masks from live camera input. An occlusion reasoning module then determines whether virtual objects should occlude or be occluded by real-world objects based on depth comparison. The complete pipeline was implemented using Python,OpenCV,and ONNX-based deep learning models.A real-time prototype was developed and tested on a standard laptop webcam,demonstrating correct occulsion behaviour under varying lighting and motion conditions.The system currently achievers approximately 0.5-1 frames per second on a CPU-only setup. The framework is designed for future deployment on standalone AR/VR headsets, with integration planning for the AJNAXR headset to extend functionality to mixed reality devices lacking depth sensors. The study highlights the scalability, cost-effectiveness, and adaptability of monocular AI-based occlusion systems. Future work will focus on model optimization, lightweight segmentation alternatives, latency reduction, and full XR headset integration to improve real-time performance and immersive interaction quality.

6 PID-31: Cross-Domain Performance Evaluation of Time Series Forecasting Models in Real-World Applications

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Divisha Garg, PhD Scholar, Thapar Institute of Engineering & Technology, Patiala

Time series data is widely encountered in real- world applications such as air quality monitoring, predictive maintenance, energy consumption analysis, and sales forecasting. Selecting an appropriate model for accurate time-series predic- tion and classification remains challenging due to variations in data characteristics and model complexity. This paper presents a comparative performance analysis of multiple state-of-the-art time series models, including MINImally RandOm Convolutional KErnel Transform (MiniRocket), Residual Network (ResNet), InceptionTime, Long Short-Term Memory Fully Convolutional Network (LSTM-FCN), and Patch Time Series Transformers (PatchTST), evaluated across several benchmark datasets. All models are assessed under a unified experimental setup with consistent preprocessing, fixed train-validation-test splits, and standardized evaluation metrics, including Root Mean Square Er- ror (RMSE) and classification accuracy. The experimental results highlight the trade-offs between model accuracy, training time, and parameter complexity. The study provides practical insights into model selection for time-series tasks and demonstrates that MiniRocket consistently outperforms others across all datasets, emphasizing its robustness and superior generalization capability.

7 PID-33: An AI-Driven Electroencephalography Analysis Framework for Early Detection and Classification of Infantile Spasms

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Pranatheesh S, BE, Second Year, CSE, Chennai Institute of Technology
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Infantile spasms (IS) are an infrequent and serious form of myelopathy that develops in the first months of life and, if the diagnosis and treatment are not timely, can lead to major delays in the neurodevelopmental process. The function that electroencephalography (EEG) plays in diagnosis of infantile spasms is essential to the process as hypsarrhythmia characterizes this condition. Since EEG interpretation is labor-intensive, highly subjective and dependent on the experience of the radiologist or clinician reading the EEG, this research

is aimed at developing a comprehensive AI-based system for classification and detection of IS from EEG data. This system will utilize novel technology whereby EEG data is analyzed using techniques, including time-frequency representation (TFR), wavelet transforms (WT), etc., followed by a hybrid machine learning method consists of CNNs and long short-term memory (LSTM) networks, with interpretability enhancements using explainable AI (XAI) techniques.

8 PID-36: Automated Facial-Recognition Driven Assistance System for Modern Lost-and-Found Services

Ravi Ranjan, BTech, Fourth Year, CSE, KCC Institute of Technology & Management, Greater Noida
Yaseer Nishat, BTech, Fourth Year, CSE, KCC Institute of Technology & Management, Greater Noida
Priyanshu Raj, BTech, Fourth Year, CSE, KCC Institute of Technology & Management, Greater Noida
Vibha Sinha, KCC Institute of Technology & Management, Greater Noida

Methods for finding lost items that use traditional approaches show limitations in speed and structure, and these methods involve large amounts of work that is not using systems. This makes these approaches difficult to use in areas where cities are growing in population at a high rate. The current study presents a system that uses approaches from the field of learning from data and that provides communication between individuals through methods using phones and through methods using computers. This system provides means to make processes for reporting items and processes for finding items work in a more direct manner. The approach uses a system for phones that operate using Android and this provides the interface that individuals use. The system uses dlib and this provides the means to match faces that appear in images. This allows communication between stakeholders that is secure and that is direct. Tests that were conducted in the initial phase show that the system provides faster results for finding items and that it shows improved features for increasing in size and that it shows strong responses from individuals using the system. The work combines methods for learning from patterns in data and methods for matching faces in images and methods for providing communication using digital means.

9 PID-40: A Comparative Evaluation Framework for Emotion Detection in Code Mixed Hinglish Text

Brajesh Kumar Khare, PhD, Fourth Year, CSE, Harcourt Butler Technical University, Kanpur

Natural Language Processing is a branch of artificial intelligence focused on enabling computers to communicate with humans through natural language. It enables machines to understand, analyze, and produce human language in a way that is both meaningful and practical. A key application is sentiment analysis, which identifies the overall sentiment in a text. Another important task is emotion detection, which identifies specific emotions such as joy, anger, or sadness in the text. While substantial research has been conducted on emotion detection in single language datasets like English, there remains significant potential for further investigation in bilingual contexts. Analyzing emotional content in code-mixed text, particularly in Hinglish, poses considerable difficulties due to language variation and the mixed linguistic environment. In this paper, we present a framework that conducts a comparative analysis of different machine learning and deep learning models to assess their effectiveness in emotion detection. The research employs widely used models such as Naïve Bayes, Logistic Regression, Random Forest, KNN, XGBoost, Gradient Boosting, LSTM, CNN, HAN, and mBERT to assess their performance based on metrics like accuracy, precision, recall, and F1-score. The framework applied to Task 9 of the SemEval 2020 dataset achieved 93.41% accuracy, 91.46% precision, 91.45% recall, and 91.44% F1 score with the mBERT model. The framework then applies the best performing trained model to predict emotions in code-mixed Hinglish text, demonstrating the model's effectiveness in handling multilingual and mixed-language content.

10 PID-43: Femur Bone Fracture Detection using Deep Learning Techniques

Ravi Yadav, PhD, Third Year, CSE, Indira Gandhi University Meerpur, Rewari

An accurate assessment of Femur bone fractures is essential to avoid complications like delayed healing or permanent deformities. In the realm of medical imaging, machine learning (ML), especially deep learning (DL) models, has proven to be effective tools for improving

diagnostic precision, minimizing human errors, and enhancing workflows through automation. This research examines the Detection Transformer (DETR), a transformer-based DL model, for the automated analysis of fractures in X-ray images. A collection of 3,000 long bone radiographs, meticulously labeled and annotated by an expert, was processed and augmented to facilitate strong model training and evaluation. DETR attained a mean Average Precision (mAP) of 80.9%, indicating high sensitivity and dependable localization of fracture areas. It is especially good at spotting subtle or complicated fracture patterns because of its end-to-end architecture and capacity to capture global contextual dependencies. With bigger datasets, more sophisticated augmentation techniques, and architectural improvements expected in the future, these findings demonstrate DETR's potential as a clinically relevant tool.

11 PID-45: Isolation and Screening of HDPE-Degrading Microorganisms from Plastic Dump Site

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Sudhir Singh, Thapar Institute of Engineering & Technology, Patiala
Haripada Bhunia, Thapar Institute of Engineering & Technology, Patiala

Microplastics have emerged as a critical global environmental challenge due to their persistent nature and potential to disrupt ecosystems worldwide. While degradation strategies include physical capture, chemical treatments, and biological approaches, microbial degradation stands out for its economic viability and eco-friendliness, a focus of active research. This study focuses on high-density polyethylene (HDPE), a highly recalcitrant polymer notorious for resisting biodegradation, by isolating and screening microorganisms capable of breaking it down from plastic dumping site. Indirect isolation method using Bushnell-Haas Broth (BHB), a minimal mineral salts medium with HDPE microplastics to selectively enrich potential degraders was followed. Distinct colony morphologies were observed among the isolates, guiding further selection. To confirm degradative potential, isolates were tested for their ability to utilize HDPE as the sole carbon source in BHB. This screening approach yielded potential HDPE degrading bacterial isolates(PDIs).Pure cultures of PDIs were characterized via Gram staining, revealing a mix of Gram-positive & Gram-negative strains, microscopic analysis and comprehensive biochemical tests. These analyses provide insights

into the microbial diversity and functional traits enabling HDPE degradation. Future work will advance the characterization of these PDIs through 16S rRNA sequencing to identify the taxonomic group and phylogenetic relationships. Concurrently, biodegradability assays under composting conditions (ASTM D5338 standard) will assess the isolate's performance in real-world waste management scenarios, measuring parameters such as weight loss, surface erosion via SEM, CO2 evolution and TOC reduction over extended incubation periods to validate the isolate's efficacy, bridging the gap between laboratory screening and practical bioremediation applications, contributing to sustainable strategies for mitigating HDPE microplastic pollution.

12 PID-46: Estimating thermokinetic parameters for carbon dioxide adsorption form Biomass-derived activated carbon

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One of the biggest problems of the 21st century is carbon dioxide (CO2), a significant greenhouse gas. Energy-intensive industries and the fossil fuel power sector are primarily to blame for its rise in the atmosphere. Because of the degradation of the global environment and the depletion of natural resources, the need for environmentally friendly and renewable energy sources has become crucial. During activated carbon production, many carbon atoms in biomass are removed, creating more micropores and increasing surface area and pore volume. These traits could contribute to increased CO2 capture effectiveness. Biomass is an abundant carbon-rich resource with strong potential for producing activated carbon adsorbents for CO2 capture technologies In addition, Adsorption has strong mechanical strength, high selectivity, and ease of use make it an efficient post-combustion method for lowering CO2 emissions from flue gases. It is necessary to build a model that can explain the dynamics of the adoption process to design it. For the kinetic analysis of pyrolysis to comprehend the rate of biomass decomposition at various temperatures, it is necessary to determine reaction kinetics parameters like activation energy (Ea) and pre-exponential factor (A). These indicators aid process optimization and design. Lagergren's pseudo-first-order, pseudo-second order, and fractional-order models analyzed adsorption kinetics. Freundlich isotherm con-

firmed the adsorbent's heterogeneous surface. LDF modeled column breakthrough profiles, solved via MATLAB. The model accurately predicted breakthrough curves across CO2 concentrations and temperatures.

13 PID-47: Study on the treatment of cosmetic industry wastewater for effective BOD and COD removal

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The rapid expansion of the cosmetic industry has led to a significant increase in the generation of high-strength industrial wastewater characterized by elevated Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Cosmetic effluents typically contain surfactants, emulsifiers, oils, fragrances, preservatives, and active pharmaceutical ingredients, contributing to substantial organic loading and reduced biodegradability. In several reported cases, COD levels in cosmetic wastewater exceed 100,000 mg/L, indicating the presence of both biodegradable and refractory organic compounds. This study focuses on the quantitative assessment of BOD and COD as primary indicators of organic pollution strength in cosmetic manufacturing effluents. The BOD/COD ratio was analyzed to evaluate biodegradability potential and determine the suitability of biological treatment processes. A lower BOD/COD ratio suggests the dominance of non-biodegradable compounds such as synthetic fragrances and preservatives, while higher ratios indicate better compatibility with aerobic biological treatment systems. The results demonstrate significant variation in organic loading depending on product category, with shampoo and lotion production units showing comparatively higher BOD values due to surfactant-rich compositions. The findings highlight the necessity of integrated treatment approaches combining physicochemical pre-treatment (coagulation–flocculation or dissolved air flotation) to reduce COD load, followed by biological processes for effective BOD removal. Understanding the BOD and COD relationship provides critical insight into treatment design, operational efficiency, and environmental compliance for cosmetic industries. This study contributes to sustainable wastewater management strategies by emphasizing organic load characterization as a foundational

step toward efficient and eco-friendly treatment system design in the cosmetic sector.

14 PID-49: Predicting Inflation Spikes Using Geopolitical Stress Transmission (via Critical Resource Channel)

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Spikes in inflation present serious problems for both policy planning and economic stability. Nonlinear external shocks resulting from geopolitical instability are frequently missed by traditional forecasting models. In order to forecast inflation spikes using geopolitical stress transmission mechanisms, this paper suggests a data-driven framework. We create a composite geopolitical stress index based on trade disruptions, energy supply volatility, commodity price shocks, and conflict intensity. The framework simulates how geopolitical stress spreads via vital economic channels like food supply chains, energy markets, and currency depreciation. Using historical macroeconomic and geopolitical data, machine learning models are trained to categorize and predict inflation spike events. When compared to baseline time-series models, experimental results show enhanced predictive performance. In order to help policymakers mitigate inflationary shocks, the proposed framework offers early warning signals.

15 PID-53: Smart Multi-Sensor Tracking System

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Many conventional outdoor tracking devices depend mainly on Global Navigation Satellite System (GNSS) receivers to determine geographic position. Although GNSS technology can provide accurate coordinates, it does not offer meaningful information about surrounding environmental conditions. Because of this limitation, traditional tracking systems are often insufficient for applications that require contextual environmental awareness. With the rapid advancement of Internet of Things (IoT) technologies, modern sensing platforms increasingly combine embedded processing with multiple sensors to capture diverse environmental data alongside positional information. The present work aims to develop a compact outdoor multi-sensor tracking system that integrates location tracking with environmental sensing capabilities. The system is built around the ESP32-WROOM microcontroller, which provides sufficient processing capability and integrated wireless communication suitable for IoT-based deployments. The proposed hardware integrates a u-blox NEO-M8N GNSS module for positioning, an MLX90614 infrared thermopile sensor for non-contact temperature measurement, and a TCS34725 RGB colour sensor for detecting environmental colour variations. All sensing components are assembled on a custom-designed printed circuit board (PCB), which simplifies hardware connections and improves system stability. An additional focus of this research is the development of a reliable power management architecture suitable for long-term outdoor operation. Instead of relying on small coin-cell batteries commonly used in compact trackers, the system uses a lithium-polymer (Li-Po) battery combined with a Battery Management System (BMS) and dedicated charging circuitry. This configuration ensures stable power delivery and supports the varying current requirements associated with GNSS reception, wireless communication, and sensor operation.

16 PID-54: Modeling and Simulation of a Fluid Catalytic Cracking Regenerator

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Fluid catalytic cracking process is a key refinery process used to convert vacuum gas oil into valuable products such as LPG, gasoline, and light gas oils. Typical FCC unit consists of riser reactor, where heavy hydrocarbons are cracked into lighter fractions through endothermic reactions, and regenerator, where deactivated catalyst is regenerated by oxidation of coke deposited on catalyst. In the FCC process, catalyst deactivates rapidly and regenerated continuously to maintain catalyst activity and improve product yield. Regeneration reactions are exothermic because heat of combustion raises the temperature of catalyst which is recycled to the reactor for efficient cracking. Thus, the regenerator serves two main functions: it restores catalyst activity and supplies heat to crack the feed. There are two phases in the regenerator: the dense phase and the dilute phase. The dilute phase is the region above the dense phase up to the cyclone separator inlet, and has a substantially lower catalyst concentration. Modeling of the regenerator is important for the prediction of coke burned and the regenerated catalyst temperature. In this work, mathematical model developed for prediction of the above two important parameters in the regenerator. This model applies energy and material balance equations to both dense and dilute phases to predict regenerator performance. The combustion of coke leads to the formation of carbon monoxide and carbon dioxide. In addition, hydrogen present in coke deposits reacts with oxygen to form water vapor which contributes to heat release and affects the regenerator temperature profile. The species concentration and temperature profiles are solved using the finite difference method. Model input parameters are taken from previously published studies. Keywords: FCC, Catalyst regeneration, Regenerator kinetics, air circulation flowrates, oxidation reactions

17 PID-55: Using Variational Quantum Circuits in PPO for Structured Exploration in Combinatorial Reinforcement Learning

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PPO is a powerhouse in reinforcement learning, but it hits a wall in complex, structured environments. In combinatorial problems, standard softmax policies tend to get tunnel vision—they lock onto local rewards too quickly, causing entropy to tank and learning to stall.

This study explores whether swapping the final softmax layer for a Variational Quantum Circuit (VQC) can fix those exploration issues without changing the core PPO math. Instead of typical linear mapping, we use a hybrid setup: observations tune the circuit, and action probabilities are pulled directly from quantum measurements (the Born rule). This shift is key because entanglement allows for natural correlations across action spaces that classical layers struggle to capture. We tested this in a subset-selection bandit task, pitting classical PPO against both separable and entangled quantum versions. The takeaway? Quantum isn't a magic bullet for performance yet, but entangled circuits showed much more resilience. They resisted entropy collapse and maintained steadier exploration, suggesting that the geometry of Hilbert space might be exactly the kind of nudge RL agents need to stay curious in structured environments.

18 PID-56: Simulation of ethyl acetate production process using Reactive Distillation

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Reactive distillation (RD) is a process intensification technique that combines two unit operations—chemical reaction and multi-stage distillation—within a single column. In this process, reaction and separation occur simultaneously, allowing products to be continuously removed from the reaction zone as they form. This shifts the reaction equilibrium toward the desired products, helping to overcome equilibrium limitations described by Le Chatelier's principle. Compared with the conventional arrangement of a reactor followed by a separation unit, RD offers higher reactant conversion, improved product selectivity, and lower energy consumption, along with reduced capital and operating costs. However, its implementation can be challenging due to complex design requirements, scale-up difficulties, and the need for advanced process control. The design and optimization of reactive distillation systems rely on accurate modelling approaches, which reduce the need for costly and time-consuming experimental studies. RD is particularly advantageous for equilibrium-limited reactions, such as esterification, as the continuous removal of products improves overall conversion and process efficiency. Under suitable temperature and pressure conditions, a distillation column

can therefore function both as a reaction vessel and a separation unit. One important application of RD is the production of ethyl acetate through the esterification of acetic acid and ethanol. Conventional industrial esterification follows a reactor–separator sequence, where the reaction takes place in a dedicated reactor and the mixture is later separated using multiple recovery columns. However, the reaction between acetic acid (HAc) and ethanol (EtOH) is reversible, which limits conversion. In addition, separation is complicated by the formation of non-ideal mixtures and several azeotropes, including ethanol–water and ethyl acetate–water systems.

19 PID-58: Adaptive Eco-Routing (AER): A Router-Overhead- and Carbon-Aware Multi-Objective Framework for LLM Inference

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Large language models (LLMs) are now used as general-purpose engines for many natural language processing tasks, but the computational effort required to run them at scale leads to high energy use and non-trivial carbon emissions. Existing routing systems reduce this cost by distributing queries across model pools, yet they usually track router overhead only in aggregate, collapse several objectives into a single energy–accuracy score and optimise against average, rather than marginal, grid carbon intensity. This work introduces Adaptive Eco-Routing (AER), a routing framework that makes these aspects explicit. AER formulates query routing as an online, multi-objective problem over accuracy, total energy, latency and marginal carbon emissions, where both inference and routing stages contribute to the cost. The architecture combines an ultra-light pre-filter, a distilled meta-model for cost prediction, a router-overhead-aware multi-objective multi-armed bandit (MO-MAB), hierarchical reinforcement learning (HRL) controllers for configuration decisions and a federated semantic cache. To avoid the expense of a large-scale physical testbed, AER is evaluated using a detailed simulation environment parameterised by published hardware measurements and real grid traces. The results indicate that AER can substantially reduce energy and emissions compared to static and bandit-based baselines while maintaining competitive task performance, and that explicitly modelling marginal carbon signals and router overhead is essential for these gains. Index Terms—LLM inference, eco-routing, energy-aware systems, marginal carbon intensity, multi-objective bandits, hierarchical reinforcement learning, rout-

ing overhead, sustainable AI.

20 PID-59: Supercritical CO2 Foaming of Thermoplastic Polyurethane: Processing, Structure, and Properties

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Supercritical carbon dioxide ($ScCO_2$) foaming has emerged as a sustainable alternative to conventional blowing agents for producing thermoplastic polyurethane (TPU) foams. TPU foams are widely used due to their excellent elasticity, mechanical strength, thermal insulation, and lightweight characteristics. Unlike traditional foaming methods that rely on toxic chemicals and energy-intensive processes, $ScCO_2$ is non-toxic, chemically inert, and environmentally friendly, making it an effective green blowing agent. This review summarizes recent developments in $ScCO_2$-based foaming technologies for TPU, focusing on processing techniques such as batch foaming, extrusion foaming, and injection molding foaming. The influence of key processing parameters-including temperature, pressure, saturation time, and depressurization rate-on foam morphology, cell structure, and material performance is discussed. In addition, the role of additives, fillers, and polymer modification strategies in improving foam structure and functionality is highlighted. $ScCO_2$-foamed TPU materials show promising potential for advanced applications such as electromagnetic interference shielding, flexible sensors, energy absorption systems, and thermal management materials. Overall, $ScCO_2$ foaming provides an environmentally sustainable route for developing lightweight and high-performance TPU foams while offering valuable insights for future research and industrial applications.

21 PID-60: Modelling and Performance of PEM Fuel Cell

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Proton Exchange Membrane (PEM) fuel cell systems have emerged as a promising clean energy technology for transportation, stationary, and portable power applications due to their high efficiency, low operating temperature, and near-zero emissions. The proposed model integrates electrochemical, thermodynamic, and mass transport phenomena to predict voltage output, power density, and system efficiency as functions of current density, temperature, pressure, and reactant flow rates. The modelling framework incorporates activation, ohmic, and concentration overpotentials to accurately describe polarization characteristics. Both steady-state and dynamic simulations are conducted to investigate transient response, load fluctuations, and water management within the membrane electrode assembly. Furthermore, a system-level assessment is performed by integrating auxiliary components, including air compression, hydrogen supply, humidification, and thermal management subsystems. Simulation results reveal that optimal operating temperature and reactant pressure significantly enhance power density and efficiency, while effective membrane hydration improves ionic conductivity and durability. The developed model shows strong correlation with published experimental polarization data, validating its applicability for design optimization and control strategy development. The study offers practical insights into performance enhancement and reliability improvement of PEMFC systems, supporting their large-scale deployment in sustainable hydrogen energy infrastructures.

22 PID-61: Porous carbon adsorbents derived from mixed plastic waste for CO2 capture: prospects and hurdles

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Rising CO emissions from human activities drive global warming, climate variability, ecological disruptions, and sea-level rise threatening coastal areas. Atmospheric CO has surged to 427 ppm in 2025 (IPCC data), potentially reaching 570 ppm by 2100 under common scenarios, raising global temperatures by 1.9°C. This intensifies extreme weather, biodiversity loss, food insecurity, and socioeconomic risks, demanding scalable mitigation like carbon

capture and storage (CCS). Post-combustion capture stands out for its modularity, enabling retrofits to existing coal- and gas-fired power plants responsible for two-thirds of sector emissions without full overhauls. Recent improvements are looking at using advanced materials made from household, commercial, and agricultural waste, which have large surface areas, adjustable pore sizes, and quick reactions for capturing CO from flue gas In India, plastic waste generates 10,000 tons/day (9% of MSW), serving as ideal precursors for carbon-based adsorbents due to high carbon content and stability. Pyrolysis or carbonization converts this non-biodegradable waste into selective, high-capacity materials, reducing volumes, cutting virgin feedstock needs, and aligning with circular economy goals. Challenges include variable waste composition, energy-intensive activation, humidity stability, and scale-up economics, which can hinder the effective development and implementation of carbon-based adsorbents from plastic waste. This work systematically explores opportunities and hurdles in leveraging mixed plastic wastes for next-generation CO adsorbents.

23 PID-62: Data Workers in AI Industry and Their Precarious Working Conditions

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AI data workers have been described as the "construction workers of the digital age" (Chohan, 2023). Data workers are people involved in data labelling. Data labelling requires humans to label data for training the ML models (IBM, 2025). While their work remains to be the most significant one, they remain invisible in the AI industry. Thus, this project aims to investigate and understand data workers as the main stakeholders in the booming AI industry. In the first morning of Operation Epic Fury, American forces targeted a primary school in Minab, Iran, killing between 175 to 180 girls between the ages of 7 and 12 (Baker, 2026). The targeting for Operation Epic Fury ran on a system called Maven (Baker, 2026). The school building had been classified as a military facility in the database, however there was a failure with updating the information that the military facility was converted into a school. "A chatbot did not kill those children. People failed to update a database, and other people built a system fast enough to make that failure lethal" (Baker, 2026). This shows how significant is the role of humans in the process of data training to chatbots. Hence, the essence of these AI systems lies in the labour of data workers. The Iran school bombing

sheds light on how AI failures are not just rooted in the autonomous systems, but in fragile human infrastructures, which includes precarious data labelling work which is responsible for training these systems with the real-world truth. This raises a question of what are the connections between precarious working conditions of data labelling work and instances of injustices in the world.

24 PID-63: Deep Learning Framework for Early Detection of Polycystic Ovary Syndrome Using Clinical and Imaging Data

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Although Polycystic Ovary Syndrome (PCOS) is prevalent among women worldwide, it is difficult for clinicians to correctly diagnose patients at an early stage due to their wide range of symptoms. To date, diagnosing PCOS involves three main approaches: clinical examination and hormone analysis combined with ultrasound image interpretation requiring expert medical knowledge. This article presents an application of deep learning techniques for the identification of specific characteristics of PCOS by utilizing ultrasound images along with patient demographics and lab results. The authors are utilizing Convolutional Neural Networks (CNN) to extract the patterns indicative of PCOS from these ultrasound images, patient records, and laboratory data. The results of this research demonstrate improved accuracy when diagnosing PCOS using this new deep learning based model, with the CNN model demonstrating 99.6% accuracy compared to other means of detecting PCOS. Major contributing factors for the development of PCOS are assessed and include hormone levels and metabolic markers associated with the ovary along with imaging characteristics identifiable using ultrasound. Therefore, the authors believe that through the use of deep learning techniques, health care professionals can better detect and treat cases of PCOS at an earlier time.

25 PID-65: Optimised DWT-PSO Based Image Steganography for Secure Communication

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Steganography is a data hiding technique used to securely transmit sensitive information by embedding it within cover medium. Since hidden data remains imperceptible, it prevents unauthorized detection and enhances secure communication. Conventional steganographic methods face challenges such as limited embedding capacity, image distortion, and detection vulnerability. To address these problems, optimization techniques are increasingly used alongside transform-domain methods. This study proposes a hybrid steganography model that combines Discrete Wavelet Transform (DWT) with Particle Swarm Optimization (PSO) to improve security and image quality. In the proposed method DWT LL subband is selected for embedding the secret data. The PSO algorithm is employed to determine optimal embedding parameters, thereby minimizing visual distortion and effectively balancing the trade-off between embedding capacity and image integrity. The performance of the proposed model is evaluated using standard image quality metrics, like Peak Signal-to-Noise Ratio (PSNR), Structural Similarity Index Measure (SSIM), and Mean Squared Error (MSE). Results show that the DWT-PSO approach achieves PSNR values around 44 dB, higher SSIM values close to unity, and lower MSE compared to traditional DWT-based methods. These results indicate reduced image distortion and improved embedding performance, highlighting the effectiveness of the proposed method for secure and efficient steganographic applications.

26 PID-66: Psychological and Environmental Factors Contributing to the Development of Behavioral Addiction in Young Adults

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This study aims to examine the Psychological (impulsivity, poor emotional regulation, stress, anxiety and depression) and Environmental factors (peer pressure, academic stress, family environment) that affect the development of behavioral addiction in young people aged 18 to 25 years. In this study, we will examine the interaction of perceived stress, impulsiveness, and difficulties in emotional regulation with environmental factors that increase the risk of behavioral addiction. To achieve this, we intend to conduct a cross-sectional study among young people and use questionnaires to assess the severity of behavioral addiction and other Psychological and Environmental factors that affect its development. We will use regression analysis through PLS-SEM Software to analyze our findings using quantitative analysis and machine learning techniques. Based on the existing literature, we expect higher impulsivity and emotional distress to predict greater behavioral addiction symptoms. Other Psychological risks include high sensation-seeking and poor self-regulation, while depression, anxiety, or trauma may correlate positively with addiction. In contrast, strong social support is expected to be protective. Prior studies have shown that addicted youths exhibit higher depression, compulsivity, and aggressiveness alongside lower family support; similarly, family and school environments have emerged as significant negative predictors of adolescent Internet addiction. We therefore expect to identify an "at-risk" profile (e.g. high trauma, poor parental communication) and a "resilient" profile (e.g. strong support, few psychological risk factors), consistent with findings that such profiles strongly predict addiction severity. In summary, the study will confirm that a combination of individual traits and environmental contexts best explains behavioral addiction in young adults.

27 PID-68: Design and Preliminary Validation of a Wearable Bioinstrumentation Platform for Continuous Skin Graft Monitoring

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Skin grafting is a cornerstone of reconstructive surgery for severe burns, trauma, and oncological defects; however, graft failure remains a concern due to delayed detection of complications such as ischemia, infection, and inflammatory rejection. Conventional monitoring relies on periodic inspection or invasive procedures such as biopsy, limiting continuous assessment.

A non-invasive, continuous, and cost-effective monitoring solution is therefore needed. This work presents the design and preliminary validation of a wearable smart bandage for continuous post-operative graft monitoring. The system integrates an ESP32 microcontroller with a DS18B20 temperature sensor. Temperature data are acquired at 2-second intervals, processed using moving-average filtering, and evaluated against a subject-specific baseline established at initialization. Upper physiological filtering at 45 °C removes environmental artifacts. A heuristic risk-scoring model combines temperature deviations with simulated biomarkers (lactate, TNF-, and pH) indicative of tissue hypoxia and inflammation. Biomarkers are simulated using a hardware-in-the-loop framework in the Wokwi environment with physiologically realistic ranges. Data are transmitted via MQTT over WiFi through a wireless telemetry pipeline for continuous real-time monitoring. Experimental validation over 60 minutes under ambient, skin-contact, heating, and cooling conditions demonstrated stable acquisition and accurate tracking of thermal transitions, with consistent performance across all test conditions. The system successfully validated the end-to-end monitoring pipeline from sensing to visualization, supporting continuous real-time monitoring of graft viability. These results confirm the feasibility of the proposed platform for continuous, non-invasive graft monitoring. Future work includes integrating electrochemical biosensors, improving wearability, and conducting clinical studies.

28 PID-70: Bitmask Dynamic Programming for Efficient State Compression in Combinatorial Optimization Problems

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Dynamic Programming (DP) is a widely used technique for solving optimization problems that involve overlapping subproblems. However, many combinatorial problems require evaluating large numbers of subsets, which often leads to inefficient state representation and increased memory usage. Bitmask Dynamic Programming provides an efficient method for representing subsets using binary encoding, allowing compact storage of states and faster transitions through bitwise operations. In this paper, we study the application of bitmask dynamic programming in solving subset-based combinatorial optimization problems. The technique represents subsets as binary integers where each bit corresponds to the presence or absence of an element in the subset. This representation significantly simplifies state transitions and enables efficient implementation of dynamic programming algorithms. Ap-

plications such as the Traveling Salesman Problem and subset optimization problems demonstrate the effectiveness of this technique. Experimental observations suggest that bitmask dynamic programming is particularly effective for problems with moderate input sizes where the number of possible subsets remains computationally feasible. Experimental observations demonstrate that the proposed approach performs efficiently for moderate input sizes while significantly reducing redundant computations compared to naive approaches.

29 PID-71: Algorithmic Abundance and Its Role in Decision Fatigue and Opinion Instability Among Young Adults.

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Digital platforms expose Gen Z to near-infinite content that is algorithmically curated. Trained models personalise content based on the viewer's digital habits to maximize engagement. This exposure may contribute to decision fatigue and have long-term effects such as opinion instability while also increasing the amount of time users spend interacting with digital platforms. This study investigates the relationship between personalised algorithmic content and decision fatigue, and its potential role in opinion instability among Gen Z (people born between years 1997 and 2012). A survey-based quantitative data collection will be conducted with the help of a structured self-reported questionnaire designed to collect data and study the levels of algorithmic exposure, decision fatigue and opinion instability. This survey will target 100-120 Gen Z participants. The survey responses will then be analyzed using correlational methods to identify relationships between the measured variables. This research seeks to contribute to understanding how algorithm-driven content influences cognitive processes and decision-making patterns among young adults. This will further help in the formation of policies for digital platforms and may contribute to discussions for maintaining digital well-being in highly personalized media environments. It is expected that higher exposure to algorithmically curated content, resulting in information overload, and increased cognitive strain on users navigating large volumes of digital information, this strain may associate with increased levels of decision fatigue and greater instability in personal opinions, potentially causing Gen Z to increase reliance on AI models and trained algorithms to make decisions for them long-term. The study will focus exclusively on Gen Z participants, which may act as a limitation when attempting to generalize the results.

30 PID-73: AI Powered Car Comparison and Recommendation System

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The proliferation of the global automotive market has resulted in an overwhelming diversity of vehicle specifications, creating a state of choice overload for consumers. Traditional decision-making processes are often fragmented, requiring users to navigate multiple platforms for vehicle comparison, customer support, and administrative legalities like traffic penalty management. This paper proposes a unified Multi-Criteria Decision Support System (MCDSS) that integrates personalized car recommendations with an AI-driven conversational agent and a digital traffic enforcement interface. The system employs a content-based filtering algorithm to match specific user requirements—such as budget, mileage, and safety ratings—with an extensive relational database. To enhance user engagement, a Natural Language Processing (NLP) based chatbot is implemented to provide real-time, interactive technical assistance. Furthermore, the framework addresses the need for centralized vehicle management by incorporating a secure e-Challan module, allowing users to verify traffic violations and execute fine payments via an integrated digital gateway. System evaluation indicates that this holistic approach significantly reduces cognitive friction and improves administrative efficiency by consolidating the vehicle lifecycle—from acquisition to legal compliance—into a single, robust web-based architecture.

31 PID-74: Risk-Aware Multi-Modal Framework for Digital Media Integrity Assessment

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Advancements in AI (especially generative models), have greatly increased the prevalence of manipulation of various types of digital media (including documents, video, and audio). In this paper, we propose a unified multi-modal forensic framework that uses both convolutional neural networks and transformer-based architectures to detect manipulation artifacts/structural inconsistencies and implement a risk-aware fusion mechanism to produce a single score across all modalities that corresponds to one of the following four categories: Low (or also sometimes referred to as non- manipulated), Moderate, High, or Uncertain. Our framework was evaluated on three separate datasets: DFDC, ASVspoof, and CASIA v2.0, producing overall accuracies of 96.1%, 93.7%, and 95.2%, respectively. The false positive rate was reduced by approximately 62% when compared to any single modality approach. The proposed multi-modal forensic framework is applicable in many real-world situations, such as KYC verification, fraud detection, and digital evidence authentication. Keywords—Multi-modal forgery detection, Digital media integrity, Deepfake detection, Audio spoofing detection, Document forgery detection, CNN/Transformer fusion, Risk-aware fusion, Explainable AI, Digital Forensics.

32 PID-75: A Multimodal Deep Learning Approach for Context-Aware Image Caption Generation

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The integration of computer vision and natural language processing has led to significant advancements in automatic image caption generation. This paper presents a deep learning–based image captioning framework that integrates a Convolutional Neural Network

(CNN) encoder with a Recurrent Neural Network (RNN) decoder. A pre-trained ResNet-152 model extracts high-level visual features from images, which are then processed by an LSTM-based decoder to generate coherent and contextually meaningful textual descriptions. The model is evaluated on the MS COCO 2014 dataset using widely adopted metrics including ROUGE and SPICE. Experimental results show an average ROUGE-1 score of 0.7223, ROUGE-2 score of 0.5050, and ROUGE-L score of 0.7074, indicating strong lexical and structural similarity with reference captions. Additionally, a SPICE score of 0.7201 highlights the model's ability to capture semantic relationships between objects and their attributes, demonstrating the effectiveness of the proposed framework.

33 PID-76: AI-Enhanced Dynamic Intrusion Detection System with Resistance to Adversarial Attacks in Cloud Infrastructures

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Cloud computing platforms are increasingly susceptible to sophisticated cybersecurity risks that capitalize on the fluid nature of their architectures, rendering conventional intrusion detection mechanisms inadequate. This study introduces an Artificial Intelligence-Enabled Dynamic Intrusion Detection Framework (AI-DIDF) specifically engineered for cloud settings, featuring built-in defenses against manipulative adversarial inputs. The framework merges advanced neural networks with real-time adaptive algorithms and robust training methods to boost identification precision and durability. Testing on established intrusion benchmarks reveals that AI-DIDF surpasses traditional detection systems in scenarios involving adversarial distortions, achieving superior identification success and reduced erroneous alerts. The findings underscore the value of dynamic adaptation and fortified training in safeguarding cloud systems.

34 PID-79: AI-Based Disease Detection for Strawberry Cultivation in Vertical Farming Using Lightweight Deep Learning Models

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Vertical farming has emerged as a promising paradigm for sustainable food production in urban environments; however, the dense planting structure, artificial lighting, and high humidity inherent to such systems significantly increase the risk of rapid disease propagation. Strawberries, a high-value crop frequently cultivated in vertical farms, are particularly susceptible to foliar diseases such as leaf scorch (Diplocarpon earlianum) and leaf blight (Phomopsis obscurans), which adversely affect photosynthesis, fruit quality, and overall yield. Early disease detection is therefore critical, yet manual monitoring becomes impractical at scale. This paper proposes a dual-method deep learning framework for strawberry leaf disease detection and severity estimation in vertical farming environments. A real-world dataset of 8,790 images, collected from a commercial vertical farm under actual cultivation conditions, was used to evaluate six state-of-the-art classification architectures—VGG16, VGG19, EfficientNet-B0, InceptionV3, ResNet50, and Vision Transformer (ViT)—as well as a lightweight YOLOv8-nano object detection model for real-time deployment. Experimental results demonstrate that VGG19 achieves the highest classification accuracy of 99.36%, while YOLOv8-nano attains 87.2% mAP, enabling lesion localization and severity estimation on edge devices such as Raspberry Pi. Severity estimation shows strong agreement with expert assessments. A comprehensive economic analysis reveals a 12-day payback period for a 5,000-plant farm, highlighting the practical viability of the proposed system. The findings emphasize that deployment feasibility, energy efficiency, and economic return outweigh marginal accuracy gains in agricultural AI applications.

35 PID-84: Isolation and Screening of PP-Degrading Microorganisms from Agriculture soil

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Microplastics are emerging global pollutants that persist for long periods and threaten terres-

trial and aquatic ecosystems. Among the available plastic management strategies, including physical filtration and chemical treatment, microbial degradation has attracted considerable attention because it is environmentally friendly and cost-effective. Microorganisms capable of utilizing plastics as carbon sources offer a promising sustainable approach for reducing plastic pollution. Polypropylene (PP) is one of the most widely used synthetic polymers and is highly resistant to biodegradation due to its stable chemical structure and hydrophobic nature. The present study focuses on the isolation and screening of microorganisms capable of degrading PP microplastics from plastic dumping sites and agricultural mulch soils, environments that are continuously exposed to plastic residues. An indirect enrichment method was employed using Bushnell–Haas Broth (BHB), a minimal mineral salts medium supplemented with PP microplastics as the sole carbon source to selectively enrich potential degraders. After enrichment, bacterial isolates were obtained by plating and distinct colony morphologies were observed. Based on these differences, promising isolates were selected for further screening. The isolates were cultured in BHB containing PP microplastics as the only carbon source to evaluate their degradation potential. Several isolates showed measurable growth, indicating possible utilization or interaction with PP. Preliminary characterization of these potential PP-degrading isolates was performed using Gram staining, microscopic observation, and biochemical tests, revealing diverse physiological traits. Future work will include molecular identification using 16S rRNA sequencing and biodegradation assays under composting conditions following ASTM D5338 standards to assess weight loss, CO_2 evolution, and surface erosion. These analyses will validate their degradation potential study.

36 PID-92: AI-Driven Harvest Time Prediction and Quality Assessment: Integrated IoT-Based Smart Agriculture System for Optimized Crop Management

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The integration of Artificial Intelligence (AI), Machine Learning (ML), and Internet of Things (IoT) technologies represents a paradigm shift in modern agricultural practices. This comprehensive research paper presents a novel framework that combines predictive modeling, IoT-based data acquisition, environmental monitoring, and XGBoost algorithms for efficient harvest time prediction and quality assessment in high-value crops such as berries (strawberries) and leafy greens. The study encompasses both theoretical foundations and practical implementation through a vertical farming setup with four distinct irrigation and cultivation methods: Manual Irrigation (Section A), Continuous Drip Irrigation (Section B), Smart IoT-based Automated System (Section C), and Traditional Ground Cultivation (Section D). The proposed system integrates a comprehensive sensor array including temperature, humidity, soil moisture, pH, electrical conductivity, and light intensity sensors connected to a NodeMCU ESP32 microcontroller platform. Data is transmitted in real-time to Adafruit.io cloud services for remote monitoring and machine learning-based automated decision-making. Through 4+ months of experimental monitoring (January 2, 2021 to May 18, 2021), the study demonstrates that the smart IoT system achieved 15% higher crop yield compared to traditional methods, 90% water savings through precision irrigation scheduling, and superior plant survival rates (80% in Section C vs. 40-70% in other sections).

37 PID-93: ETL Performance Benchmark

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This study benchmarks four ETL architectures in Node.js with PostgreSQL using a large Stack Overflow dataset. Sequential processing, PostgreSQL COPY, multi threaded pipelines, and an edge based Cloudflare Workers approach are compared across execution time, throughput, and memory use. Results show that the edge based design sustains high performance with low memory consumption while bulk loading offers speed at the cost of scalability. The findings guide ETL architecture choices for varying data volumes and system constraints. Index Terms—ETL, Node.js, PostgreSQL, Cloudflare Workers, Edge Computing, Parallel Processing, Bulk Loading, Performance Benchmarking, Scalability, Throughput, Memory Optimization

38 PID-95: A Comprehensive Review of Quantum Machine Learning: Theoretical Foundations, Algorithms, and Applications

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Quantum Machine Learning (QML) stands at the intersection of quantum computing and classical machine learning, offering a promising paradigm to overcome the computational and data processing limitations inherent in traditional machine learning approaches. This review provides a comprehensive overview of QML, detailing its foundational principles rooted in quantum mechanics such as superposition, entanglement, and quantum parallelism. It explores how QML enhances traditional machine learning capabilities, including accelerated computation, efficient handling of high-dimensional data, improved optimization, and the generation of novel data representations. The paper then systematically compares existing QML algorithms, including Quan-tum Support Vector Machines (QSVMs), Quantum Neural Networks (QNNs), Variational Quantum Algorithms (VQAs), Quantum Generative Models, Quantum Anomaly Detection, Quantum Reinforcement Learning (QRL), and Quantum Principal Component Analysis (QPCA) highlighting their descriptions, advantages, and limitations. Further-more, it discusses the diverse applications of QML across fields like image classification, medical image analysis, natural language processing, and cybersecurity. Finally, the review addresses critical challenges such as hardware limitations, data encoding, noise propagation, and the nascent field of QML explainability, concluding with an out-look on future research directions necessary for realizing the full transformative potential of QML.

39 PID-97: Exploring Mixed Alkali Effect in Silicate Glasses Using Machine Learning Approach

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This study investigates the mixed alkali effect (MAE) in the SiO2–Li2O–Na2O ternary silicate glass system using an interpretable machine learning framework. A Random Forest regression model was trained on compositional data to predict the glass transition tempera-

ture (Tg), achieving a coefficient of determination $R^2 \approx 0.88$ and a mean absolute error of $\sim$19K. SHapley Additive exPlanations (SHAP) analysis was applied to quantify individual oxide contributions and reveal strong coupling between coexisting alkali oxides. Compositional sweep predictions identified non-linear Tg trends and stable compositional regimes, offering practical guidance for glass composition design. These results demonstrate that interpretable machine learning can provide quantitative mechanistic insights into the MAE and effectively complement experimental exploration.

40 PID-109: Association of Breast Cancer Patients with Alkaline phosphatase levels in North Indian Population

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The most common cancer worldwide today to be identified is breast cancer (BC), continues to be a global public health concern. Understanding BC, improvements and public awareness, in breast imaging have improved BC detection and screening. For women, the leading cause of death is BC and a potentially fatal illness. Although some women can live for many years, metastatic BC is regarded as an incurable disease with a bad prognostic. It has historically only been treated with medical attention. The belief was that breast surgery was only done to treat palliative symptoms like discomfort, infection, or local bleeding. It appears that this kind of cancer is very diverse and has biological characteristics that are both complex and potentially aggressive. However, the complex biology of this type of cancer is still unknown and unexplored, and management techniques, suggestions, and options are not age-based. Breast anatomy, risk factors, BC presentation, BC kinds, BC stages, and diagnostic tests are all included in this study. We only came across a small number of earlier researches that examined the correlation of the protein profile and liver function tests (LFTs) in female BC patients. So, our aim was to detect Alkaline phosphatase levels in BC patient in our current investigation. In order to conduct this study, which used a retrospective and observational methodology, 61 patients with BC were selected from a private hospital in the tri-city area. The duration for this study was 6 months. Depending on their age, the patients are split into two groups: Group I consisted of 28 patients under 45 years, while Group II included 33 patients over 45 years. In these individuals, Alkaline phosphatase levels were examined for

any notable increases or declines. The current investigation found an extensive association between BC patients and ALP levels. According to the study findings, patients with BC have an impact on their ALP levels

41 PID-114: Association of Breast Cancer Patients with SGOT (AST) and SGPT (ALT) levels in North Indian Population

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The most common cancer worldwide today to be identified is breast cancer (BC), continues to be a global public health concern. Understanding BC, improvements and public awareness, in breast imaging have improved BC detection and screening. For women, the leading cause of death is BC and a potentially fatal illness. Although some women can live for many years, metastatic BC is regarded as an incurable disease with a bad prognostic. It has historically only been treated with medical attention. The belief was that breast surgery was only done to treat palliative symptoms like discomfort, infection, or local bleeding. It appears that this kind of cancer is very diverse and has biological characteristics that are both complex and potentially aggressive. However, the 'complex' biology of this type of cancer is still unknown and unexplored, and management techniques, suggestions, and options are not age-based. Breast anatomy, risk factors, BC presentation, BC kinds, BC stages, and diagnostic tests are all included in this study. We only came across a small number of earlier researches that examined the correlation of the SGOT (AST) and SGPT(ALT) in female BC patients. Assessing if SGOT (AST) and SGPT(ALT) are linked to BC patients is the aim of our current investigation. In order to conduct this study, which used a retrospective and observational methodology, 61 patients with BC were selected from a private hospital in the tri-city area. The duration for this study is January 1, 2025, to April 15, 2025. Depending on their age, the patients are split into two groups: Group I consisted of 28 patients under 45 years, while Group II included 33 patients over 45 years. These individuals' SGOT (AST) and SGPT(ALT) levels are examined for any notable increases or declines. The current investigation found an extensive association between BC patients and SGOT and SGPT levels. According to the study's findings, patients with BC have an impact on their SGOT and SGPT levels

42 PID-115: Association of Breast Cancer Patients with Blood Urea levels in North Indian Population

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Breast cancer (BC) continues to rank among the top contributors to cancer-related mortality in women, despite its distinct epidemiological patterns and notable variation. Disruption of specific cells in breast tissue that proliferate and divide uncontrollably leads to BC. These cells typically build together to create a lump known as a tumor, which can be benign or malignant. Mutations in genes such as BRCA1 and BRCA2 have been identified to pass down the risk of BC from parents to kids. BC detection and treatment approaches have changed dramatically over the last two decades, with an emphasis on minimizing patient discomfort, increasing patient compliance, and reducing off-target adverse effects. Urea is the major metabolite resulting from food protein and tissue protein turnover. Malignant tumors improperly metabolize both food and host proteins, which leads to a negative nitrogen balance. Breast cancer cells evade the damaging effects of ammonia by transforming it into useable nitrogen, a required factor for the rapid growth of tumors. The changes in BC development and progression will alter the levels of hematological and biochemical parameters. Previous studies reported an association of some hematological and biochemical parameters with BC, but most of the studies are from other countries. It is essential to find the association between blood urea with BC patients in the north Indian population. We conducted cross-sectional and retrospective research in a private hospital from 1 January 2025 to 15 April 2025. The research was comprised of 61 BC patients. We divided the patients based on age: ¡45 (group I) and ¿45 (group II). The study showed that there is a significant correlation between blood urea and BC patients. The findings suggest that the presence of BC influence the level of blood urea

43 PID-116: Disease Prediction Analysis: Predicting Health Outcomes Through Patient Data Insights

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The healthcare sector is one of the fastest-evolving sectors presently, as medical data are increasing and the need for quicker yet accurate diagnosis is becoming more crucial. Early detection of diseases such as diabetes, heart disease, and kidney disorders provides an edge in minimizing health hazards and ensuring better health outcomes. A Multiple Disease Prediction System is being proposed in this context, which will use three supervised machine learning models—Logistic Regression, Decision Tree, and Random Forest—to estimate the probabilities of different diseases based on patient symptoms and medical data. The system follows a straightforward workflow: cleaning and organizing the data, selecting the most relevant features, and training the machine learning models. Later, the trained models are tested using evaluation measures such as accuracy, precision, and recall to gauge the effectiveness of their predictive abilities. Among the models, Random Forest shows strong performance due to its ensemble structure, while Logistic Regression provides easy-to-read probability outputs, and the Decision Tree offers simple rule-based predictions. It will also help healthcare professionals make quicker assessments and provide a basic understanding of their health status to patients. Future developments might include the addition of more diseases, real-time data from the latest wearable gadgets, and a full mobile or web-based platform for healthcare services.

44 PID-117: Improving DDoS Resilience Through Intelligent Detection and Load-Aware Traffic Redistribution

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The growing use of cloud computing, Software Defined Networking (SDN), and Internet of Things (IoT) environments has increased this risk DDOS Attacks. Conventional detection techniques, which depend on rules and signatures, frequently overlook how DDoS attacks are evolving. As a result, there are numerous false positives and delays in thwarting these attempts. In this study, a machine learning-based architecture for precise DDoS attack detection and efficient mitigation is proposed. In order to differentiate between benign and malicious traffic, the system uses flow-based network traffic characteristics to assess five

supervised classifiers: K-Nearest Neighbors (KNN), Support Vector Machine (SVM), Decision Tree, Random Forest, and Gradient Boosting. The suggested model makes use of a more deployment-relevant dataset to enhance generalization, in contrast to traditional methods that depend on benchmark datasets. The Decision Tree classifier obtains the greatest accuracy of 99.97%, with near-perfect precision, recall, and F1-score across many traffic classifications, according to experimental data. To lessen the effect of attacks, the framework incorporates adaptive load balancing and dynamic rate restriction in addition to detection. In the event of an attack, these methods ensure service availability, maximize resource use, and drastically minimize traffic congestion. The findings show that a scalable and efficient solution for real-time DDoS protection may be achieved by integrating adaptive mitigation techniques with high-accuracy machine learning models.

45 PID-128: Enabling Secure Intelligent Network with Cloud-Assisted Privacy-Preserving Machine Learning

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With the increasing use of smart devices and data-driven applications, protecting user privacy while enabling effective machine learning has become a major concern. Traditional approaches that collect and store data in centralized servers are no longer reliable due to risks such as data breaches and regulatory restrictions. This paper presents a cloud-assisted privacy-preserving machine learning framework that allows multiple devices to collaboratively train a model without sharing their raw data. The proposed system uses federated learning, along with techniques like differential privacy and secure aggregation, to ensure that sensitive information remains protected. Each device trains the model locally and only shares secure updates with a central cloud server, reducing the chances of data leakage. The framework also considers real-world challenges such as limited network connectivity and device variability by reducing communication overhead and supporting efficient model updates. The system is evaluated based on privacy guarantees, model performance, and resistance to potential security threats. Overall, the proposed approach demonstrates that it is possible

to build intelligent systems that are both efficient and privacy-aware, making them suitable for applications in healthcare, IoT, and smart environments.

46 PID-132: NAS-based Compression for Single Image Dehazing using a CoA Framework

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Single Image Dehazing (SID) aims to recover clear scene radiance from a single degraded hazy image. SID is critical for autonomous driving, intelligent transportation systems, and outdoor surveillance. The original clear scene undergoes attenuation while airlight is added, forming the basis of classical Atmospheric Scattering Model (ASM). CNN-based models effectively extract local information but are limited in modelling global scene context, leading to Vision Transformers (ViTs) which model global dependencies more effectively but are computationally intensive. The above addressed models are unsuitable for resource constrained devices. The proposed model builds on the Compressed-oriented-Adaptation (CoA) framework which employs a teacher-student model to guide a lightweight student model with a high-capacity teacher. Proposed model, integrates Neural Architecture Search (NAS) in the compression module, enabling automatic learning of efficient architectures under resource constraints, replacing manually designed components.

47 PID-141: KRISH-E Smart Crop Advisory for Small and Marginal Farmers

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Agriculture plays a vital role in India's economy, supporting a significant portion of the population and contributing notably to the national income. However, many small-scale farmers

still depend on traditional knowledge rather than data-driven decision-making, which often leads to inefficient crop selection and delayed disease detection. This paper presents KRISH-E, a web-based intelligent crop advisory system that combines multiple machine learning techniques for recommending suitable crops and detecting plant diseases. Various supervised learning models, including Decision Tree, Support Vector Machine, Naïve Bayes, Random Forest, and XGBoost, are used to analyze soil parameters such as nitrogen, phosphorus, potassium, pH, temperature, humidity, and rainfall. Additionally, a Convolutional Neural Network (CNN) is employed for identifying plant diseases from leaf images. Experimental results show that ensemble models, particularly Random Forest, provide high prediction accuracy. The system aims to assist farmers by delivering reliable recommendations through an easy-to-use interface, thereby improving productivity and reducing uncertainty in agricultural practices.

48 PID-157: Navigating the AI J-Curve: A Comparative Cliometric Analysis of the Productivity Paradox Across General Purpose Technologies

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This study investigates the Productivity Paradox—the persistent lag between technological innovation and measurable economic growth—through the lens of Cliometrics. While massive investments have been made in Artificial Intelligence and digital infrastructure as of 2026, national productivity statistics remain sluggish. To determine if this current stagnation mirrors historical patterns, this research employs a secondary data methodology utilizing historical GDP and labor productivity datasets from the Maddison Project Database and the Economic History Association (EH.net). A comparative quantitative analysis maps the J-Curve of the 19th-century British Industrial Revolution against the 21st-century digital economy, specifically comparing metrics across the Age of Steam (1780–1830), the Age of Electricity (1890–1920), and the current Age of AI (2010–2026). Drawing on literature regarding General Purpose Technologies (GPTs), the study expects to find that the current AI Paradox results from an implementation lag driven by outdated institutional habits. Anticipated data will likely reveal a repeating historical pattern where productivity only spikes following a systemic redesign of workflows, rather than the mere adoption of new tools.

Ultimately, by proving that technological lags are a repeating historical necessity, this research provides a roadmap for modern policymakers and business leaders to navigate the productivity dip, contributing to more realistic economic forecasting and practical shifts in management practices.

49 PID-158: Cost–Performance Co-Optimized Design of a Compact EMG Acquisition System for Assistive Communication Applications

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Silent Speech Interfaces (SSI) enable communication without relying on acoustic signals by interpreting articulatory muscle movements. Electromyography (EMG) is a promising modality for SSI because it captures the electrical activity generated by facial muscles during speech articulation. However, many existing EMG-based systems rely on high-cost sensing hardware and external computing platforms for signal processing and inference, which limits their portability and real-time applicability. This work primarily focuses on the development of a hardware-efficient silent speech recognition system using FPGA-based neural network inference. A lightweight neural network will be trained to recognize silently articulated Hindi words from EMG signals. After training, the model will be deployed on an FPGA platform to perform real-time inference. Implementing neural network inference directly on reconfigurable hardware enables low-latency processing, improved energy efficiency, and reduced dependency on external computing resources, making the system more suitable for embedded and portable assistive technologies. To support this objective, an EMG acquisition pipeline will also be developed to capture facial muscle signals. The analog front-end consists of an instrumentation amplifier and basic filtering stages to amplify weak EMG signals and suppress noise before digitization using an Analog-to-Digital Converter (ADC). The digitized signals will then be used for model training and evaluation. Overall, this work investigates the feasibility of integrating EMG sensing with FPGA-based neural network acceleration to create a compact, real-time silent speech interface capable of translating silently articulated words into text.

50 PID-160: Performance comparison of AI-Based Techniques for Stock Price Movement Prediction

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The prediction of stock price movement has always intrigued investors. The accurate forecasting of stock price movements is a critical and challenging task in computational finance. Multiple factors, including macroeconomic events, corporate announcements, investor sentiment, and inter-stock relationships, affect its price movement. Substantial research has been carried out to address this challenging computational finance problem. The existing AI-based stock price prediction techniques exploit fusion strategies that have issues in handling the noise, sparsity, and semantic inconsistency of real-world financial data. So a comparative analysis of these techniques and their performance is critical, which includes the key features and experimental results with real datasets.

51 PID-161: Design of Smart Home Energy Conservation System

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The rapid growth in residential electricity consumption has emerged as a critical global concern due to rising energy costs, increasing carbon emissions, and the depletion of natural resources. A large portion of household energy is wasted due to inefficient usage patterns, unattended appliances, and lack of monitoring. Traditional energy-saving approaches rely heavily on manual control, which are unreliable and inconsistent. With the advancement of the Internet of Things (IoT), sensor technologies, and intelligent automation, smart home systems present a promising solution to address these inefficiencies. This abstract aims to develop a smart home automation project to avoid inefficient usage pattern and eliminate the need of manual control. The project also aims to cut down the carbon emission by sustainable growth and minimising the waste of electricity.

52 PID-163: Design and Analysis of a Hyperthermia Applicator for Skin Tumor Treatment

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The increasing global prevalence of cancer and the limitations associated with conventional treatments such as chemotherapy and radiotherapy have driven the need for safer and more effective therapeutic techniques. Microwave hyperthermia has emerged as a promising non-invasive approach that selectively elevates tumor temperature to a therapeutic range of 41–45 °C, enhancing treatment efficacy while minimizing damage to surrounding healthy tissues. However, achieving precise energy deposition and controlled heating remains a major challenge in clinical applications. This research focuses on the design and development of a compact, non-invasive microwave antenna for localized cancer hyperthermia treatment. The proposed system aims to improve electromagnetic coupling between the antenna and biological tissues to ensure efficient microwave energy delivery. The antenna design is optimized to maximize Specific Absorption Rate (SAR) within malignant tissues while minimizing unwanted heating in healthy regions. Advanced computational tools such as CST or HFSS are used to model and simulate antenna performance parameters including reflection coefficient, gain, and radiation patterns. A multilayer human tissue model consisting of skin, fat, muscle, and tumor is developed to analyze SAR distribution and penetration depth. Thermal analysis is performed using bio-heat equations to evaluate temperature distribution and ensure it remains within the therapeutic range. Additionally, tissue-equivalent phantom models are designed for experimental validation of antenna performance. The study also investigates techniques such as impedance matching and field focusing to enhance heating uniformity and depth of penetration. The expected outcomes of this research include the development of a compact and efficient antenna capable of delivering targeted heating, improved SAR concentration in tumor regions, stable performance in biological environments, and validated experimental results.

53 PID-165: Investigating the Effect of Driver Seat Height Adjustment on Driving Skill and Control of Passenger Vehicle During Parking

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The present study examines the impact of driver seat adjustment on car parking performance. The study involved 35 participants who voluntarily performed into three different types of parking operations under Low and High seating configurations. The quantitative analysis indicates significant efficiency and accuracy gains with elevated seating. There is 18.8% reduction in total parking time and an 18.5% reduction in the total number of attempts required for successful parking operations. The observations revealed a substantial reduction in the frequency of brake (26%) and clutch (21%) applications, suggesting that higher seating positions spatial awareness, thereby reducing operational workload and increasing driver confidence. Study highlights the importance of seat height adjustment feature for all variants of the passenger vehicles in optimizing urban driving tasks.

54 PID-166: The Mirror of Desire: Deconstructing the Autonomous Self through Girard's Mimetic Theory

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This study aims to investigate how mimetic desire, as theorized by René Girard, shapes the aspirations, self-concept, and identity formation of Gen Z individuals, ultimately challenging the notion of autonomous selfhood. Specifies primary data (interviews, focus groups with Gen Z), secondary data (Girard's books, articles), and analysis method (thematic analysis). Grounded in Girard's literature, the study is expected to reveal that Gen Z's desires—for careers, aesthetics, relationships, and consumer goods—are not internally generated but are imitated from digital and social models, thereby validating Girard's concept of triangular desire in a contemporary context. It is further expected to identify unique digital-age patterns, such as the role of social media influencers acting as internal mediators and the amplifi-

cation of mimetic rivalry through algorithmic content curation. Highlights the empirical contribution (new data on Gen Z), Theoretical contribution (bridging philosophy with lived experience) and practical implications (for educators, mental health).

55 PID-167: Integrative Multi-Omics Approaches for Understanding and Predicting Neurodegenerative Diseases

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Neurodegenerative diseases such as Parkinson's disease, Amyotrophic Lateral Sclerosis, Huntington's disease, and Frontotemporal Dementia present significant challenges due to their progressive nature and complex molecular basis. Traditional single-omics studies often fail to capture interactions across biological layers. This work proposes an integrative computational framework combining genomic, transcriptomic, proteomic, and metabolomic data from public repositories including AMP-PD, GEO, PRIDE, and Metabolomics Workbench. Machine learning models such as Random Forest, Support Vector Machines, and deep learning approaches are employed for disease classification and progression prediction. Feature selection techniques including Boruta, LASSO, and mutual information are used to identify robust biomarkers. Additionally, survival analysis and pathway enrichment methods are applied to understand disease mechanisms. The proposed approach aims to improve early diagnosis, enhance patient stratification, and provide biologically meaningful insights into neurodegeneration. Furthermore, the framework emphasizes comparative evaluation of multiple integration strategies to determine the most effective approach for capturing cross-omics interactions. By leveraging large-scale datasets and robust validation techniques, this study seeks to bridge the gap between computational predictions and clinical applicability, ultimately contributing to the advancement of precision medicine in neurodegenerative disorders. The outcomes of this work may also support the identification of novel therapeutic targets and improve decision-making in clinical research settings. In addition, the framework is designed to be scalable and adaptable, enabling its application to other complex diseases where multi-omics integration can provide valuable insights into disease mechanisms.

56 PID-168: Deep Learning Modeling and Optimization of CRISPR-Cas9 Off-Target Effects Using Genomic Sequence Features

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CRISPR-Cas9 genome editing has emerged as a powerful tool for precise genetic modification and therapeutic genome engineering. Despite its high efficiency, unintended off-target cleavage remains a significant challenge, posing risks for clinical applications. Existing computational approaches often rely on heuristic mismatch scoring or manually engineered features, which fail to capture complex sequence dependencies and contextual genomic interactions. This study proposes a deep learning-based framework to model and predict CRISPR-Cas9 off-target effects using genomic sequence features. The framework integrates curated datasets from high-throughput experimental platforms such as GUIDE-seq and CIRCLE-seq, enabling robust supervised learning across diverse biological conditions. Genomic sequences are encoded using advanced representation techniques to preserve nucleotide-level and positional information. Deep learning architectures, including convolutional neural networks (CNNs) and transformer-based models, are developed to capture both local sequence motifs and long-range dependencies influencing off-target activity. To enhance interpretability, explainable AI methods such as SHAP and LIME are incorporated to identify critical sequence features contributing to model predictions. The proposed approach also employs cross-dataset validation to evaluate generalization across experimental platforms and cell types. By combining predictive modeling with biological interpretability, this work aims to improve off-target prediction accuracy, support safer guide RNA design, and contribute to the advancement of reliable and clinically applicable genome editing technologies.

57 PID-171: Predicting Academic Performance from Sleep Patterns: A Machine Learning Approach

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Sleep is often treated as something students can sacrifice when deadlines pile up, but in reality, it plays a much deeper role in how well they perform academically. Many earlier studies have tried to link sleep with performance, but most rely on self-reported data, which is not always reliable. In this work, we take a more data-driven approach. We collected structured information from 375 undergraduate students, focusing on sleep duration, consistency of sleep schedules, and screen usage before bedtime. Using this data, we trained five machine learning models to classify students into high and low GPA groups. Among all models, the Decision Tree performed the best, achieving an accuracy of 97.33%. Random Forest, Naive Bayes, and Gradient Boosting followed with accuracies around 91–92%, while Logistic Regression performed significantly lower at 63%. Interestingly, the results showed that consistency in sleep patterns was just as important as total sleep duration. These findings suggest that sleep behavior, especially regularity, has a strong relationship with academic outcomes. The study also briefly explores the potential of real-time prediction using sequential models like LSTM, while highlighting the importance of privacy and ethical considerations in such systems.

58 PID-174: Microlearning as an Emerging Paradigm in Education: A Review

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Microlearning is a modern pedagogical approach that delivers content in small, focused units. This paper reviews the current landscape of microlearning, and explores its applications, benefits and limitations across domains such as healthcare training, professional training and formal education. A literature review methodology was adopted, where Google Scholar

database was used to find relevant studies using the keywords “Microlearning” and “Just-In-Time” learning. The review suggests that microlearning improves overall memory retention and cognitive behaviour, and is overall more engaging when compared to traditional learning methods. However, the study also highlights that microlearning is best used as a supplement to the conventional methods, rather than a complete replacement. Moreover, frameworks need to be built before we can adopt microlearning on a global scale.

59 PID-175: Explainable Automated Grading Using BERT: A Review

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Automated assessment systems are essential in modern education for delivering timely feedback and ensuring consistent, rubric-based evaluation, particularly for complex tasks such as laboratory reports. However, many existing methods rely on surface-level similarity measures and lack transparency in scoring. This paper proposes a conceptual framework for automated grading based on Bidirectional Encoder Representations from Transformers (BERT) and its variants, developed through a structured literature review. The framework emphasizes both accurate score prediction and the generation of rubric-aligned explanations for student responses. Prior studies demonstrate that transformer-based models, including BERT, DistilBERT, RoBERTa, ALBERT, and XLM-RoBERTa, outperform traditional feature-based approaches in terms of accuracy and quadratic weighted kappa. Despite these advancements, challenges related to computational complexity, interpretability, fairness, and practical usability persist. The findings indicate a clear transition from conventional scoring techniques to context-aware and explainable automated grading systems.

60 PID-176: Energy-Aware HPC Framework for Mutation-Driven Protein Folding Analysis of HBB Variants in Sickle Cell Disease

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Deep learning–based protein folding models such as AlphaFold have enabled highly accurate structural prediction directly from amino acid sequences, but their large-scale deployment relies on GPU-accelerated high-performance computing (HPC) systems with significant energy demands. This work proposes a mutation aware, energy-efficient framework for analyzing protein folding workloads in GPU-enabled HPC environments. Using clinically relevant HBB gene variants associated with sickle cell disease, mutation-specific sequences are processed through GPU-accelerated folding pipelines. Structural perturbations between wild-type and mutant proteins are quantified using root mean square deviation (RMSD) and thermodynamic stability change (). Concurrently, execution-level metrics including runtime, GPU utilization, and power consumption are monitored. Energy consumption is modeled as the time integral of instantaneous power usage and evaluated using the Energy–Delay Product (EDP). The proposed framework enables systematic characterization of the energy behavior of mutation-driven folding workloads and provides insights for improving the efficiency of large-scale protein structure prediction pipeline

61 PID-177: Scalable Data-Driven Monitoring Framework for Performance and Fault Analysis of Large and Distributed Solar Power Plants

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Solar energy is one of the fastest-growing renewable energy sources, with large-scale and geographically distributed solar power plants being rapidly deployed. However, monitoring and managing such systems remains a major challenge. Existing monitoring solutions are primarily designed for small or localised plants and lack scalability when handling large data volumes and multiple installations. They often provide only basic visualisation with limited support for centralised performance analysis and early fault detection, leading to unnoticed performance degradation and increased maintenance costs. This research proposes a scalable, software-based data-driven monitoring framework for large and distributed solar power plants. The framework enables centralised real-time data collection, structured processing, and performance comparison across multiple installations. It facilitates systematic performance analysis and early identification of underperforming units and abnormal conditions. The proposed architecture ensures easy integration of new plants without significant modifi-

cations, supporting scalability and cost-effectiveness. The framework can also be extended to incorporate advanced analytics such as machine learning for predictive maintenance. Overall, the system aims to improve reliability, efficiency, and fault management in large-scale solar power systems.

62 PID-178: A Hybrid Multimodal Architecture for Secure Agentic Personal Assistants

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The current deployments Local Executive Frameworks introduce significant security vulnerabilities such as unauthorized access to sensitive system-level commands and the exposure of private data of the user. A Privacy-first AI Model for user's safety and secrecy is also as part of the study. Our proposed framework introduces a biometric verification layer which utilizes a real-time computer vision as a mandatory security layer which does not let an unauthorized user to use executive functions. To ensure the privacy of the user, the system process termination upon biometric failure and restricted credential retry limits. The high-privilege actions are only carried out when the authorized user is physically verified by the two-factor authentication layers and effectively reducing the Confused Deputy problem. We have also implemented a structured local logging mechanism that stores previous conversations that happened between the system and the user across sessions without depending on cloud-based external servers. It further keeps user's privacy as top priority by using a local database. The assistant stores the previous conversational data while maintaining a strict privacy from the external servers. Various tests against attempts to gain unauthorized access by providing fake credentials are used to validate our framework. In addition, to demonstrate the high-speed inference and hardened security of the system, we tested the base speed of responses and operations. We provide a scalable blueprint idea which demonstrates that advanced multimodal reasoning can coexist with strict privacy and security for the user's sensitive data. We have implemented a secure and low latency interface that maintains system integrity across different device environments such as Windows and Android.

63 PID-182: Crop yield prediction using machine learning

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Accurate crop yield forecasting is crucial for stakeholders' decision-making regarding risk management and food security. This study evaluates various machine learning models—Multiple Linear Regression, Support Vector Regression, K-Nearest Neighbors, Random Forest, Multilayer Perceptron, and decision/regression trees—using publicly available data on pesticides, rainfall, temperature, and historical yields. After data pre-processing, models are assessed using metrics such as RMSE and MAE. Results indicate that ensemble and tree-based methods outperform simpler linear models, even with limited data. Feature importance analysis helps identify key variables influencing yield estimates, while challenges like overfitting and model transferability are discussed, along with future improvements using deep learning and remote sensing for better predictive capabilities.

64 PID-183: NLP-Based Mental Wellness Chatbot with Suicide Alert Email System and Spotify Mood-Based Song Recommendations for Students

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Aditya Vijay, SRM Institute of Science and Technology
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The problem of mental health has become a more important issue as the impact of using digital communication and interactions on social media on human behavior has become even greater. Automated systems can be used to identify emotional distress at an early stage in order to support and intervene in time. This paper introduces an artificial intelligence framework of monitoring mental wellness by textual communication. The suggested system combines a conversational interface and emotion analysis model to understand the input user and extract the underlying emotional patterns. The framework is a combination of machine learning and the natural language processing methods to categorize the emotional

states based on text messages shared between users and the chatbot. Its system architecture consists of user interaction web based interface, data processing and communication backend service and a trained model that does the emotion prediction. In case the observed emotional condition provides evidence of possible psychological distress, the system gives supportive responses and allows a notification mechanism to alert a registered guardian. This strategy aims at enabling constant tracking of the emotional state of the users and keeping the environment friendly and interactive. Combining conversational assistance with automated emotion recognition is expected to offer a helping digital platform that could prompt the users to share their ideas and make them recognize vital situations in time. The mentioned framework shows that artificial intelligence and web technologies may be integrated to aid mental wellness monitoring by performing systematic textual communication analysis.

65 PID-184: Plastic vs. Non-Plastic Waste Classification Using EfficientNet-B0 Transfer Learning

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Plastic pollution is one of the most pressing environmental challenges today, with global output exceeding 300 million tons annually and manual sorting methods proving wholly inadequate at scale. We present a binary image classifier built on EfficientNet-B0 transfer learning that separates plastic from non-plastic waste with 99.2% validation accuracy and zero false negatives on a 35,209-image dataset. Against a MobileNetV2 baseline trained under identical conditions, EfficientNet-B0 delivers a 5.41-point accuracy gain and eliminates the 123 false negatives that MobileNetV2 produces at its default threshold false negatives that would contaminate recycling streams in production. Real-time inference at 15–20 FPS on commodity CPU hardware demonstrates practical deployability without specialized equipment.

66 PID-185: Multi-modal CKD Risk Stratification: Fusing BioBERT-Encoded Drug Labels with Clinical Biomarkers using XGBoost

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Chronic Kidney Disease (CKD) impacts almost 10% of adults globally, and it is frequently developing silently in an individual to become End-Stage Renal Disease (ESRD), necessitating immediate risk assessment. Current models are based on data of structured clinical parameters such as GFR, serum creatinine, and blood pressure but neglect pharmacological events controlling disease progression. Drug-induced nephrotoxicity, particularly when polypharmacy occurs, is one of the most potent but least-exploited predictors, as related information is usually encoded in unstructured data sources, including drug labels. We present a multimodal learning framework for combining structured clinical data with semantic representations from drug-related text. Here we present a 1,659 patient sample dataset over 37 features pre-processed via imputation and normalization. BioBERT was used to encode drug label information, which generates embeddings capturing hidden nephrotoxic signals. These embeddings applied with clinical characteristics were included in data models such as Logistic Regression, Random Forest and XGBoost. The multimodal approach outperformed unimodal models with a total of 96.00% accuracy, 0.9498 F1-score, and 0.9982 AUC on XGBoost. Text-based embedding contributed approximately 24% of total performance while demonstrating the significant importance of pharmaceutical data. The results indicate high sensitivity and small misclassification, which enhances identification of high risk patients. This framework helps optimize CKD risk stratification by integrating clinical and text data, with future work primarily directed towards validation and interpretability.

67 PID-186: Computational Analysis of Missense Variants in BRCA1 and RAD51 Genes Involved in Homologous Recombination Repair

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Hereditary Breast and Ovarian Cancer (HBOC) is driven by germline mutations in DNA repair genes that elevate cancer risk. The homologous recombination (HR) pathway maintains genomic stability, with BRCA1 coordinating DNA damage signalling and RAD51 mediating strand invasion and repair. Disruption of this pathway leads to genomic instability and carcinogenesis, while missense variant interpretation is difficult due to the high prevalence of variants of uncertain significance (VUS) and conflicting classifications. Research Objective: To analyse missense variants in BRCA1 and RAD51 to identify impactful variants and detect patterns in conserved domains, prioritising those that may impair homologous recombination repair.
Methodology: Missense variants of BRCA1 and RAD51 were retrieved from dbSNP and analysed using multiple tools. Cross-tool comparison identified consistent and conflicting predictions. Variants were mapped to domains using InterPro, and selected variants will undergo 3D structural modelling.
Key Results: A total of 4788 single nucleotide variants were retrieved for BRCA1, of which 4633 were selected based on SIFT. Multi-tool comparison identified 12 deleterious variants, 11 localised to the Zinc/RING finger (C3HC4) domain, a zinc-binding motif involved in ubiquitination and protein interactions in DNA repair. For RAD51, 474 variants were retrieved, with 84 selected based on SIFT and 10 identified as deleterious, 9 mapping to RecA-like ATPase domain (Pfam: PF08423), essential for DNA strand pairing and invasion and 1 mapping to cathgene3d G3DSA:1.10.150.20 involved in DNA repair and DNA metabolic processes.
Conclusion: Combining multi-tool prediction with domain mapping enables identification and prioritisation of impactful missense variants in BRCA1 and RAD51. Clustering in conserved domains suggests disruption of HR pathway. Future structural modelling is expected to improve VUS interpretation and guide future hereditary cancer research.

68 PID-187: Driver Visibility Challenges, Risks and Safety Solutions for Driving in Dense Fog

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Reduced visibility due to fog is a major safety challenge for road transportation systems. As a result, drivers face difficulties in detecting obstacles, estimating distances, and recognizing road boundaries, which increases the risk of road accidents. Fog is a major cause of road accidents in India, particularly in regions like the Indo-Gangetic Plain, where dense winter fog can reduce visibility to below 200 meters. In addition, limited driver situational awareness under foggy conditions highlights the need for supportive systems that enhance safety. This study analyses key driver visibility challenges in fog conditions, reviews existing sensing technologies, and highlights the need for cost-effective technological solutions to improve driver awareness and enhance road safety during fog-affected driving conditions.

69 PID-189: Out of Body Experiences

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The purpose of this study is to investigate the nature, cause, and effects of Out-of-Body Experiences and the various psychological, neurological, and spiritual factors that lead to OBEs and examine them as a phenomenon of altered states of consciousness, and also to investigate the ways in which individuals perceive and interpret Out-of-Body Experiences and the effects of these experiences on the individual's beliefs and perceptions of reality.

70 PID-191: Chronos: Adaptive CPU GPU Co Scheduling for Multi Omics Machine Learning Workloads

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Efficient training of machine learning models requires coordinated scheduling of heteroge-

neous resources, particularly CPUs and GPUs. Conventional frameworks often separate CPU orchestration from GPU execution, leading to underutilization and higher latency for high-dimensional biomedical workloads. We advance Chronos, an adaptive CPU–GPU co-scheduling framework that aligns workload characteristics with low-level hardware policies to optimize training performance. Chronos is evaluated on a real-world multi-omics dataset for preterm birth prediction, integrating plasma cell-free RNA transcriptomics (20,659 features), targeted plasma proteomics (1,002 proteins), and urine metabolomics (6,630 metabolites) collected early in pregnancy from 81 participants across four international cohorts (39 preterm, 42 term). The dataset's high-dimensional, multimodal structure generates diverse computational patterns suitable for scheduling analysis. Baseline ensemble models achieve an AUROC of approximately 0.83 with modality integration. Chronos constructs workload signatures capturing computational intensity, memory demand, and kernel diversity, enabling dynamic adaptation of CPU policies and GPU execution strategies. Prototype results demonstrate reduced training latency and improved resource coordination, supporting adaptive optimization for data-intensive biomedical machine learning systems.

71 PID-192: Physics-Informed Machine Learning for Remaining Useful Life Prediction of Aircraft Gas Turbine Engines

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Predictive maintenance for aircraft gas turbine engines depends on accurate Remaining Useful Life (RUL) prediction. Conventional maintenance techniques rely on set schedules, which frequently result in ineffective component use or unplanned failures. Based on the NASA C-MAPSS turbofan engine dataset, this study explores a data-driven method for RUL prediction using deep learning models. Multivariate time-series sensor data is modelled using a Temporal Convolutional Network (TCN). Correlation analysis is used in feature selection to find the most informative degradation-sensitive sensors. The regression problem is stabilised by capping Remaining Useful Life values at 125 cycles, and information leakage is avoided by using an engine level data split. Time-series windows are created for model training, and sensor data is normalised using training-set statistics. According to preliminary findings, the suggested TCN model exhibits strong predictive ability, achieving an RMSE of roughly 17 cycles on the FD001 dataset. The outcomes demonstrate how well temporal convolutional

architectures work for predictive maintenance applications when paired with appropriate data preprocessing methods.

72 PID-193: Digital Twin Architecture for Predicting Fatigue in High-Stress Parts in Real Time

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Industrial machinery that runs under cyclical mechanical loads—think flanged couplings, stop valves, and high-cycle testing rigs—faces ongoing material fatigue. If nobody catches it in time, this stress builds up and leads to catastrophic structural failure. Standard maintenance routines, whether they're based on schedules or monitored conditions, miss the mark because they don't track the real-time, component-level wear and tear happening in active machines. This paper lays out a framework for turning static three-dimensional CAD models of these assemblies into living digital twins, synced with sensors and updated in real time to mirror the physical state of the machinery. By combining live telemetry from strain gauges, torsion sensors, and thermocouples with finite element analysis (FEA) solvers and physics-informed machine learning models, this system makes it possible to predict fatigue life for each component accurately. It creates a predictive maintenance setup that flags parts at risk of failing weeks before trouble hits. In the end, you get less unplanned downtime, longer intervals between services, and a solid empirical foundation for recertifying components. This research provides a replicable, open-architecture framework for modernizing legacy mechanical assets with the predictive capabilities of Industry 4.0.

73 PID-194: Multimodal Prediction of Cognitive Fatigue Using Survey-Based Behavioural Data and Reaction Time Analysis with Machine Learning

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This study is an investigation of the application of machine learning in predicting cognitive fatigue among university students by incorporating behavioural, psychological, and physio-

logical factors. A pilot survey was conducted, and data were collected from 52 students by employing a series of validated measures to collect data on sleep quality, perceived stress, fatigue, screen time, physical activity, caffeine intake, and reaction time. As a result of a limited sample size, data augmentation was applied to increase the sample size to 300 while maintaining statistical patterns and relationships. Here, we implement a Random Forest classifier, the approach involves to classify and predict cognitive fatigue among university students by identifying various levels of fatigue, such as low, moderate, and high, with a cross-validated accuracy of 86.0% (+-4.5%) and a test accuracy of 83.3%, showing a stable and consistent performance of the model in predicting cognitive fatigue among university students. Therefore, it was found that sleep quality (37.7%), perceived stress (33.8%), and reaction time (28.5%) played a crucial role in predicting cognitive fatigue among university students, suggesting a strong correlation with established biological patterns of cognitive fatigue. On the other hand, behavioural factors such as screen time and physical activity contributed least in predicting cognitive fatigue, though they might have an impact on predicting cognitive fatigue indirectly by showing a strong correlation with sleep and perceived stress variables. Consequently, these results suggest that integrating subjective and objective measures by applying a machine learning algorithm is effective in cognitive fatigue prediction, which might lay a foundation for future research in developing a system to monitor fatigue in various settings, such as academia and workplaces.

74 PID-195: Design and Analysis of a Chaotic Circuit based on CMOS Active Inductor and its Application

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Nonlinear circuits that exhibit chaotic behaviour have become increasingly important in secure signal processing research. Chua's circuit, introduced by Leon O. Chua, is one of the most well-known simple setups with just two capacitors, one inductor, one resistor, and a nonlinear element called Chua's diode, capable of producing chaotic and double-scroll behaviours. Its underlying inspiration comes from Lorenz attractors and the butterfly effect, which is the idea that tiny changes in initial conditions can lead to drastically different outcomes. However, passive spiral inductors used in Chua's circuit take up large silicon area

and perform poorly at high frequencies, making them difficult to fit into miniature Integrated Circuits. This work tackles that problem by replacing the passive inductor with a CMOS-based active inductor within Chua's circuit framework. The active inductor's equivalent inductance is set by the ratio of gate-source capacitance to the product of two transistor transconductances, and can be electronically tuned by adjusting bias currents, covering a frequency range of 20 MHz to 400 MHz. Built in the 0.18 µm CMOS process, it offers better quality factors, low supply voltage operation, and minimal chip area. LTSpice simulations were carried out at various input values to evaluate the active inductor's tunability and its suitability for driving chaotic dynamics in Chua's circuit. LTSpice simulations helped in analyzing the chaotic and double-scroll behaviour of the active inductor emulated Chua circuit.

75 PID-196: Density, Infrastructure Performance and Livability: A Comparative Study of Kowloon Walled City and Dharavi

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Rapid urbanization across the Global South has placed extreme population density at the center of debates on urban livability. Conventional planning frameworks treat high density as a primary driver of poor living standards. Yet some of the densest settlements in recorded history have demonstrated levels of social cohesion, economic productivity, and resident satisfaction that challenge this assumption. This paper compares Kowloon Walled City (KWC) in Hong Kong and Dharavi in Mumbai, arguing that livability outcomes are determined not by density alone, but by the interaction of built form, infrastructure adaptability, and spatial integration of economic activity. Despite a fourfold density differential, household floor areas converge in both settlements: KWC's median flat was approximately 23 square meters, compared with Dharavi's existing average of 21 to 25 square meters. KWC's density record was therefore an artifact of built form, not evidence of worse household conditions. Both settlements constituted functional urban infrastructure through collective resident practice and derived economic vitality from the spatial inseparability of home and work. These findings carry direct implications for the Dharavi Redevelopment Project, which proposes rehousing families in standardized vertical towers of 32.5 square meters. Thermal modeling indicates Dharavi's horizontal built form outperforms proposed vertical replacements on habitability

indicators, while the scheme would sever the spatial integration on which Dharavi's informal economy depends. An estimated 33,000 families face displacement without rehousing entitlement. Infrastructure-blind density policies risk leaving residents materially worse off despite significant capital investment.

76 PID-197: Bridging the Transparency Gap in AI Chatbots: A User-Centric Approach

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Chatbots based on artificial intelligence (AI) have widely disseminated to a large range of industries, including customer services, healthcare and education. It provides the way to the users interact with digital systems. Existing systems offer several advantages, but they are constrained by transparency and data privacy limitations that result in the uniformed sharing of sensitive information without adequate awareness or supervision. This highlights a critical research gap in ensuring secure and interpretable chatbot interactions. To overcome this issue, this paper proposes a Transparency-Privacy Shield aimed at enhancing user awareness and safeguarding sensitive data. The approach employs a dual-interface mechanism integrated within web based chatbot systems to monitor and regulate data flow, while reducing the storage of sensitive information on cloud-based systems. Furthermore, Explainable Artificial Intelligence (XAI) techniques are incorporated to enable source-based responses and improve system interpretability. The proposed approach mention in this research work effectively reduces privacy risks, enhances transparency and improve user trust in chatbot systems. Further, the envisaged approach contributes to the development of reliable and user-centric AI systems by transforming conventional black-box models into more transparent and interpretable solutions.

77 PID-198: Development, Implementation, and Validation of Deep Reinforcement Learning-Based Control for an Inverted Pendulum System

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This study employs Deep Reinforcement Learning (DRL) to create model-free, adaptive control policies through environmental interaction. By comparing DRL with classical methods, this research offers scalable insights for robust control of complex robotic systems. This research aims to study the dynamics and control challenges of an inverted pendulum system through mathematical modelling and simulation. It aims to develop a DRL-based control strategy to stabilize the inverted pendulum and achieve desired control performance. The project will implement the trained DRL controller in simulation and/or real-time control environments. It will then evaluate and validate its performance, using quantitative metrics such as stability, settling time, control effort, and robustness to disturbances. Finally, the study will compare the performance of the DRL-based controller with classical control methods such as PID or LQR. Following DRL controller training and verification in MATLAB/Simulink, the system will transition to hardware. A physical prototype will be fabricated per the CAD design to validate the control policy's real-world stability. The trained agent will then be deployed on an NVIDIA platform to facilitate real-time control of the inverted pendulum. This work emphasizes the implementation and validation of existing DRL frameworks over the development of new algorithms. Expected results of this work include a detailed CAD model and a physical prototype of an inverted pendulum system. The project will establish a MATLAB/Simulink simulation environment for modelling and implementation of classical control (PID/LQR) of the inverted pendulum. It delivers a trained and validated DRL controller that stabilizes the inverted pendulum in simulation. This process ensures the successful deployment of the trained DRL controller on an NVIDIA platform, enabling precise, real-time balancing of the physical system.

78 PID-201: Next-Generation Biodegradable Elastomeric Nanocomposites for Sustainable Contraceptive Applications

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The global contraceptive market, valued at over USD 30 billion in 2023, is predominantly dominated by natural rubber latex (NRL) and synthetic polymers such as polyurethane. Despite their widespread use, approximately 1–6% of the global population exhibits latex sensitivity, leading to allergic responses ranging from mild irritation to severe hypersensitivity. Furthermore, over 90% of commercially available contraceptive materials are non-biodegradable, contributing significantly to environmental waste. Studies have also demonstrated that conventional latex materials can lose up to 30–40% of their mechanical integrity when exposed to oil-based lubricants, increasing the probability of structural failure. These limitations highlight the urgent need for next-generation contraceptive materials that are biocompatible, biodegradable, and mechanically reliable.This research focuses on the development of a biodegradable elastomeric nanocomposite using polylactic acid (PLA) as the base polymer. Although PLA is widely recognized for its biocompatibility and biodegradability, its inherent brittleness restricts its application in flexible biomedical devices. To overcome this limitation, epoxidized vegetable oils (EVOs) are incorporated as reactive plasticizers, which have been reported to enhance elongation at break by up to 200–300%. Additionally, surface-modified cellulose nanocrystals (CNCs), particularly polydopamine-coated CNCs, are introduced to improve tensile strength and interfacial adhesion, resulting in an estimated strength enhancement of up to 50%. Complementary bio-based additives such as lignin nanoparticles and citrate esters are utilized to improve flexibility, stress distribution, and non-toxicity.The work has already commenced, and an initial prototype of the PLA-based polymer blend has been successfully synthesized, demonstrating preliminary flexibility and film-forming capability.

79 PID-202: Automatic image annotation using deep learning

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Image annotation is a fundamental task involving the identification and labelling of objects within an image. Traditionally, image annotation is performed by humans, making it time consuming and inefficient. Therefore, this study of image annotation system based on a pre-trained model YOLOv8 model that automatically performs object recognition creating bounded box around them and creating accurate labelling of resulting images. This system enhances by improving the ability to rapidly extract various objects from images. Using this new system, it significantly reduces the time compared to manual methods.

80 PID-203: AI-Based Sign Language to Multilingual Speech Translator

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People who are non-verbal frequently use sign languages, but most hearing people cannot understand these gestures, creating communication barriers that are compounded by cross-lingual interactions. This paper presents a practical, modular architecture and prototype implementation for an AI-based system that recognizes sign language gestures in real time and converts them into speech in multiple target languages. The system combines robust hand-pose tracking, motion-pattern recognition, a gloss/word-level recognition stage and a translation+TTS stage to produce low-latency multilingual audio. A first-stage prototype using MediaPipe-style pose extraction and rule+motion-based recognition is described and evaluated qualitatively; plans for expanding into deep end-to-end recognition and neural translation (using large sign datasets and sequence-to-sequence models) are provided.

81 PID-204: SD-LAB: An Explainable Structural Dynamics Framework for Colorectal Polyp Segmentation via Geometric State Evolution

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Colorectal cancer commonly begins with polyps that are missed during colonoscopy, especially small or flat ones that closely resemble the tissue around them. Existing deep learning methods classify each pixel independently, without accounting for shape geometry or predictive uncertainty, which reduces reliability near indistinct boundaries. We propose SD-LAB, a framework that approaches segmentation as an iterative refinement process rather than a direct labeling task. The model jointly maintains four channels capturing region occupancy, boundary activation, signed distance, and epistemic uncertainty across multiple spatial scales. Predictions are guided by geometric context rather than surface appearance, keeping the model consistent across varying clinical conditions. During training, uncertain regions contribute less until the model gains confidence, which naturally steadies learning without any manual tuning. Each channel also produces an interpretable diagnostic output, giving clinicians direct insight into model priorities without separate explanation tools. On both Kvasir-SEG and CVC-ClinicDB, SD-LAB achieved Dice scores of 0.9199 and 0.8560, outperforming PraNet, DeepLabV3+, and Attention U-Net, suggesting that structure-aware segmentation holds practical value for clinical polyp detection.

82 PID-206: Computational Design of Conserved Peptide Vaccine Candidate Targeting EHDV Outer Coat Protein and in vitro validation

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Epizootic Hemorrhagic Disease Virus (EHDV) is a segmented double-stranded RNA Orbivirus with a triple-layered capsid and high antigenic variability caused by genome reassortment. Environmental conditions that favor vector transmission have increased outbreaks in livestock and wildlife, leading to significant economic losses through mortality, reduced productivity, veterinary costs, and trade restrictions. Conventional vaccines based on atten-

uated or inactivated viruses pose biosafety risks, such as reversion to virulence, and often fail to provide cross-protection against multiple serotypes. Epitope-based peptide vaccines provide a safer alternative by targeting conserved antigenic regions and inducing specific immune responses. Advances in artificial intelligence and immunoinformatics have enabled rapid identification of B-cell and T-cell epitopes. This study proposes an integrated computational immunoinformatics pipeline to design a multi-epitope vaccine targeting the VP2 protein of EHDV. VP2 sequences will be obtained from NCBI and UniProt. Multiple sequence alignment will be performed to identify highly conserved regions across different viral strains. These conserved regions will be subjected to epitope prediction to identify potential immunogenic candidates, including B-cell, cytotoxic T lymphocyte (CTL), and helper T lymphocyte (HTL) epitopes. Predicted epitopes will be evaluated using IEDB tools for antigenicity, allergenicity, toxicity, and stability. Selected epitopes will be linked into a single construct, followed by codon optimization and in silico cloning. Finally, immunogenicity will be assessed using in vitro ELISA-based cytokine assays.

83 PID-207: Casteism In Sikhism - Text vs. Reality

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Sikhism, as a religion, emerged in the late 15th century, after the enlightenment of the First Sikh Guru, Guru Nanak Dev Ji. The main ideology behind the Sikh religion was against casteism, which was culturally and traditionally present in the state of undivided Punjab. The basic principle of Sikhism is equality, be it in the spheres of caste, gender, or background, and it seeks to eradicate caste-based discrimination. He sought to overcome this by instituting the langar system (srigranth.org). Despite Guru Nanak Dev Ji's teachings, the caste identities continued to influence Sikhism, which then led to the establishment of the Khalsa Panth by the 10th Sikh Guru, Guru Gobind Singh Ji, where he got 5-pyare to get baptised, who all belonged to different castes (Nangia, 2026)(Kaur, 2019). Despite all this, casteism managed to infiltrate the Gurudwaras and raised questions on the interaction between religious ideals and inherited social traditions. This contradiction between religious doctrine and social practice has generated my scholarly interest in understanding how caste persists within Sikh religious spaces.

84 PID-209: AI-Based Multimodal Plant Disease Detection and Climate-Aware Crop Health Prediction System

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The effect of plant diseases on the productivity of agriculture is massive; therefore, the detection and prevention of diseases play a crucial role in ensuring productivity. The current techniques used for detecting and preventing diseases revolve around image classification; however, there are no measures taken into account for other environmental factors that may affect the development of the disease. In this study, a multimodal AI model is introduced for the detection and prediction of plant diseases. The proposed model includes three models: image processing for detecting diseases, climate forecasting for predicting diseases, and geospatial analysis for predicting diseases. The image classification algorithm uses a convolutional neural network algorithm for detecting plant diseases from the leaf images. An LSTM network is also developed for predicting diseases based on climate data. Additionally, an attention mechanism is introduced for interpreting the output produced by the LSTM network. The system can also be used for predicting and preventing diseases. Moreover, a chatbot can also be created for providing real-time assistance in agriculture.

85 PID-210: Tunable Acoustic Metamaterials: Recent Advances and Future Perspectives

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In recent years, acoustic metamaterials have attracted a lot of attention because they can control sound in ways that conventional materials cannot achieve. These specially designed structures show unusual behaviour such as improved sound attenuation and wave manipula-

tion. Earlier studies mostly focused on passive metamaterials with fixed geometries, which limited their ability to work under changing conditions. One important advantage of these materials is their effectiveness in reducing low-frequency noise, which is usually difficult to control using traditional sound-absorbing materials. Conventional methods required bulky and thick structures, whereas metamaterials can achieve similar results using compact designs based on resonance. Because of these limitations, researchers have started developing tunable acoustic metamaterials that can adjust their properties under external inputs such as mechanical changes, temperature variation, magnetic fields, or electrical signals. These systems provide better flexibility and can work over a wider range of frequencies. More recently, the use of smart materials and programmable structures has further improved their adaptability. In addition, the idea of 4D metamaterials, where structures can change with time when exposed to external stimuli, is gaining interest and offers new possibilities for dynamic acoustic control. This paper presents a brief review of recent developments in tunable acoustic metamaterials, along with possible future research opportunities.

86 PID-211: Adaptive Probabilistic Multi-Agent Framework for Deadlock-Aware Resource Allocation in Concurrent Systems

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This paper presents an adaptive probabilistic multi-agent framework for modeling concurrency, resource contention, and deadlock in operating systems using a game-based abstraction. In the proposed approach, processes are represented as autonomous agents that compete for shared resources under semaphore-based synchronization. An Expectimax-inspired decision model enables agents to select actions under uncertainty through probabilistic reasoning, capturing realistic behavior in dynamic concurrent environments. Unlike traditional deterministic approaches, deadlocks are not explicitly enforced but emerges as a result of stochastic interactions among agents. Experimental evaluation in an 8-agent system demonstrates that deadlock occurrence varies between 40% and 70% depending on agent decision policies, highlighting the trade-off between concurrency and system stability. The results show that increasing contention leads to higher deadlock probability and reduced effective resource utilization, emphasizing the limitations of parallelism in resource-constrained environments. The proposed framework provides a unified platform for analyzing emergent behaviors in concurrent systems by integrating concepts from operating systems, artificial

intelligence, and game theory.

87 PID-213: JudicAI: An Extended Judicial Syllogism Framework for Multi-Document Summarization of Indian High Court Appellate Cases

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Indian High Court judges must read three separate documents before every appellate hearing: the dis trict court order, the petitioner's appeal, and the State's reply. Existing AI-based legal summarization tools address only single judgments and were evaluated on Chinese or European corpora, leaving the adversarial structure of Indian appellate proceedings unsupported. This paper presents JudicAI, a multi-document summarization system that takes all three documents as joint input and produces a structured six-component summary grounded in an ex tended judicial syllogism framework. The six components are the victim's account, the State's position, the legal issues in dispute, the applicable provisions under IPC, CrPC, or BNS, an explicit reasoning step linking facts to law, and the final decision. The reasoning step is a deliberate addition over prior work, which moves directly from law to conclusion without articulating the inferential bridge. JudicAI employs Llama 3 in a two-stage pipeline: Stage 1 extracts factual claims and cited provisions from each document independently, and Stage 2 integrates the three extractions into the structured summary while preserving both factual accounts separately and surfacing contradictions. BERTScore returned precision and recall of 0.53 and 0.32, reflecting metric unsuitability since no reference summaries exist for Indian appellate cases. LLM-based scoring produced an inflated 9.02 due to the known bias of language models toward similar-model outputs. A domain expert rated JudicAI 8.60 out of 10, affirming that the summaries were sufficient to understand each case without consulting source documents, and specifically commending the adversarial separation of facts as absent in existing tools. The primary limitation is factual grounding in complex cases, to be addressed through a verification module in future work.

88 PID-214: Design and Implementation of a Wearable Thermoelectric Energy Harvesting Smart Band

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Wearable devices have a power problem. Batteries wear out, need replacing, and don't scale well as devices get smaller and more embedded into daily life. There's also the environmental side — disposing of batteries at scale isn't clean or cheap. This pushed us toward something the body already does constantly — releasing heat. Not harvested, not stored, just lost into surrounding air. The idea was straightforward: intercept that heat and turn it into something useful. The device we developed is a wrist band. It sits against the skin, pulls heat from that contact point, and runs it through thermoelectric modules exploiting the temperature difference between skin and air. That difference — usually between 3°C and 8°C — drives the Seebeck effect, generating a small voltage. Small is the key word. We're talking millivolts. Nothing practical runs on millivolts without serious conditioning — that gap between raw output and usable power is where most of the engineering effort went. The modules were stacked in series — more modules, higher cumulative voltage. That output feeds into a harvesting circuit for ultra-low input signals, boosting it into a range real components can use. A supercapacitor stores the charge — not a battery, deliberately. They charge quickly, discharge on demand, and don't degrade the way batteries typically do. The microcontroller doesn't stay awake. It wakes, reads sensors, pushes a wireless transmission, then sleeps. That duty-cycling holds the energy budget together — without it, consumption would outpace generation. Three layers make up the band — a skin-contact base, thermoelectric stack, and outer dissipation surface. That outer layer keeps one side cooler, preserving the gradient everything depends on. Lose the gradient, lose the voltage. Testing confirmed it works under real wearing conditions. For periodic sensing and short-burst transmission, body heat covers the load. No battery required — and demonstrating that concretely was the point.

89 PID-215: Development of Acetone-Selective MOS Sensor for Breath-Based Diabetes Detection

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Diabetes mellitus is a major global health issue affecting nearly 600 million people and requires accessible and patient-friendly diagnostic approaches. Conventional glucose monitoring methods are invasive and often reduce patient compliance. Breath analysis has emerged as a promising non-invasive alternative, as exhaled breath contains volatile organic compounds (VOCs) that reflect metabolic activity. Among these biomarkers, acetone has been reported to exhibit elevated concentrations in individuals with diabetes, making it a potential indicator for non-invasive detection. Metal oxide semiconductor (MOS) gas sensors are widely proposed for VOC detection due to their high sensitivity, low cost, and simple fabrication processes. Tin oxide (SnO) is one of the most extensively investigated MOS materials for acetone sensing. However, pristine SnO sensors suffer from limited selectivity and interference from other gases and humidity, posing challenges for breath-based applications. To address this, catalytic noble metal modification using palladium has demonstrated improved sensing response and selectivity. The present study proposes the in-house fabrication of a SnO-based thick-film MOS gas sensor followed by palladium surface modification to enhance acetone selectivity under laboratory conditions. The sensing layer is prepared by dispersing SnO nanopowder in a solvent–binder mixture to form a homogeneous paste, which is deposited onto substrates with conductive electrodes using drop-casting. The deposited films are thermally treated to activate gas sensing properties. Gas sensing characterization is performed by measuring resistance variations under controlled acetone exposure using a laboratory-scale gas generation system. Comparative analysis between bare SnO and palladium-modified SnO sensors evaluates sensitivity, selectivity, response time, and repeatability. The study aims to contribute toward the development of non-invasive breath-based diagnostics.

90 PID-216: Rice-Straw Derived Activated Porous Carbon for Electrochemical Applications

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Agricultural biomass waste has gained significant attention as a sustainable precursor for functional carbon materials. Rice straw is one of the most abundant agricultural residues produced worldwide, particularly in regions with intensive rice cultivation. However, improper disposal through open-field burning causes serious environmental problems, including air pollution and greenhouse gas emissions. Converting rice straw into value-added carbon materials therefore provides an effective strategy for sustainable waste management while generating materials for environmental and electrochemical applications. In this study, rice straw was used as a biomass precursor for the synthesis of porous carbon materials through pyrolysis, chemical activation, and hydrothermal treatment. The collected rice straw was washed and dried to remove impurities and moisture, and then subjected to pyrolysis at approximately 500 °C to obtain biochar. The resulting biochar was chemically activated using potassium hydroxide (KOH) and potassium nitrate (KNO) to enhance pore development and surface properties. After activation, the material underwent further thermal treatment at around 600 °C for about one hour to improve structural stability. Hydrothermal treatment at approximately 200 °C for one hour was subsequently carried out to modify surface chemistry and introduce functional groups on the carbon surface. The synthesized materials were characterized using scanning electron microscopy (SEM), X-ray diffraction (XRD), Fourier transform infrared spectroscopy (FTIR), and BET surface area analysis. Electrochemical studies, including cyclic voltammetry (CV), galvanostatic charge–discharge (GCD), and electrochemical impedance spectroscopy (EIS) were conducted to evaluate their potential as electrode materials for energy storage and capacitive deionization applications.

91 PID-217: Structural and Acoustic Characterization of DLP 3D-Printed Tetrakaidecahedron Metamaterials

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Polymer foams and fibrous materials are commonly utilized for sound absorption and exhibit commendable performance; however, they typically lack the requisite strength for load-bearing applica- tions and frequently require additional thickness to mitigate low-frequency noise. Engineers working on automotive, aerospace, and industrial systems find it hard to deal with noise without weakening the structure. Acoustic metamaterials have started to get more attention in the last few years as an alternative. This is mostly because they control how sound travels through carefully designed internal geometries instead of just relying on the properties of the base material [6]. Recent research indicates that modifying parameters such as strut thickness and cell size in 3D-printed tetrakaidecahedron lattice structures can significantly enhance their sound absorption properties [1]. Simultaneously, research on multifunctional metamaterials capable of managing both low-frequency noise and mechanical loads has underscored the critical importance of effective structural optimization [2]. The tetrakaidecahedron shape is often used to show open-cell foams. It usually has a good balance of porosity and strength [3]. Porous materials also absorb sound because some of the energy gets lost in the structure because of thermal and viscous effects [5]. The objective of this research is to examine the structural and acoustic properties of Digital Light Processing (DLP) 3D-printed tetrakaidecahedron lattice metamaterials, with the intention of creating lightweight structures capable of fulfilling both functions. The method consists primarily of geometric modeling, succeeded by Finite Element Analysis (FEA) to assess stress distribution and buckling behavior, in addition to experimental mechanical testing. The anticipated result is a validated metamaterial design that demonstrates enhanced mechanical strength while preserving effective acoustic performance in practical applications.

92 PID-219: Upgrading Bio-Oil Using Algal Co-liquefaction with Agricultural Waste

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The growing demand for sustainable energy and concerns over fossil fuel use have driven research into renewable biofuels. Microalgae have emerged as a promising third-generation feedstock due to their rapid growth, high photosynthetic efficiency, and high lipid content. Hydrothermal liquefaction (HTL) is an efficient thermochemical process that converts wet biomass directly into bio-crude oil without energy-intensive drying. Typically operating at 260–350 °C and 10–25 MPa, HTL produces bio-oil along with gaseous, aqueous, and solid by-products. However, the resulting bio-oil contains oxygen- and nitrogen-rich compounds that reduce stability, increase viscosity, and lower fuel quality, making upgrading necessary before use as transportation fuel. Recent studies show that co-liquefaction of microalgae with lignocellulosic biomass, especially agricultural residues, improves bio-oil yield and quality through synergistic interactions. Agricultural waste, rich in cellulose, hemicellulose, and lignin, serves as an abundant and suitable co-feedstock. In this study, algal biomass was co-liquefied with agricultural residues using HTL. A slurry (5–25 wt%) was prepared with deionized water and processed in a high-pressure batch reactor at 280–350 °C and 10–25 MPa for 30–60 minutes. Post-reaction, products were separated into bio-oil, aqueous, gaseous, and solid fractions. The bio-oil was extracted and analyzed for yield, composition, and heating value, while other phases were assessed for conversion efficiency. Compared to single-feedstock HTL, co-liquefaction showed higher carbon conversion and improved hydrocarbon formation. Overall, integrating agricultural residues with algal biomass enhances bio-oil yield, reduces oxygenated compounds, and offers a promising route for sustainable fuel production and integrated biorefinery development.

93 PID-220: Mitigation and Analysis of Power Quality Disturbances using Machine Learning.

Gouri Sainath, CMR College of Engineering & Technology

Power quality (PQ) distortion has become a major concern in modern electrical power systems as renewable energy sources, distributed generators, nonlinear loads and power electronic converters and sources become more and more integrated into the grid, bringing complicated operating dynamics to the grid. Although these developments enhance efficiency

and sustainability, they are also more prone to cause voltage sags, swells, harmonics, flicker, interruption, and transient disturbances which are negatively ill-suited to the industrial equipment and smart grid infrastructure. Such disruptions may culminate in overheating, breaking of delicate electronic equipment, decreased power supplies, and a huge economic loss. Conventional signal processing tools were not frequently adequate in examining non-stationary and noisy signals with the exception of real-time applications where prompt and correct decision making is necessary. In order to cope with such challenges, a smarter machine learning-powered Power Quality Analyzer is suggested, which relies on more sophisticated time-frequency analysis methods, i. e. Wavelet Transform and S-Transform, to obtain the discriminative features of voltage and current waveforms. The approaches are effective in capturing the local frequency variations, temporal dynamics, harmonic distortion and energy distribution so that the disturbance can be classified properly. Other critical parameters that have been optimized in the system include the sampling frequency, levels of decomposition, window size, normalization of features and hyper parameters to improve performance and stability. It uses a hybrid deep learning network consisting of Convolutional Neural Networks (CNN) and Long Short-Term Memory (LSTM) networks in which CNN is used to extract spatial features and LSTM is used to learn temporal dependencies in sequential prediction with different load and noise levels.

94 PID-221: Real- Time Multi-Class Emotion Detection from Facial Expressions in CPU-Based Systems

Gouri Sainath, CMR College of Engineering & Technology

Reading human emotions through facial expressions presents a challenging problem because people automatically perform this task while machines struggle to complete it through real-time processing. The research introduced EmotiScan which functions as a web-based system for facial emotion recognition by combining deep learning technology with Sobel gradient heatmaps that display facial expression energy distribution. The system operated on two selectable models which users could switch between: a Mini-XCEPTION network that provided fast responses and a VGG-16 model that delivered improved accuracy at the cost of decreased performance speed. The two models which we tested on FER2013 used a dataset containing 35,887 grayscale facial images that depicted seven different emotions, including angry, disgust, fear, happy, neutral, sad, and surprise. Our team faced severe operational difficulties when we tried to solve class imbalance problems because the training data included

disgust at 436 instances while happy appeared 8989 times, which led us to apply balanced class weighting to stop the model from ignoring infrequent emotional states. We improved the VGG-16 training loop by implementing a system that allows frozen lower network layers to process once per epoch while their outputs get stored on disk as float16 memory-mapped arrays, which led to training time reductions of approximately 75 percent on standard CPU systems. Mini-XCEPTION reached 59% validation accuracy while running at more than 6 frames per second because it operated without any GPU. The system functioned as a FastAPI service which transmitted annotated results to the browser through WebSocket, maintaining end-to-end latency under 150 milliseconds for each frame. The system provided classification results together with a color-coded Sobel heatmap which showed facial region predictions and proved valuable to both clinicians and interaction designers.

95 PID-222: Design and Development of a Modular Electromagnetic Levitation-Propulsion System

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Magnetic levitation eliminates mechanical contact between the vehicle and guideway, reducing friction and energy losses compared to conventional rail systems. At laboratory scale, maglev prototypes still face practical challenges, including electromagnetic interference between levitation and propulsion subsystems, control instability requiring fast feedback, and thermal stress during sustained high-current operation. This work proposes a modular design approach in which levitation, propulsion, and integration are treated as related but independently verifiable subsystems with clearly defined interfaces. The levitation stage uses electromagnetic suspension with attractive force control, where electromagnets above a steel guideway generate lift and hall-effect sensors measure magnetic flux density for gap estimation and feedback. This arrangement removes separate gap hardware and supports 1 kHz control for maintaining a 4 mm equilibrium gap. The force model follows classical magnetostatic theory, where force increases with current squared and decreases with gap squared, allowing feedback control to stabilise an unstable system. Propulsion uses three to six electromagnetic coils interacting with a permanent magnet track, with the same sensing principle used to detect magnet positions and trigger coil energisation in sequence. Pulse-width modulation improves thrust efficiency, while pole transitions detected during

commutation also serve as position encoder pulses. The integration strategy accounts for shared computational and electrical resources under different timing requirements, using a microcontroller-based architecture where time-critical tasks run on fixed millisecond deadlines while communication remains separate. Physical separation and isolated power rails reduce magnetic coupling and electrical noise. Validation follows staged testing, including fixed-power characterisation, closed-loop testing under load, and disturbance testing before full operation.

96 PID-223: Designing and Deploying Honey Prompts for Detecting AI-Driven Automation

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The rapid advancement of large language models (LLMs) has enabled the emergence of AI agents capable of interacting with digital systems, performing tasks such as information extraction, content generation, and service interaction. While these capabilities offer significant advantages, they also introduce new cybersecurity challenges. In particular, distinguishing between human users and automated AI-driven interactions has become increasingly difficult, as modern systems can closely mimic human behaviour [2]. Recent approaches, such as UniGuardian, focus on detecting malicious prompts and adversarial patterns by masking tokens and analysing variations in model predictions to uncover hidden trigger instructions [1]. Although effective for identifying prompt injection and backdoor attacks, these perturbation-based methods primarily target model sensitivity and do not directly address the problem of identifying automated behaviour during real-time interactions. To address this gap, this work proposes Honey-Prompts, a prompt-level deception technique based on embedding low-salience instructions within user-facing interfaces. These instructions are designed to be largely ignored by human users but may be followed by AI systems due to their instruction-following bias. By analysing response behaviour to such prompts, it becomes possible to detect signals indicative of automated interaction. A diverse set of Honey-Prompts is generated using manually crafted seed prompts and expanded through API-based language model generation with light fine-tuning. These prompts are evaluated using an agentic testing framework that interacts with multiple language models, enabling the collection and analysis of behavioural patterns. This work extends existing prompt security research by integrating behavioural detection with prompt-level techniques, offering a complementary

and practical approach for identifying AI-driven automated interactions.

97 PID-225: CrisisStream: Real-Time Multimodal Triage of Disaster Tweets using Transformer Fusion

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Natural disasters generate a torrent of multimodal social media content that, if processed rapidly, can dramatically improve situational awareness for emergency responders. During major disaster events, platforms such as X (formerly Twitter) produce thousands of posts per minute combining first-hand textual accounts with photographs of damage, casualties, and infrastructure failure. Separating actionable, informative posts from irrelevant noise — and further distinguishing reports of severe damage from minor ones — is essential for effective resource allocation. Automated systems capable of performing this triage in real time could meaningfully support emergency management operations at scale. Transformer based multimodal models have recently achieved strong performance on this problem, with architectures pairing BERT for text and Vision Transformers for images delivering state-of-the-art results on the CrisisMMD benchmark. However, a fundamental and surprisingly unaddressed gap persists: every existing system is evaluated entirely offline, on static dataset splits, under no time pressure. The most operationally critical questions remain open — do these models hold their accuracy under streaming conditions, and can they respond fast enough to be useful when it matters? This paper presents CrisisStream, an end-to-end real-time multimodal triage pipeline designed to close this gap. The system deploys fine-tuned BERT and Vision Transformer (ViT-B16) encoders in an asynchronous parallel inference architecture, classifying each incoming crisis tweet for both informativeness and damage severity as it arrives. Beyond classification, CrisisStream introduces a priority-scoring module that combines the informativeness probability, a three-class damage-severity signal, and a model confidence term into a single triage score, enabling the most actionable posts to surface for operator review within seconds of arrival.

98 PID-226: Hybrid Quantum–Classical Learning for Multi-Class Ophthalmic Disease Classification

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Ophthalmic conditions like diabetic macular edema and diabetic retinopathy are among the top causes of preventable vision loss worldwide. This is especially true in areas where access to specialist screening is limited. Although there have been rapid improvements in automated retinal image analysis, current diagnostic support systems still struggle to perform consistently. This inconsistency arises from differing datasets, acquisition conditions, and labelling standards, which limits their use in real-world clinical screening. These issues highlight the urgent need for screening frameworks that are not only accurate but also reliable and flexible in various healthcare settings. We must systematically evaluate learning methods that can maintain reliability despite real-world variations. Such comparative evaluation is especially important for understanding how new quantum learning methods perform with real-world dataset variations. This research systematically evaluates both classical and hybrid quantum–classical learning frameworks for classifying ophthalmic diseases using real-world retinal fundus images. It compares traditional convolutional neural networks with quantum-inspired architectures that integrate quantum convolutional neural networks and quantum-enhanced support vector classifiers. The experiments utilised the clinically curated IDRiD dataset, applying two clinically significant labelling schemes: three-class macular edema and five-class ICDR grading, all following consistent training and evaluation protocols. This setup enables a direct comparison of model behaviour across diagnostic tasks with different levels of classification complexity. Hybrid quantum–classical models showed competitive and, in some cases, superior performance compared to classical models, especially in multi-class and class-imbalanced scenarios. The study also supports further investigation of quantum-inspired learning methods for reliable medical image classification.

99 PID-227: Machine Learning & Deep Learning-Based Fault Detection & Categorization in Smart Grids

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The addition of renewable energy and the development of smart grids have radically changed the detection of faults and Categorization requirements in today's power systems [1]. Conventional schemes used to protect against unidirectional power flow and to achieve predictable fault-signature performance are challenged by variable fault currents, intermittency, and operational variability introduced by distributed generation [2]. This extensive literature review discusses the state of the art in machine learning (ML) and deep learning (DL) methods for fault detection and Categorization in smart grids, with a focus on recent developments from 2022 to 2026. In the review of 30 most recent and relevant works, it is evident that the classic approaches to ML, including the (KNN) K-Nearest Neighbor, (SVM) Support Vector Machines, and (RF) Random Forest, have been supplanted by novel deep learning frameworks, such as Transformers, Long Short-Term Memory (LSTM) networks, Convolutional Neural Networks (CNNs), and concatenations of them. Although traditional ML (machine learning) tools show acceptable accuracy (87-90% for KNN (k-nearest neighbors), RF (random forest), and decision trees), recent deep learning models are the ones that provide consistent results. high performance, where derived models like Transformer-BIGRU have the highest accuracy of 98.84 per cent. ANFIS-LSTM with 99.99% accuracy on controlled experiments. The review outlines three important research frontiers, including (1) the specifics of the challenges of high levels of renewable energy penetration and (2) explainable AI designs that would build the level of trust and regulatory compliance. and (3) enabling real-time edge deployment through optimized architectures and federated learning approaches.

100 PID-228: Process Optimization of Additive Manufacturing for Improved Orthopaedic Implants

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Bone breaks when the load on it is greater than what the bone can bear. The patterns of the fractures indicate the type of mechanical stress to which the bones have been subjected: e.g., direct blows cause transverse fractures, twisting causes spiral fractures, and comminuted fractures are the result of high-energy trauma. In fact, in the elderly, osteoporosis results in fragility fractures even from minor falls, whereas athletes get stress fractures due to repeated loading both leading to an enormous socioeconomic impact. When bone damage goes beyond what the body's healing system can handle, a surgical method called internal fixation with bone plates is usually done. Stainless steel and titanium metal plates help keep the bone working together and growing properly, yet they are not without disadvantages. The main one is stress shielding: bones are so much more flexible than metals that metals take up the most of the load, which results in bones becoming weaker and the likelihood of refracture after the removal of the metal. Drilling in surgery can cause the frictional heat to increase to more than 47°C which kills the bone cells and eventually leads to the loosening of the hardware. With Additive Manufacturing (AM), patient-specific implants can be made directly from digital models, making a good match to the individual's anatomy with functionally graded lattice structures that can be tuned locally to match bone stiffness, this completely gets rid of the problem of modulus mismatch and stress shielding. But the mechanical properties of AM materials depend greatly on things like layer thickness, infill density, print speed, and build orientation, where even small variations can lead to defects or anisotropy, so it is very important to do systematic process optimization before clinical use of AM implants can be considered safe.

101 PID-229: Ultrasonic assisted bone drilling

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Bones are like living things that are always changing. They are really important for helping us move around protecting the parts inside our body and storing important minerals like calcium and phosphorus. There are cells called osteoblasts and osteoclasts that help bones get stronger when they are under stress and fix themselves when they get damaged. Bones have an outer layer and a soft inner layer, which helps them absorb shocks but if something hits them too hard, they can break. Sometimes bones break because of an accident. Because they have been stressed too much or because of a disease that makes them weak. There are kinds of breaks like spiral breaks, transverse breaks, comminuted breaks and stress breaks. How we treat a break depends on how bad it's if it is not too bad it can heal just by being still but if it is really bad, we might need to do surgery and use special plates, screws or rods to fix it. Drilling into bones is a part of surgery when we need to put implants in the right place. It is not easy because it can make the bone too hot and cause damage to the cells inside. If we push hard, it can make tiny cracks in the bone, which can make the implant not work as well. Things like how fast we drill how force we use, how sharp the drill is and how we keep the bone cool can affect how well the drilling works. If we control the force and temperature right usually by using a special cooling system, we can avoid damaging the bone. So, when we drill into bones in a controlled way it makes the surgery safer helps the bone heal better and makes sure the implant works well for a long time. Bones are important and bone drilling is a critical part of taking care of them. We need to be careful when we drill into bones because it can affect how well they heal and how well the implants work. Bones, like our bones need to be treated with care.

102 PID-230: A Unified Explainable Graph Neural Network Framework for Molecular Property Prediction in Drug Discovery

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When using machine learning to help choose which compounds to test in computational drug discovery, it's very important to be able to accurately guess how molecules will behave. Graph Neural Networks (GNNs) are good at modeling molecular structures, but they can be hard to understand, which makes them hard to use in real life. This paper presents UXGNN, a Unified Explainable GNN framework that achieves a balance between interpretability and predictive accuracy. The model uses edge-aware message passing and an attention-guided multi-scale readout to find molecular features on both a small and a large scale. To make sure they are strong, UXGNN tests a number of attribution methods, including Integrated Gradients, GNNExplainer, GraphSHAP, and attention scores. It does this by checking for fidelity, sparsity, and stability. On the MoleculeNet benchmarks (BBBP, HIV, and Tox21), UXGNN gets an AUC of 0.8127 on Tox21, which is better than baseline models. It also stays competitive on BBBP. Edge-aware convolution and attention pooling help, as shown by ablation studies. Robustness analysis shows that the predictions stay the same even when the features are noisy. These findings demonstrate that UXGNN is an effective and comprehensible method for predicting molecular properties in drug discovery.

103 PID-231: Change Detection in Electro-Optical Imagery using Deep Learning for Surveillance

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Change detection (CD) in electro-optical (EO) imagery identifies meaningful temporal variations.Automated CD is critical for surveillance, urban planning, and disaster manage-

ment. Deep learning archi-tectures like Siamese Networks and Fully Convolutional Networks (FCNs) provide state-of-the-art segmen-tation but suffer from high computational intensity and lack uncertainty quantification. To address this, we propose a multi-modal fusion approach using lightweight, uncertainty-aware architectures. A dual-stream Siamese encoder extracts temporal features, followed by an attention-weighted difference module and FCN decoder. An uncertainty quantification stage outputs calibrated confidence scores alongside the binary mask for reliable human-in-the-loop decisions. Evaluating a lightweight MobileNetV2 (3.5M parameters) against BTC-B/Swin-B (88M parameters) on LEVIR-CD and CLCD shows robust feature extraction and competitive boundaries, proving viability for resource-constrained edge deployment without catastrophic accuracy loss.

104 PID-232: Additive Manufacturing in Surgery

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Additive manufacturing, or 3D printing, is important in modern surgical planning because it enables the creation of precise, patient-specific anatomical models. This study examines its application through the development of a 3D-printed pelvis model, a complex anatomical structure. We processed CT scan data using segmentation and CAD techniques to create a precise digital model, which was then made using inexpensive FDM printing. The final model helps visualize fractures and anatomical relationships, enables preoperative simulation, and assists in planning for implants. It also aids patient education and communication among medical teams. The study shows that this method improves surgical accuracy, shortens operation time, and lowers complications. It also offers a scalable and affordable solution for clinical use.

105 PID-233: Development of Deep Learning Models for Sea-Surface Object Detection from Electro-Optical Sensor Data

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The safety of autonomous and smart ships depends on fast and accurate perceptual information. While marine radar is the standard for obstacle detection, Electro-Optical (EO) sensors provide critical high-resolution visual supplements. However, processing EO data in dynamic maritime environments remains challenging. This study transitions from traditional background subtraction to advanced deep learning approaches, presenting a performance evaluation of various YOLO (You Only Look Once) models for sea-surface object detection. We evaluated five distinct models (YOLO26S, YOLOv8s, YOLOv9s, YOLOv10s, YOLO11s) on the VHR ships dataset. The experimental results highlight significant performance trade-offs: YOLO26S achieved the highest precision (0.6585), while YOLO11S yielded the highest recall (0.6841). Notably, YOLOv9s demonstrated the most robust overall performance, attaining a mean Average Precision (mAP50) of 0.6752 and mAP50-95 of 0.5120. These findings establish a baseline for developing uncertainty-aware, multi-modal detection pipelines that dynamically leverage the most reliable sensor streams.

106 PID-235: Photocatalytic reforming of sawdust to hydrogen by Ag-ZnO catalyst

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This study aimed at finding ways to harvest sustainable hydrogen energy. Most abundant clean energy available worldwide, which is solar energy, was used and the transformation to hydrogen was done of waste produced from wood by hydrothermally reforming sawdust. Cellulose was made as sacrificial agent and the photocatalyst used to utilize solar energy as well as transform our sacrificial agent was ZnO photodeposited with Ag. ZnO is a semiconductor that is both non-toxic and environmentally friendly, possessing a suitable band gap of approximately 3.4 eV, which renders it an effective photocatalyst. Nevertheless, its effectiveness is hindered by the rapid recombination of electron–hole pairs. To overcome this, Ag of (1,3,5) wt. percentage was photodeposited onto ZnO, as metal deposition enhances charge separation. Ag also exhibits surface plasmon resonance (SPR), improving light absorption. Among the different loadings tested, 3% Ag proved to be the most effective, increasing

efficiency without obstructing active sites. The research successfully illustrated biomass photoreforming into green hydrogen up to 140 mmol, as verified by gas chromatography.

107 PID-237: Sequence-Guided Design and Structural Optimization of a DNA Aptamer-Based Bioreceptor for Aflatoxin B1 Detection

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Due to its widespread presence in contaminated agricultural products such as cereals, nuts, and spices, aflatoxin B1 (AFB1) is a highly toxic and carcinogenic mycotoxin that poses a significant threat to global food safety and public health. Its association with severe health effects, including hepatotoxicity and carcinogenesis, necessitates the development of rapid and selective detection methods. Conventional analytical techniques, although accurate, are often limited in routine applications due to complex instrumentation and long processing times. Aptamer-based biosensors have emerged as promising alternatives due to their high specificity, stability, and ease of synthesis. Aptamers are short single-stranded DNA or RNA molecules that fold into unique structures enabling selective target binding. In this study, a computational approach is used for the design and optimization of a DNA aptamer-based bioreceptor for AFB1 detection. Experimentally validated aptamer sequences are analyzed using multiple sequence alignment to identify conserved binding regions. Based on this motif, a truncated aptamer of approximately 20 nucleotides is designed to obtain a minimal functional unit. The optimized sequence is evaluated using Mfold to predict secondary structure and assess thermodynamic stability through free energy (G) calculations. Molecular docking is further performed using HADDOCK to evaluate aptamer–target interactions, and the best docking cluster is selected based on scoring parameters. The interaction is visualized using PyMOL to analyze binding interfaces. The results indicate that the truncated aptamer retains stable folding and favorable binding interactions, supporting its potential for biosensing applications.

108 PID-238: Development of a Bio-Inspired Flapping-Wing Micro Aerial Vehicle for Surveillance and Reconnaissance

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Bio-inspired micro air vehicles (MAVs) that use flapping-wing mechanisms have become a promising alternative to traditional fixed- and rotary-wing UAVs. This is especially true in low Reynolds number regimes, where unsteady aerodynamic mechanisms are the main way to create lift. Reviews of flapping-wing MAVs highlight the importance of phenomena such as leading-edge vortices, clap-and-fling, wake capture, and rotational circulation in enhancing lift at small scales. These aerodynamic principles are closely linked to the coordination of flapping and feathering motions, as demonstrated in the mechanism design for biaxial wing rotation, where precise synchronization of stroke and pitch significantly improves hovering performance. Building on these aerodynamic and kinematic foundations, the present work adopts a bio-inspired flapping architecture aimed at exploiting unsteady lift mechanisms through controlled stroke-plane motion and passive deformation.

109 PID-239: IoT based Intelligent Monitoring System for NICUs: A Review and the way forward

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Babies born too early or very sick need constant watching. Doctors need to know their heart rate, breathing, oxygen levels, and body temperature at all times. Missing something even for a minute can be really dangerous. Right now, most hospitals use wired sensors stuck to the baby's skin. It works, but it's kind of a mess. There are cables everywhere, the sticky

pads hurt the baby's sensitive skin, and nurses have to deal with all the wires just to pick the baby up. People have been trying to fix this, and here's what they've come up with so far. Some researchers figured out you can actually track a baby's heartbeat and breathing just using a camera. It picks up tiny color changes and movements you can't even see with your eyes. Pretty cool honestly, but it doesn't work great if the lighting changes or the baby moves around too much. Still a work in progress. These are basically small soft stickers that stick to the baby and send data wirelessly. Way less messy than wires. Parents can actually hold their baby without worrying about unplugging something. The downside is the battery doesn't last that long and they sometimes give wrong readings when the baby wiggles. With IoT, all the sensors talk to each other and send data to doctors' phones or computers even if the doctor is on a different floor. Really useful for emergencies. The problem is keeping all that medical data safe and secure on a network is tricky. Hospital monitors beep constantly. Like, constantly. Most of those alarms are fake the sensor just shifted or the baby moved. Nurses start ignoring them after a while which is obviously bad. AI can actually learn what's a real emergency vs. a false alarm, which is a huge deal. The catch is it needs a ton of good data to learn from.

110 PID-240: Sustainable Energy for Future Power System

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Energy plays an important role in modern life, but the increasing use of fossil fuels such as coal, oil and natural gas has created serious environmental and economic challenges. The lack of sustainable energy leads to problems like air pollution, climate change and the gradual depletion of natural resources. These issues highlight the urgent need to shift toward cleaner and more reliable energy sources that can support long-term development without harming the environment. The main objective of this study is to understand the importance of sustainable energy and to explore how renewable energy sources can help address current energy and environmental challenges. It aims to highlight the need for adopting cleaner technologies and improving energy efficiency in order to create a more sustainable energy system. The methodology used in this work is based on reviewing existing studies, reports and developments related to sustainable and renewable energy technologies. The study examines different renewable energy sources such as solar, wind and hydro energy, along with modern energy systems like smart grids and microgrids that help manage electricity

more efficiently. To overcome the problems caused by dependence on non-renewable energy sources, the study suggests increasing the use of renewable energy technologies, improving energy efficiency and integrating advanced energy management systems into current power networks. Encouraging innovation, supportive policies and greater awareness among people are also essential for promoting sustainable energy solutions. The expected outcome of this study is to show how the adoption of sustainable energy systems can reduce environmental damage, improve energy security and support long-term economic and social development. Overall, moving toward sustainable energy is a necessary step for building a cleaner, safer and more sustainable future.

111 PID-241: Valorization of Plant Polymer Waste into Bioplastics through Green Crosslinking

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The environmental burden caused by conventional plastics has driven the search for sustainable material alternatives that are both biodegradable and resource-efficient. Many currently available bioplastics depend on food-based inputs, which limits their large-scale applicability and raises concerns regarding cost and resource competition. This work presents an approach for developing biodegradable films by combining plant-derived polymers with naturally occurring organic acids, offering a more sustainable and scalable solution. To validate the concept, films were fabricated using commercially available cellulose, glycerol as a plasticizing agent, and citric acid as a crosslinker. A solution casting technique was employed to prepare thin films, followed by thermal curing (140°C) to promote crosslink formation through esterification between cellulose and citric acid. This process enables the formation of a stable polymer network, improving film properties without the use of toxic chemicals. Initial experimental observations confirmed the successful formation of smooth, transparent, and continuous films with visual characteristics comparable to thin plastic wrap. The films exhibited good flexibility during manual handling and maintained structural continuity without visible fractures. Additionally, thermal curing reduced surface stickiness and enhanced overall film stability, indicating effective crosslinking and improved intermolecular interactions. The optimized protocol will be extended to incorporate cellulose extracted from biomass waste, such as spent tea leaves, and organic acids derived from citrus residues. This transition aims to develop a fully waste-based system for biodegradable material production.

Overall, this study demonstrates a practical pathway for converting low-value organic waste into functional bioplastics, contributing to sustainable material development and supporting circular economy principles.

112 PID-242: Influence of Resin 3D Printing Parameters on Tensile, Flexural, and Impact Strength of SLA Based 3D Printed Parts

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Additive manufacturing (AM) has emerged as a transformative technology in modern manufacturing, enabling the fabrication of complex geometries with high precision and minimal material waste. Among the various AM techniques, stereolithography (SLA) is one of the most widely used vat photopolymerization processes due to its high dimensional accuracy, excellent surface finish, and capability to produce intricate structures. SLA printing operates by selectively curing liquid photopolymer resin layer by layer using ultraviolet (UV) light to fabricate three-dimensional components. However, the mechanical performance of SLA printed parts is highly dependent on several process parameters, including layer thickness, printing orientation, exposure time, and post-curing conditions. Improper selection of these parameters can result in weak interlayer bonding, dimensional inaccuracies, and reduced mechanical strength of printed components. Consequently, researchers have focused on understanding the relationship between SLA printing parameters and important mechanical properties such as tensile strength, flexural strength, and surface quality. Among these parameters, layer thickness and printing orientation play a significant role in determining the anisotropic behaviour and structural integrity of printed parts. Optimizing these parameters can improve interlayer adhesion, mechanical strength, and overall reliability of printed components. This study reviews recent research on the influence of SLA printing parameters on the mechanical performance of resin-based 3D printed components and highlights the importance of parameter optimization to enhance the strength, reliability, and functional performance of SLA-fabricated parts for engineering and biomedical applications.

113 PID-243: Computational Design and Prediction of Ricin-Specific Bioreceptors and Aptamers for Advanced Biosensing Applications

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The emergence of ricin as a serious biosecurity threat highlights the urgent need for rapid and highly sensitive diagnostic tools capable of detecting its presence in complex environments. Ricin is an extremely toxic protein derived from the castor bean plant and is known for its lethal effects, rapid action, and easy availability, making it a potential bioweapon. The toxin consists of two components: the A-chain, which inhibits protein synthesis by damaging ribosomal RNA, and the B-chain, which facilitates cellular entry. Detecting ricin is therefore essential for public health protection, environmental monitoring, and biodefense. Conventional antibody-based detection methods, although widely used, face limitations such as high cost, limited stability, and complex preparation. In contrast, aptamers short single-stranded DNA or RNA molecules that bind specifically to targets offer a promising alternative due to their chemical stability, ease of synthesis, and design flexibility. In this study, computational approaches were used to design and optimize DNA aptamers capable of recognizing both ricin A- and B-chains for biosensing applications. Previously reported aptamer sequences were collected and aligned to identify conserved regions and sequence similarities, followed by screening based on GC content and structural stability. Secondary structure prediction and thermodynamic analysis were performed using the Mfold server to evaluate folding and energy configurations. Optimized truncated variants were designed to enhance stability. Molecular docking with ricin structures from the Protein Data Bank was carried out using HADDOCK or AutoDock Vina to assess binding affinity and interaction stability. The results are expected to identify stable aptamers with strong binding, enabling the development of rapid, sensitive, and cost-effective biosensors for ricin detection in environmental, food, and clinical samples.

114 PID-244: Orthomorph: A Semantically-Preserving Adversarial Attack Framework for Evading Smishing Detection Models

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Short Messaging Service (SMS) is one of the most extensively utilised mobile applications for personal and corporate communication around the world. Smartphones popularity and continual availability to the Internet have made them vulnerable to smishing attacks. Smishing is the technique of delivering harmful SMS to users in which intruders send malicious SMS to the victim. This content may contain links that direct the user to websites that contain harmful software and user interfaces. Researchers have acquired outstanding accuracy scores in proposing SMS spam detectors (smishing detectors) utilising transformer-based deep learning algorithms. Despite their superior performance in NLP-related tasks, deep learning models are vulnerable to adversarial attacks that result in misclassification. A few words or characters are altered to create adversarial text, fooling the machine into making inaccurate predictions. This work introduces Orthomorph a character-level black-box attack algorithm. The proposed strategy generates more powerful adversarial instances while causing less text distortion. We evaluated our framework on three encoder-based transformers (BERT, DistilBERT, RoBERTa) and one decoder-based transformer (LLaMA), all of which are state-of-the-art architectures within the transformer family. Using various smishing detectors, we examined and analysed the behaviour of our attack approach. We assessed the probable outcomes using several measures such as attack success rate, after attack accuracy, perturbation rate, and query number. When compared to baselines, the new attack technique achieved the best evaluation scores. SMS contain fewer characters, are written in informal languages, and lack a public SMS spam corpus, which is why earlier attack methods are ineffective on this dataset.Furthermore, we evaluated and analysed the behaviour of different models under various attack setups to identify which smishing detector is the most vulnerable.

115 PID-245: Comparative Analysis of MoveNet Lightning, MoveNet Thunder, and YOLOv8 for Exercise-Based Human Pose Estimation

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Many individuals exercise without proper supervision, leading to incorrect posture and injuries. This study proposes a real-time pose estimation–based guidance system. Three models like YOLOv8n, MoveNet Lightning, and MoveNet Thunder, were evaluated using accuracy, PCK, jitter, and FPS keeping Medipipe as pseudo ground truth. YOLOv8n achieved the best performance with accuracy up to 0.9918, PCK up to 1.0000, low jitter (0.002–0.009), and highest speed (9–10 FPS). MoveNet Lightning showed moderate performance with accuracy up to 0.9762 and FPS around 4.6–5.1 but inconsistent PCK. MoveNet Thunder underperformed with lower accuracy (0.7499–0.8489), high jitter, and lowest speed (1.4–1.6 FPS), limiting real-time applicability.

116 PID-246: Comparative Study of Deep Learning Approaches for Deepfake Detection Across Real and Synthetic Face Datasets

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The increasing complexity of generative models has made synthetic facial images more realistic and has made it harder to detect deepfakes. Convolutional neural networks perform well on controlled datasets, but their effectiveness often drops when they encounter data with different features. This research examines the DenseNet-121 model, which is trained

on the DeepDetect-2025 dataset. This dataset includes images generated by both GAN and diffusion methods. The model is tested on several external datasets, including 140K Real vs Fake Face, 130K Real vs Fake Face, and GRAVEX-200K, to assess its performance in various data situations. Standard metrics like accuracy and AUC are used for evaluation. The results indicate that the model performs well on datasets with similar generation patterns and achieves high accuracy on StyleGAN-based images

117 PID-247: Development of a Bio-Organic Mineral Fertilizer Based on Oxalotrophic Bacteria and Mineral Weathering for Sustainable Soil Restoration

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Industrial agriculture was never designed to work with nature; rather, it prioritizes monoculture, heavy pesticide use, and synthetic fertilizers. It allows short-term yields but weakens biodiversity and crop resilience, leading to ecosystem deterioration. All these factors make crops more vulnerable to disease, pests, and climate stress, leading farmers to rely heavily on chemical fertilizers, pesticides, and herbicides, which, in turn, cause heavy metal contamination, soil acidification, and soil erosion. Sustainable soil restoration is crucial for ensuring food security and mitigating carbon emissions through carbon sequestration. Bio-organic mineral fertilizers (BOMF) offer a promising, sustainable alternative by harnessing microbial processes to slowly release nutrients, remediate contaminants, and enhance soil structure. This proposal aims to develop a novel BOMF integrating oxalotrophic bacteria and oxalogenic fungi via the oxalate-carbonate pathway (OCP). Multiple plants and fungal species produce oxalates as a part of their metabolism. When these plants shed leaves or decay, oxalotrophic bacteria digest the oxalate compounds as a carbon source and convert them into carbonate compounds. Through this multi-step process, atmospheric CO is effectively transformed into a stable, mineralized form within the soil. OCP represents a fascinating intersection of biology, chemistry, and ecology. Beyond carbon sequestration, the Oxalate Carbonate Pathway offers additional environmental benefits. The formation of carbonate minerals can stabilize soil structure by binding particles together, reducing erosion, and combating desertification. Moreover, this process can potentially immobilize harmful heavy metals such as lead and cadmium, reducing their toxicity and preventing their spread into

groundwater. Thus, OCP is not merely a climate solution but part of a broader framework for environmental restoration and sustainability.

118 PID-249: Automotive Lighting Solutions and Associated Risk on Indian Road

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Vehicle lighting equipment is fundamental to road safety as it enables drivers to see the roadway clearly while limiting excessive glare for other road users. The Original Equipment Manufacturer (OEM) lighting systems are engineered according to strict photometric and electrical standards. However, the rapid growth of the aftermarket automotive lighting industry has led to widespread modification of vehicle headlamp systems. The present study reviews relevant Automotive Industry Standards (AIS), legal wattage limits, and the availability of high-performance lighting products in the market. Many vehicle owners install higher-wattage halogen bulbs, LED conversion kits, projector fog lamps, and Bi-LED projector modules to increase brightness for better visibility and personalized vehicle appearance. Most of the time aftermarket (non-OEM) upgrades alter the original optical design of the headlamp and can introduce safety and regulatory concerns. This study investigates aftermarket lighting fitments through field survey and consumer interaction. The findings indicate that several aftermarket installations exceed OEM design specifications and may result in excessive glare, improper beam patterns, and increased electrical load on vehicle systems. The study highlights the need for improved regulatory enforcement, better testing methods, and increased awareness regarding safe lighting practices to ensure that aftermarket modifications do not compromise road safety.

119 PID-250: Mapping the Allergic Interactome: A Network Pharmacology Framework for the Discovery of Immunomodulatory Food Constituents

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Allergic diseases like allergic rhinitis ,and anaphylaxis result from disrupted immune signaling pathways. These pathways activate mast cells, encourage T-helper 2 (Th2) cell differentiation, and trigger the release of inflammatory cytokines. Traditional drug treatments often take a single-target approach. They focus on blocking specific molecules to relieve symptoms. While effective in short-term management, these methods do not tackle the overall immune imbalance that leads to allergic responses. In contrast, naturally occurring bioactive compounds found in foods have multi-target effects. They can improve immune function by interacting with various biological pathways. This project aims to use a systems biology and network pharmacology framework to study how dietary compounds interact with the molecular mechanisms of allergic diseases. By combining data from publicly available sources like FooDB, DisGeNET, and OMIM, we will create a bipartite network linking food-derived metabolites to genes associated with allergies. Additionally, we will include protein-protein interaction (PPI) data to capture relationships at the molecular level and create a detailed allergy interactome. Using graph theory-based topological analysis and centrality measures, we will identify key regulatory nodes and important compounds within the network. Pathway enrichment analysis through KEGG and Reactome databases will help us understand how these compounds affect immune pathways, especially related to Th2-driven inflammation and mast cell activation. This computational study seeks to connect nutrition science and immunology. We aim to develop a high-resolution Food- Allergy Topology Map. The results should highlight specific dietary compounds that work as multi-target regulators, providing a scientific foundation for food-based therapeutic strategies. Ultimately, this research aims to move from a narrow focus on drugs to broader, systems-based approaches for managing allergic diseases.

120 PID-251: APF-Tangent Bug based Obstacle Avoidance of Mobile Robot

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This extended abstract presents an obstacle avoidance strategy for mobile robots by integrating the artificial potential field (APF) method [1] with an improved tangent bug algorithm [2], using a multi-sensor perception system [3], to overcome the limitations of conventional reactive navigation techniques. The proposed approach utilizes an RGB camera for obstacle detection [4] and geometric characterization, while a laser rangefinder (LRF) provides the robot's instantaneous position for navigation. Unlike conventional approaches that rely solely on LRF data and are limited in handling multiple obstacles simultaneously, the proposed framework incorporates vision-based sensing to improve environmental perception and navigation reliability. The extracted obstacle coordinates, along with the robot's current pose and predefined goal position, are used within the APF formulation to compute a resultant force that guides the mobile-robot toward the target while maintaining safe distances from obstacles. This force is further translated into desired linear and angular velocities to ensure smooth and continuous motion. To enhance navigation in the vicinity of obstacles, the tangent bug algorithm is integrated as a local decision-making mechanism, enabling efficient path selection based on obstacle boundary information. The proposed framework operates in a reactive manner without requiring prior knowledge of the environment, making it suitable for real time applications. The integration of APF with the tangent bug algorithm, supported by multi sensor perception, provides a reliable and scalable solution for mobile robot [5] navigation in complex environments.

121 PID-252: An Intelligent Tracking System for Enhancing Sustainable: A Case Study on NPTEL

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Massive Open Online Courses (MOOCs), particularly platforms such as NPTEL, have sig-

nificantly transformed the landscape of higher education by offering accessible, flexible, and scalable learning opportunities to a diverse population of learners. Despite the widespread adoption and high enrollment rates in these courses, a persistent challenge remains in the form of low completion rates, which undermines the effectiveness of digital learning and leads to suboptimal utilization of educational resources. This issue poses a serious concern for the sustainability and impact of online education systems in academic institutions. To address this challenge, this paper proposes an intelligent student tracking and monitoring system designed specifically for analyzing and improving student participation in NPTEL courses within a college environment. The system integrates data collection, learning analytics, and performance evaluation to provide a comprehensive view of student engagement and progress. The proposed framework is structured into four key layers: data acquisition, data processing, monitoring, and intervention. It captures critical learning parameters such as login frequency, course progression, video engagement, and assignment submission patterns. These metrics are analyzed using analytical models to identify students at risk of non-completion. The system further provides an interactive dashboard for faculty members, enabling real-time monitoring of student performance and facilitating timely academic interventions such as mentoring, reminders, and support mechanisms. By promoting proactive engagement and personalized guidance, the system aims to enhance course completion rates and overall learning outcomes. This approach contributes to the development of sustainable digital education practices and aligns with Sustainable Development Goal 4 (Quality Education) by ensuring inclusive, equitable, and effective learning opportunities for all students.

122 PID-254: Investigations in Robotic Assisted Craniotomy Planning

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This work presents a method for precise localisation of brain tumours using medical image processing, three-dimensional modelling, and robot-assisted drilling and validation. MRI brain images are segmented in 3D Slicer to obtain accurate tumour coordinates, which are used to calculate the required drilling angle and depth so that the tumour can be reached

with minimal disturbance to surrounding tissues. A patient-specific brain model with the planned drilling path is fabricated using additive manufacturing to verify the trajectory before robotic drilling. The coordinates are mapped to the robotic workspace through calibration, and kinematic analysis is used to position the robotic arm. The expected results indicate that the proposed workflow can achieve high positional accuracy for precise neurosurgical drilling.

123 PID-255: Medicine Dispensers for Quick Relief of Asthmatic Patient–A Review of Indian Market

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Asthma is a long-term breathing problem that affects millions of people around the world. In India alone, there are almost 34.3 million cases. There are a lot of inhalation therapies out there, but managing the disease is still not very effective because a lot of patients have trouble following directions, using inhalers correctly, and dealing with different socioeconomic issues. There are some clear problems with common inhalation devices like pressurized metered-dose inhalers (pMDIs) and dry powder inhalers (DPIs). pMDIs need the user to coordinate their hands and breath, which is hard to do when they are having an acute respiratory distress episode. DPIs, on the other hand, usually require the user to load the device manually, which can be a little confusing. Breath-actuated inhalers and soft-mist inhalers are more advanced systems that are easier to use, but they are also often too expensive for many people, especially in low- and middle-income countries.

124 PID-258: A Study of Steering Geometry using Iterative Design ideology

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Normally, steering geometry is calculated under pure rolling assumptions where tyre slip angles are negligible. However, in actuality, especially in performance cars, tyres gain significant slip angles, resulting in deviation from ideal steering angles and tyre grips. Our study presents a methodology to optimize our steering geometry by integrating our geometric steering analysis with tyre slip behavior. To achieve optimal cornering performance, we require precise alignment between steering kinematics and tyre behavior. A CAD-based model was made, which gave us our required geometric steering angles to perform a corner of a given turning radius. Then tyre data was uploaded on MATLAB and slip angles were calculated. Using geometric steering angles and load transfer on wheels in addition to vertical tyre loading slip angles were calculated, which then were used to calculate cornering forces and actual steering angles. These simulations were iterated and then used to determine our actual steering angles for a corner. Then a parametric steering system CAD was iterated to reach our required steering angles and the error between both was minimized. The results gave us our resultant optimal cornering force at parallel steering geometries and Ackermann steering geometries.

125 PID-260: A Comparative Study on the Biocompatibility of Metal Nanoparticles Biosynthesized by Bacteria and Fungi

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Biogenic synthesis of metal nanoparticles has emerged as a sustainable, cost-effective alternative to conventional physicochemical methods. Microorganisms such as bacteria (Bacillus, Pseudomonas, E. coli) and fungi (Fusarium oxysporum, Aspergillus) can produce nanoparti-

cles through biological reduction. Gold and silver nanoparticles are widely studied for their unique properties like high surface area, stability, and easy manipulation making them suitable for antimicrobial therapy, drug delivery, biosensing, and cancer treatment. E. coli and Bacillus species are commonly employed due to their rapid growth, ease of cultivation, and efficient enzyme-mediated metal ion reduction, often yielding stable, monodispersed nanoparticles with enhanced biocompatibility. Fungi offer distinct advantages through secretion of large quantities of extracellular enzymes and metabolites that serve as both reducing and stabilizing agents. Rhizoctonia solani, a soil borne pathogenic fungus, remains underexplored in nanoparticle biosynthesis, presenting a novel opportunity given its extracellular biomolecule production and ease of cultivation. Biocompatibility, the ability of a material to perform its intended function without eliciting adverse host responses, is critical for biological applications. Thorough physicochemical characterization (UV–Vis, FTIR, XRD) and biological evaluation (MTT/XTT, hemolysis, cytotoxicity assays) are therefore essential. Comparative studies on biocompatibility of bacterially versus fungally derived nanoparticles remain limited. This study aims to (i) biosynthesize gold and silver nanoparticles using E. coli, Bacillus, and R. solani, (ii) characterize the nanoparticles, and (iii) comparatively assess their biocompatibility to identify the safest candidate for biomedical applications.

126 PID-261: Multilingual Fake News Detection System (Telugu & Hindi): A Comparative Study of Transformer-Based Models

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The rapid growth of social media has significantly increased the spread of misinformation, creating serious challenges for society, especially in multilingual countries like India. A large number of users rely on regional languages such as Hindi and Telugu for consuming news, while most existing fake news detection systems are primarily designed for English. This leads to a major gap in detecting misleading content in regional languages. To address this issue, this study proposes a multilingual fake news detection system for Hindi and Telugu using transformer-based models. The approach employs pre-trained models such as BERT (base-multilingual-cased), XLM-RoBERTa, IndicBERT, and DistilBERT. A unified framework is

designed to process both languages, including stages like data collection, preprocessing, tokenization, and classification. The Telugu dataset is manually annotated using reliable and unreliable news sources, whereas the Hindi dataset is sourced from publicly available labeled data. Both datasets are balanced and split into training, validation, and testing sets to ensure fair evaluation. The models are fine-tuned and evaluated using metrics such as accuracy, precision, recall, and F1-score. Experimental results indicate that model performance differs across languages. For Hindi, IndicBERT achieves the highest performance with an F1-score of 0.88, outperforming other models, while DistilBERT shows comparatively lower results. For Telugu, BERT achieves the best performance with an F1-score of 0.99, followed closely by DistilBERT and XLM-RoBERTa, demonstrating strong contextual understanding. Overall, the proposed system proves that transformer-based models are effective for detecting fake news in low-resource languages. The study highlights the importance of selecting suitable models for different languages and offers a scalable framework that can be extended to other regional languages for improved misinformation detection.

127 PID-262: Privacy Preserving Federated Learning for Brain Tumor Classification

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This paper presents a privacy preserving approach for brain tumor classification using MRI images by combining federated learning with differential privacy. A ResNet50 based model is used to classify tumors into four categories, achieving strong performance in both centralized and distributed settings. The federated learning model benefits from data across multiple clients without sharing raw information. The effect of differential privacy is also studied, showing that stronger privacy leads to lower accuracy. Overall, the study highlights the balance between maintaining data privacy and achieving reliable classification performance.

128 PID-264: Enhanced DehazeFormer for Single-Image Dehazing via Color-Preserving Combined Loss

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In the extreme cold regions, the environment is surrounded by dense-haze during the night time. Night-time can decrease the visibility which increases the risk of accidents, which increases the life loss and manufacturing delays creates unavailability of the material that interrupts the global supply from manufacture to customer. These challenges required suggestions to enhance the DehazeFormer model this framework suggested using the Color-Preserving Combined Loss (CPCL), integrating L1, SSIM and Perceptual losses. The approach is evaluated based on these functions which are later combined to form a loss function.

129 PID-265: In-Silico Analysis of Alpha-Synuclein Structure and Its Role in Parkinson's Disease

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In this study we perform a detailed in-silico analysis of a neuronal protein, alpha synuclein which plays a crucial role in the pathogenesis of Parkinson's disease. There is an urgent need to study the molecular mechanism of Parkinson disease patients due to an increase in their number. Parkinson's disease is a progressive neurodegenerative disorder in which symptoms are motor dysfunction, loss of dopaminergic neurons, and the accumulation of misfolded alpha-synuclein aggregates knowns as Lewy bodies are usually seen. Due to propensity of alpha-synuclein to misfold and aggregate under pathological conditions it has emerged as a key protein in this context. The amino acid sequence of alpha-synuclein was retrieved from the UniProt database and its detailed physicochemical analysis was done using ExPASy ProtParam. The protein consisted of 140 amino acids with a molecular weight of 14.46 kDa, hence it can be classified as a relatively small protein. The protein carries a net negative

charge at physiological pH which is indicated by its theoretical isoelectric point (pI) of 4.67, which significantly influences its interaction with cellular membranes, metal ions, and other biomolecules. The instability index of 25.47 suggests that the protein is stable under in vitro conditions; however, instability index does not fully capture its dynamic conformational behavior in vivo. The aliphatic index of 69.64 indicates moderate thermostability, suggesting that the protein can maintain its structure under varying temperature conditions. The hydrophilic nature of the protein is confirmed by a negative GRAVY score of -0.403, which is a hallmark of intrinsically disordered proteins that lack a stable hydrophobic core. Index Terms - Alpha-synuclein, aggregation, in-silico, intrinsically disordered protein, Lewy bodies, Parkinson's disease, protein misfolding

130 PID-266: Alvi-Gemini: A Python-Native Digital Twin Framework for Evaluating Autonomous Navigation Robustness in the Arduino Alvik Ecosystem

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Autonomous robotics development often struggles with algorithms that succeed in simulations but fail in the real world. This Reality Gap is common in MicroPython-based platforms like the Arduino Alvik. Idealized code often faces issues from sensor inaccuracies and environmental interference when transitioning to physical hardware. Traditional simulators lack the mathematical basis for proper behavioral validation. This research introduces Alvi-Gemini, a Python-native Digital Twin (DT) framework. It is designed to bridge this gap through high-fidelity behavioral mirroring and virtual commissioning. Alvi-Gemini emphasizes Behavioral Fidelity. A stochastic engine injects Gaussian noise into virtual sensor arrays. This replicates the signal fluctuations found in real-world infrared and ultrasonic sensors. Using a unified Python-MicroPython architecture ensures complete code portabil-

ity. The navigation logic developed within the twin is identical to the code on the physical Alvik's STM32/ESP32 processors. This removes the software friction that delays robotics development. To assess the framework's robustness, the Alvi-Gemini twin underwent testing in four research environments: a Nominal baseline for kinematic calibration, a Stochastic Noise track for sensor interference testing, an Edge Case course for sharp-turn recovery, and a High-Stress environment to find failure points. Performance was measured through real-time telemetry, including Terminal Velocity, Yaw Oscillation, and Mean Path Deviation. Results show that Alvi-Gemini can predict failure thresholds within a 95% margin of theoretical physical limits. By making the virtual world realistically difficult, this research shows that a well-modeled Digital Twin can be a validation tool. Alvi-Gemini provides a path for the robotics community, ensuring that code is resilient enough to handle real-world complexities.

131 PID-267: Multimodal Deep Learning Framework for Dysarthria Detection and Severity Estimation in ALS and Cerebral Palsy Speech

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Dysarthria is a motor speech disorder that commonly affects individuals with neurological conditions such as Amyotrophic Lateral Sclerosis and Cerebral Palsy. It reduces speech clarity, lowers intelligibility, and disrupts the natural rhythm of communication. As voice driven technologies such as smart assistants and speech recognition systems become increasingly part of everyday life, individuals with dysarthria often struggle to use these tools effectively. Most existing speech recognition models are trained on typical speech and perform poorly on atypical patterns, creating a real accessibility gap that is both a technical problem and a human one. This work proposes a multimodal deep learning framework for automatic detection and severity estimation of dysarthric speech. The system combines acoustic features, prosodic characteristics, and temporal speech patterns to capture how speech breaks down across different dimensions. A self supervised learning approach based on wav2vec 2.0 is used to build strong speech representations from large volumes of unlabeled data, before being fine tuned on clinical datasets including TORGO and UASpeech. The model handles two tasks at the same time, classifying speech as healthy or dysarthric while also estimating the degree of impairment, which helps it learn better and hold up across different speakers and

conditions. A severity aware loss function is introduced so that larger prediction errors are penalized more heavily than minor ones, keeping the outputs clinically useful. An attention based interpretability module also highlights which parts of a speech sample most influenced the model's decision, making the system more transparent for clinical use. Performance is measured using accuracy, F1 score, mean absolute error, confusion matrices, and ROC curves. Overall, this framework is aimed at making voice technology work better for people with speech differences and pushing toward more inclusive assistive healthcare tools.

132 PID-268: An Integrated Approach to Employee Retention and Layoff Risk Prediction Using Predictive Analytics and Machine Learning for Strategic Workforce Management

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Employee attrition and workforce volatility have become major challenges for organizations, and traditional human resource assessment techniques are not appropriate in dealing with such issues, as they are based on manual evaluation and are not able to identify complex patterns in employee data. This study proposes a predictive model using machine learning techniques for employee attrition and layoff risk assessment using HR analytics techniques. The model uses significant employee characteristics such as employee age, experience, performance rating, skill level, and job satisfaction, which are collected from HR data. The study uses data preprocessing techniques such as feature selection and Synthetic Minority Over-sampling Technique (SMOTE) for improving model performance, and it uses multiple classification algorithms such as Logistic Regression, Random Forest, and XGBoost for employee attrition and layoff risk assessment. The experimental evaluation of the model shows that the Random Forest model achieves an overall prediction accuracy of about 87.8%. The system divides employees into three risk levels: Low, Medium, and High, and it helps HR managers in strategic workforce planning and employee retention strategies.

133 PID-269: A Physics Informed Neural Network for Functionally Graded Plates

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This study presents a Physics-Informed Neural Network (PINN) framework for the static bending analysis of functionally graded material (FGM) plates. Unlike traditional numerical methods that require dense mesh discretization to resolve continuous material gradients, the proposed mesh-free approach embeds the governing equations of Classical Laminated Plate Theory (CLPT) directly into the network's loss function. The framework utilizes a total potential energy minimization strategy to predict the displacement fields of a simply supported square FGM plate under sinusoidal transverse loading. Material properties are modeled using a power-law distribution varying through the thickness. A hybrid optimization scheme, combining Adam and L-BFGS algorithms, was implemented to ensure global stability and high-precision convergence. Results for a power-law index of m=1 demonstrate a relative error of only 3.3% compared to analytical solutions, achieved in 80 seconds of computational time. The findings highlight the efficiency of PINNs in capturing complex structural responses in graded composites without the computational complexity of mesh generation.

134 PID-270: A Study and Development of One-Class Classification Techniques for Text Data

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The rapid expansion of digital information across social media, healthcare, cybersecurity, and scientific publishing has intensified the need for systems that can identify anomalous or harmful content. In many scenarios, labeled data for all categories are unavailable or con-

tinuously evolving, limiting conventional supervised classification. One-Class Classification (OCC) addresses this by learning from a single target class and identifying deviations as anomalies. This paradigm suits problems such as fraud detection, cyberattack monitoring, medical anomaly identification, and misinformation analysis, where negative examples are rare or undefined. Despite its relevance, OCC for high-dimensional text data faces challenges in robustness, scalability, representation learning, and threshold selection. Classical approaches like OCSVM and SVDD struggle with semantic complexity of language. Deep learning methods such as Deep SVDD and autoencoders offer better representations but depend on manual thresholds and show limited robustness under distributional shift. This paper presents an ongoing study analyzing existing OCC techniques and developing enhanced models for textual data. The methodology involves reviewing classical, ensemble, and deep learning-based OCC approaches, followed by designing models integrating modern representation learning with one-class objectives. Emphasis is on adaptive thresholding, noise robustness, and lightweight architectures. Evaluation will use benchmark text datasets with appropriate one-class metrics. Expected outcomes include novel OCC models for text with improved robustness, scalability, and generalization.

135 PID-276: Sustainable Rural Development through Participatory Governance: A Case Study under Unnat Bharat Abhiyan

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Sustainable community development is essential for inclusive and resilient growth, particularly in rural areas facing infrastructural and social challenges. This paper presents a case study on Unnat Bharat Abhiyan (UBA), based on field interventions conducted in selected villages of Ponneri Block, Thiruvallur District, Tamil Nadu. The study evaluates key sustainability indicators, including water supply, sanitation, healthcare, education, employment, and governance. A participatory field-based approach involving transect walks, village mapping, household surveys, and Grama Sabha participation was adopted. The findings reveal challenges such as inadequate infrastructure, irregular water supply, limited healthcare access, and restricted employment opportunities, alongside strong community participation and grassroots governance. The study highlights the importance of participatory planning and academic involvement in addressing rural challenges. It demonstrates that Unnat Bharat Abhiyan is an effective framework for promoting sustainable development and

strengthening rural communities in alignment with Sustainable Development Goals. Index Terms—Sustainable Communities, Unnat Bharat Abhiyan, Rural Development, Participatory Governance, Field Interventions

136 PID-279: Machine Learning-Based Prediction of Chemotherapy-Induced Adverse Effects using Baseline Quality of Life Metrics in Breast Cancer Patients

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Breast cancer is actually the most common cancer affecting women around the globe, with about 2.3 million new cases and 670,000 deaths every year. The side effects from chemotherapy can really impact how well patients do with their treatment and their overall quality of life. This study is looking to predict the main side effects caused by chemotherapy by using quality of life data collected before treatment. We're applying a deep learning technique called TabNet, which uses baseline quality of life features reported by patients to forecast symptoms like fatigue, pain, insomnia, and loss of appetite. To train a multi-output classification model, we created a synthetic dataset that matches standard quality of life areas. Since there aren't clear toxicity labels in real-world datasets, we validate our findings using harmonized datasets, converting symptom scores into binary labels. The results show we can achieve high accuracy in classification, although things like class imbalance and the method of labeling do influence performance. Overall, this study highlights how useful baseline quality of life data can be for spotting patients who might be at risk for chemotherapy side effects early on, which can really help with clinical decision-making and guide future research.

137 PID-281: RIS-Assisted RF Redundancy Framework Using V2X and UWB for Robust Autonomous Vehicle Operation

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Autonomous vehicles rely on sensors such as cameras, LiDAR, and radar for perception and decision-making. However, these sensors are highly affected by environmental conditions such as fog, rain, glare, and urban obstructions, which degrade their performance and compromise vehicle safety. In dense urban environments, non-line-of-sight (NLOS) conditions further reduce sensing reliability. To enhance system capabilities, wireless technologies such as Vehicle-to-Everything (V2X) communication and Ultra-Wideband (UWB) are increasingly integrated into modern vehicles. Despite their advantages, these technologies are primarily designed for communication and localization, with limited use as safety-critical redundancy systems.This work proposes an RF redundancy framework using a Reconfigurable Intelligent Surface (RIS) to improve system robustness under sensor-degraded and NLOS conditions. The system integrates a V2X antenna (5.9 GHz) and a UWB antenna (3.1–10.6 GHz) with RIS to control electromagnetic wave propagation . Simulations in CST Microwave Studio are used to evaluate antenna performance, coexistence, and propagation behavior. The proposed system aims to enhance communication reliability and provide a fallback mechanism for autonomous vehicle operation.

138 PID-282: Design and Experimental Validation of a Load Prioritization System for Power Optimization in Smart Homes

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The widespread use of electrical and electronic devices in homes has significantly increased energy consumption and made load patterns more complex. In smart homes, this becomes a challenge, especially during peak demand periods or unexpected power cuts, where uncontrolled usage of appliances can lead to inefficient energy use and even failure of important systems. The situation becomes more critical when limited backup sources such as batteries and solar inverters are involved, requiring proper energy management. In this work, a load prioritization system is designed and tested to improve energy usage in smart homes. The system is built using a microcontroller along with sensors, a solar inverter, and battery support. It organizes household appliances into different priority levels so that essential devices like lights, refrigerators, and security systems continue to operate even during power short-

ages. Less important devices are automatically turned off when energy availability is low. The approach combines concepts from smart grid systems, demand-side management, and home energy optimization. A prototype model was tested under different load conditions to evaluate system performance. The results show that the system can effectively manage limited power resources while improving efficiency and maintaining user comfort. This solution is affordable, scalable, and suitable for future smart home applications. Moreover, the proposed system supports flexible integration with existing home infrastructures and can adapt to varying user requirements and energy availability conditions. Its modular design allows easy upgrades and future enhancements, including the incorporation of intelligent algorithms for predictive energy management. This makes the system not only efficient but also future-ready for evolving smart grid environments and advanced home automation technologies.

139 PID-284: Machine Learning-Based Phishing URL Detection: A Comparative Study of Classical and Ensemble Classifiers

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Phishing attacks are among the most widespread cybersecurity threats. Adversaries create harmful URLs to pretend to be legitimate websites and trick unsuspecting users. Traditional detection methods, which rely on rules and blacklists, are becoming less effective against complex phishing schemes. This study compares classical machine learning algorithms for detecting phishing URLs using features derived from structured URLs. Four classifiers are tested: Logistic Regression, Decision Tree, Random Forest, and XGBoost. The study also proposes a hard-voting ensemble model that combines Decision Tree, Random Forest, and XGBoost. Experiments use a publicly available phishing URL dataset, measuring accuracy, precision, recall, F1-score, and ROC-AUC. The results show that the ensemble classifier achieves 97.60% accuracy and an F1-score of 97.86%, outperforming all individual classifiers. These results highlight the importance of ensemble learning in real-world phishing detection systems.

140 PID-285: M-GAN: A Conditional GAN Framework for Accurate Retinal Vessel segmentation using Deep Residual Networks

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The paper focuses on automatically segmenting retinal blood vessels from eye fundus images. Segmenting these vessels is important for diagnosing diseases like diabetic retinopathy, glaucoma, and hypertension.Identifying blood vessels from fundus images helps doctors examine abnormalities in the vascular structure. Manual segmentation is a lengthy and complicated process that needs expert knowledge. This paper presents a deep learning-based Modified Generative Adversarial Network (M-GAN) model for automated retinal vessel segmentation. The proposed system has three main stages preprocessing, segmentation, and post-processing The model is evaluated on two standard retinal datasets, DRIVE and STARE. Experimental results show that the proposed approach achieves high accuracy, an improved F1-score, and better detection of thin vessels compared to traditional and baseline deep learning methods. Overall, the proposed M-GAN framework provides an efficient and reliable solution for automated retinal vessel segmentation, which supports early diagnosis and large-scale medical screening applications.

141 PID-288: Fidelity Analysis of Imperfect Quantum Teleportation via Werner States

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Quantum teleportation is a fundamental protocol [1] in quantum information that enables the transfer of an unknown quantum state using shared entanglement and classical communication. In ideal scenarios, the protocol assumes the availability of a maximally entangled Bell state; however, practical implementations are subject to noise and decoherence, leading to imperfect entanglement. In this work, we investigate the performance of quantum teleportation under such non-ideal conditions by modelling the shared entangled resource as a Werner state [2]. The Werner state is parameterized by a mixing parameter p, which interpolates between a maximally entangled state and a completely mixed state. Using known analytical results, the average teleportation fidelity is given by F(p)=((2p+1))/3, which increases linearly with the entanglement parameter. The result is compared with the optimal classical fidelity limit of 2/3 [3], allowing us to identify the threshold p¿1/2 required for achieving a quantum advantage. Furthermore, we discuss the entanglement threshold p¿1/3, as determined by the Peres-Horodecki criterion, and the Bell inequality violation threshold p¿1/2. Notably, there exists a region 1/3¡p¡1/2 where the shared state is entangled but does not provide any advantage over classical communication. These results show that entanglement usefulness depends on its strength, with different tasks requiring different correlation levels.

142 PID-291: Design of a Low-RCS V2X Antenna System using a Metasurface Absorber Ground Plane for Autonomous Vehicles

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The rapid advancement of autonomous vehicle technology has led to the widespread deployment of multiple sensing and communication systems, including radar, LiDAR, and Vehicle-to-Everything (V2X) antennas. However, the dense electromagnetic environment created by these systems introduces a critical challenge known as radar interference and clutter. Conventional V2X antennas utilize Perfect Electric Conductor (PEC) ground planes, which act as strong reflectors of incident radar signals, resulting in increased Radar Cross Section (RCS). This leads to the formation of ghost targets and false detections, thereby compromising the reliability and safety of automotive collision avoidance systems. This work proposes

the design of a frequency selective metasurface absorber integrated as a ground plane for a 5.9 GHz V2X microstrip patch antenna to achieve reduced radar visibility without degrading communication performance. The proposed metasurface is engineered to exhibit dual electromagnetic behaviour, high reflection at the V2X communication band (5.85–5.925 GHz) to support efficient radiation, and strong absorption in the X-band radar frequencies (8–12 GHz) to minimize reflected signals. The ongoing research focuses on the design and simulation of a metasurface unit cell using CST Studio. Initial studies involve analysing periodic structures under Floquet boundary conditions to evaluate their reflection and absorption characteristics. Parametric optimization of geometric features such as slot dimensions, substrate properties, and periodicity is being carried out to achieve the desired frequency-selective response. The designed metasurface will be integrated with a rectangular patch antenna, and its impact on key performance parameters will be investigated. The expected outcome of this work is a reduction in RCS by at least 10 dB within the radar frequency band while maintaining a realized gain greater than 5 dBi at 5.9 GHz.

143 PID-293: Hidden Barriers to Learning: Sensory Filtering and Temporal Processing in Socioeconomically Disadvantaged Children

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Children from low socioeconomic status backgrounds show reduced classroom engagement even when educational resources, teacher attention, and instructional time are fairly allocated. Existing literature links this to deficits in executive functions such as attention, self-control, and working memory, but these are higher-order thinking abilities. Recent developmental research in cognitive psychology has established that the mental timeline, the culturally acquired representation of duration and temporal order, runs along a left-to-right spatial axis. We propose that this basic perceptual processing of time and sensory information, as it operates during real classroom environments, is underdeveloped in these children. Thus, when most tasks in classroom settings are organised according to left-to-right spatial logic, these children must consciously reconstruct temporal sequence for every task, incurring a hidden cognitive load that teachers are not trained to recognise. Thus, classroom disengagement in these children may not be a failure of motivation or access. It may instead be a failure of poor environments to provide the left-to-right spatial scaffolding through which the mental timeline is built, even before the child enters the classroom.

144 PID-294: Simulation-Based Design and Analysis of a Robust High-Power H-Bridge Motor Driver

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This paper presents the simulation-based design and analysis of a high-power NMOS H-bridge motor driver for DC motor control applications. The system is developed to operate within a 24–48 V supply range while driving a 12 V, 15 A motor using PWM-based speed control. The proposed design focuses on efficient bidirectional control, robust switching performance, and enhanced reliability under high-load conditions. MOSFET selection is carried out based on voltage margin and current capability, leading to the implementation of the IRFB4410 NMOSFET to ensure safe operation with a sufficient safety factor. The driver incorporates essential protection mechanisms, including reverse polarity protection, overcurrent protection, short-circuit handling, and suppression of inductive voltage spikes using flyback diodes. These features improve system robustness and prevent component damage under abnormal conditions. The proposed design demonstrates a practical and scalable solution for high-power motor control in robotics and industrial automation applications

145 PID-298: Explainable Deep Learning Framework for Alzheimer's Disease Classification using Transfer Learning

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Alzheimer's disease is a progressive neurodegenerative disorder and a leading cause of dementia, requiring early and accurate diagnosis for effective management. Magnetic Resonance Imaging provides detailed insights into brain structural changes, however, its analysis and interpretation are time consuming and reliant on clinical expertise, thereby emphasizing the need for automated deep learning based approaches.. This paper proposes a comparative evaluation of deep learning models for Alzheimer's disease classification using MRI images. The proposed system uses a kaggle Alzheimer's MRI dataset, which comprises 6,400 labeled

images, categorized into four different classes: non demented, very mild demented, mild demented, and moderate demented. In this paper, transfer learning methods are used that include VGG16, ResNet50, and DenseNet121. The performance of these models is compared on the basis of accuracy, precision, recall, and F1-score, while the use of Grad-CAM enhances the interpretability of the results by highlighting the key regions of interest in the image that are responsible for the outcome. The results show that ResNet50 performs better than other models, with a high accuracy of 97% along with high precision, recall, and F1-score, followed by VGG16, while DenseNet121 shows comparatively lower performance.

146 PID-299: Valorization of Sugarcane Bagasse for Nanocellulose-Based Microplastic Filtration

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Microplastic pollution has emerged as a critical environmental concern due to its persistence, small size (typically ¡5 mm), and ability to bypass conventional water treatment processes, resulting in contamination of aquatic ecosystems and drinking water sources. Simultaneously, the accumulation of agro-industrial waste presents an opportunity for sustainable material development through biomass valorization. In this study, sugarcane bagasse — a fibrous by-product of sugar extraction — is utilized as a renewable feedstock for the production of nanocellulose-based filtration materials. Sugarcane bagasse constitutes approximately 25–35% of processed sugarcane mass and is primarily composed of cellulose (40–50%), hemicellulose (25–35%), and lignin (15–35%). Despite its high cellulose content, it is largely used as a low-value fuel, highlighting the need for its conversion into high-value materials within a circular bioeconomy framework. The methodology involves extraction of cellulose from sugarcane bagasse through chemical pretreatment to remove lignin and hemicellulose, followed by controlled hydrolysis and mechanical processing to produce nanocellulose in the form of cellulose nanofibres and nanocrystals. Due to its nanoscale dimensions, high aspect ratio, and abundant hydroxyl groups, nanocellulose exhibits key physicochemical properties including high surface area, mechanical strength, hydrophilicity, and biodegradability, making it suitable for filtration applications. To enhance performance, the extracted nanocellulose

is fabricated into porous nanofiber mats using electrospinning, producing interconnected fibrous networks with tunable morphology and nanoscale pores. The membranes are expected to remove microplastics through size exclusion, adsorption, and entrapment mechanisms.This approach integrates waste utilization with nanotechnology-based water purification, offering an eco-friendly, cost-effective solution for sustainable treatment.

147 PID-301: An Adaptive Multi-Resolution Fusion Framework for Power Quality Disturbance Classification using Haar-Hilbert-Huang-SST and Triggered Fuzzy Logic

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Ensuring Power Quality (PQ) is essential for the stability and efficiency of modern smart grid infrastructures. Conventional Artificial Intelligence (AI) approaches, particularly Deep Learning, provide high classification accuracy but are constrained by high computational complexity and dependence on large labeled datasets. This paper proposes a computationally efficient hybrid framework for PQ disturbance classification with minimal data dependency. The methodology integrates the Stationary Haar Wavelet Transform (SHWT), Hilbert–Huang Transform (HHT), and Synchrosqueezing Transform (SST) within a hierarchical Fuzzy Inference System (FIS). To reduce computational burden, a trigger-based execution strategy is adopted. SHWT operates as a low-complexity monitoring stage that evaluates energy coefficients (d) to detect abrupt signal variations. When a disturbance exceeds a predefined threshold (), the HHT stage is activated. HHT performs Empirical Mode Decomposition (EMD) to extract Intrinsic Mode Functions (IMFs) and obtain instantaneous frequency characteristics suitable for non-linear and non-stationary signals. If HHT fails to resolve overlapping spectral components, SST is invoked as a refinement stage to enhance time–frequency resolution through spectral energy reassignment. Features extracted from HHT and SST are fused and processed using a Mamdani-type Fuzzy Inference System for robust classification. This hierarchical framework activates computationally intensive transforms only when required, reducing processing overhead. Preliminary evaluation indicates improved classification accuracy for complex PQ disturbances while maintaining low computational requirements, making it suitable for real-time smart grid applications.

148 PID-303: Detection Techniques at the LHC:Ongoing Experiments, Recent Developments and Future Prospects

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The Large Hadron Collider (LHC) at CERN, Switzerland, is one of the most sophisticated experimental facility developed throughout human history. Since its first proton-proton collisions in 2008, there have been continuous revolution in the detector technology, data acquisition and particle identification methods. This extended abstract probes the evolution of principal experiments- ALICE, CMS, ATLAS and LHCb, from the foundational Run 1 Infrastructure, through transformative upgrades of Run 3 and forthcoming High-Luminosity (HL-LHC) facility. The landmark achieved at LHC in 2012 when most major predictions of the Standard Model of Particle Physics were validated through the discovery of the Higgs Boson demonstrated the extraordinary capability of multilayer detection systems at the facility.This paper also discusses key scope for future improvements, leading to developments toward unprecedented precision in probing fundamental forces and searching for dark matter, extra dimensions and supersymmetric particles.

149 PID-304: Optimization and Scale-Ready Engineering of Bacterioboats for Cost-Effective, Reliable, and Enhanced Oral Drug Delivery

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The Bacterioboat (BB) drug delivery system is a new way to deliver drugs orally with the help of probiotics. It combines Lactobacillus reuteri with mesoporous chitosan nanoparticles to make drugs more available, keep them in the intestines longer, and work better while causing less harm to the body. While proof-of-concept experiments have yielded encouraging outcomes, especially for short half-life pharmaceuticals like 5-fluorouracil (5-FU), other obstacles persist that hinder the scalability, reproducibility, and industrial applicability of this approach. Some of these problems are that the thickness and porosity of the nanoparticle coating can vary, the amount of drug loaded can vary between batches, the synthesis process is complicated, there is a risk of material waste during formulation, and there is not much

information about how stable Bacterioboats are when they are in the stomach. The goal of this research is to use a systematic process-engineering approach to increase the consistency, stability, and cost-effectiveness of the Bacterioboat platform. We will carefully optimize important synthesis parameters like chitosan concentration, crosslinker (STPP) stoichiometry, reaction time, and incubation conditions to get a uniform nanoparticle coating, better drug-loading efficiency, and controlled drug release profiles while keeping batch-to-batch variability to a minimum. The study also aims to enhance the physicochemical and functional stability of the Bacterioboat structure by fortifying nanoparticle integrity, optimizing bacterial surface interactions, and improving biofilm properties to guarantee sustained drug delivery under simulated gastrointestinal stresses. The research also aims to create a simpler and more industry-friendly synthesis workflow by finding measurable quality-control standards such nanoparticle size, porosity, zeta potential, drug-loading efficiency, release kinetics, and microbial viability.

150 PID-307: Track defect detection system: : A review report and the way forward

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Ensuring railway structural integrity is critical for safe mass transit and heavy-haul freight networks. Increasing operational speeds and axle loads subject track components to extreme dynamic stresses, propagating discontinuities like rolling contact fatigue and transverse fissures. Current monitoring relies on reactive, interval-based manual inspections and vehicle-mounted Ultrasonic Flaw Detection (USFD). These methods suffer from severe temporal and acoustic blind spots, allowing defects to propagate undetected between cycles. To overcome this, we present the Track Defect Detection System (TD2), an autonomous, IoT-enabled ultrasonic inspection architecture. TD2 deploys a 25-probe ultrasonic array using polymethyl methacry- late (PMMA) wedges to achieve multi-angle acoustic tomography (0◦ , 45◦, and 70◦ orientations). For robust micro-volt signal ac- quisition in vibratory railway environments, the hardware utilizes an analog front-end featuring TL072 JFET operational amplifiers and MCP3564 24-bit delta-sigma Analog-to-Digital Converters. Edge-level signal processing is executed via a dual-core RP2040 microcontroller, leveraging Programmable I/O (PIO) and Direct Memory Access (DMA) to prevent CPU stalling during high- speed data ingestion. Extracted acoustic features are wirelessly transmitted via an ESP32-S2 mod-

ule to a cloud architecture. A Categorical Boosting (CatBoost) machine learning ensemble classifies complex defect signatures. Achieving high empirical accuracy, the model effectively distinguishes healthy structural acoustics from critical metallurgical degradation. By synthesizing multi-angle acoustic sensing, edge computing, and predictive ML, TD2 transitions railway monitoring to a proactive, data-driven predictive maintenance paradigm.

151 PID-308: Towards Physics-Aware Micro-Leak Prognosis in FESTO Pneumatic Systems Using FluidSIM-Based Signal Analysis

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Compressed air systems are widely used in industrial automation but suffer from low energy efficiency, with only 10–20% of input energy converted into useful work. A significant portion of losses arises from pneumatic leaks, especially micro-leaks that remain undetected due to stable system pressure maintained by compressor regulation. This limits the effectiveness of conventional pressure-based monitoring in programmable logic controllers (PLCs). This study explores early leak detection using a physics-aware AI framework supported by simulation data. A FESTO-style pneumatic system was modeled in FluidSIM, incorporating key components such as a compressor, FRL unit, sensors, control valve, and double-acting cylinder. Controlled leaks were introduced via a variable orifice, and time-series data including pressure, airflow, displacement, and velocity were collected. Results show that pressure remains nearly constant even under leak conditions, making it an unreliable indicator. In contrast, airflow exhibits a clear increase with leak severity, highlighting its effectiveness for early detection. By integrating compressible flow physics into machine learning models, the approach aims to improve prediction accuracy and interpretability. Future work involves developing physics-aware models and validating them on FESTO hardware. Early detection of pneumatic leaks can significantly reduce energy losses and enhance industrial system reliability.

152 PID-309: Foundation Model-Driven lncRNA Identification and Classification in Glycine max Using Plant-Specific RNA Language Embeddings

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Long non-coding RNAs (lncRNAs) are crucial regulators of plant gene expression, influencing development and stress responses. In soybean (Glycine max), accurate lncRNA identification is hindered by false positives from small ORFs encoding micropeptides, poor sequence conservation, and condition-specific expression. Current catalogues built with tools like CPC2 and FEELnc struggle to distinguish genuine lncRNAs from coding transcripts. While BERT-style RNA models (e.g., lncRNA-BERT) have shown success in humans, no plant-specific foundation model has been applied. This study proposes the first use of PlantRNA-FM, a Transformer pre-trained on RNA sequences from 1,124 plant species, for lncRNA coding potential classification in soybean. The pipeline begins with de novo transcript assembly from strand-specific, rRNA-depleted RNA-Seq data (NCBI SRA), ensuring diverse tissues, developmental stages, and stress conditions with 3 biological replicates. Strand specificity resolves antisense lncRNAs, while rRNA depletion captures non-polyadenylated transcripts. Candidate transcripts (¿200 nt) will be assessed using PlantRNA-FM fine-tuned on curated Arabidopsis thaliana datasets. DeepPlnc, a CNN validated for plants, will serve as an independent classifier. To reduce micropeptide contamination, transcripts 200–500 nt will be screened with sORF finder and CPPred-sORF, combining hexamer bias, substitution rates, and SVM-based descriptors. Structural validation via ViennaRNA (MFEI ¿0.85) will further refine candidates. Confirmed lncRNAs will be categorized into intergenic, intronic, antisense, and overlapping types using FEELnc. This work will test whether plant-specific foundation model embeddings outperform traditional feature-engineering methods, while producing an updated, classified soybean lncRNA catalogue for molecular breeding applications.

153 PID-310: Linear Magnetic Generator (LMG) Tiles for Road-Based Energy Harvesting

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This study presents the conceptual design and analytical evaluation of a linear magnetic tile system for energy harvesting from vehicular motion. The system converts mechanical input generated by vehicle load into electrical energy using a combination of mechanical transmission and electromagnetic induction. A controlled vertical displacement of the tile is utilized to initiate motion within the system. The mechanical stage includes a transmission mechanism and an energy-buffering unit to ensure smooth, continuous motion. The electrical stage consists of a magnetic assembly and coil arrangement designed to maximize flux variation and induced output. System performance is evaluated using theoretical modelling of energy transfer, efficiency, and electrical output under different operating conditions. The analysis focuses on estimating system behaviour, identifying major sources of loss, and determining feasible efficiency ranges. The energy in a flywheel is stored in the form of rotational kinetic energy, and rack and pinion systems can push efficiency to 97 percent, while flywheel systems demonstrate "Round-trip efficiency 87.00%". This work represents an initial design and analytical phase aimed at establishing the viability of the proposed system.

154 PID-314: Real Time Traffic Accident Prediction and Detection using YOLOv8

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Road accidents pose a serious global threat, claiming thousands of lives annually. Existing traffic monitoring systems predominantly detect accidents after they occur, limiting their preventive utility. This paper proposes a real-time accident detection and prediction system using YOLOv8 and motion-based risk analysis. Vehicles are detected from live video, and a composite risk score computed from inter-vehicle distance, relative velocity, and bounding box overlap is used to flag high-risk scenarios before a collision occurs. A Streamlit dashboard provides real-time visualization, and a generative AI module produces automated incident

summaries. The system achieved a precision of 89.5%, recall of 92.1%, F1-score of 90.7%, mAP@0.5 of 91.3%, and 38 FPS, demonstrating reliable real-time performance. Results confirm that the proposed framework effectively shifts traffic safety from reactive detection to proactive prevention. Keywords— Accident prediction, YOLOv8, computer vision, risk analysis, intelligent transportation, real-time detection.

155 PID-318: Detecting Multi-Stage DDoS attacks in an IoT environment by implementing an online IDS using ML

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The Internet of Things (IoT) devices have grown at an accelerated pace which has helped digital attackers to execute DDoS attacks more effectively. The existing defensive systems show limited success when they need to identify and stop attack patterns which range from basic to advanced and changing attacks. The present research introduces a Multi-Stage Adversarial Defense system which protects against online DDoS attacks in Internet of Things devices by providing effective protection against DDoS attacks. The research work aims to implement advanced ML models for DDoS detection and mitigation which include LSTM, CNN, LightGBM and Naive Bayes into the multi-stage defense system. The proposed method consists of a feature selection, data preprocessing, and model training process which are creatively combined to improve detection, reduce false alarm rates. The system performance estimation used standard metrics which included evalution matrix for evaluation purposes. The LightGBM model achieved its highest accuracy of 97.73% which makes it the superior model in comparison with all other tested models. The proposed system outperforms existing systems because the comparative analysis shows its advanced features. The paper presents a strong argument for using a multi-stage method to enhance IoT security while it examines future research directions for developing adversarial defense systems

156 PID-323: Implementation of a Power Efficient, Cost Effective Architecture for Continuous Crop and Soil Data Gathering in Precision Agriculture

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Agricultural activities can be very productive by using IOT based technology. One of the activity is the regulation of moisture detection and monitoring in cultivated fields. Which is Directly connected to productivity of crops. since insufficient and excessive irrigation may not only be obstructive, but also destructive. This scheme based on the collaboration of an integrated system for automated irrigation management for Wireless Sensor Network (WNS) , ECHERP (Equalized Cluster Head Election Routing Protocol). The system takes into the historical data and the change on the climate values to calculate the quantity of water that is needed for irrigation. Incase that the change on the collected values is above the particular limit. More frequent data is proposed to minimize the necessary quantity of water. On the other hand, incase that the change of the values is below a present particular level then the time of interval to collect the data increase to save sensor energy, leading to prolonged sensor lifetime. The result show that the network lifetime using ECHERP is improved time. The model provide energy efficiency using smaller water quantities connect the data and exchange data, take actions based on the data and gather this information to develop more efficient improvement in near future. Like in many other domains, IoT technology brought about the next era of in- agriculture. IoT is a smart or precision agriculture system, plays a critical role. Developing especially decision support system, especially in developed countries and high-end markets. The continuous increase in global population result in an increased need of food and agriculture stuff while reducing water requirement for farming.

157 PID-328: Blockchain-Based Decentralized Procurement System Using Smart Contracts

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In both the public and private sectors, procurement systems are very important because they make it easier to buy goods and services by using regulated bidding processes. But there are a lot of problems with traditional ways of buying things, such as not being clear, rigging bids, corruption, delays in the process, and having too much power. These limits hurt trust, make things less efficient, and make operations more dangerous. Blockchain technology is a new way to solve these problems. It can't be changed and is not centralized. Blockchain uses distributed ledger technology to make sure that transactions are permanent, open, and can be done without trust through smart contracts that can be programmed.This study outlines the design and implementation of a Blockchain-Based Procurement System built on the Ethereum blockchain, employing Solidity smart contracts and disseminated through the Foundry development framework. The proposed system has a bidding length that the owner can control, procedures for whitelisting bidders, encrypted bid submissions to protect privacy, automatic timebound enforcement, and limited access to bids once the bidding is over. Smart contracts take care of procurement rules on their own, which cuts out middlemen and makes it harder to cheat. The architecture [6] keeps bids secret while making the process more open by storing encrypted data on-chain and off-chain. Changes to access control make sure that only certain people can interact with the contract at certain times. Experimental evaluation shows that this model is safer, easier to audit, and more reliable than traditional procurement models. The system shows that it doesn't depend on central authorities as much. It also creates a safe, accountable, and efficient way for governments, institutions, and businesses to buy things.

158 PID-341: Vitamin D status in hospitalized patients with chronic obstructive pulmonary disease : A Meta Analysis

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Chronic Obstructive Pulmonary Disease (COPD) is a progressive lung disorder influenced by smoking, pollution, as well as nutritional and genetic factors. Poor nutritional status, including malnutrition, muscle loss, and obesity, worsens disease severity. Vitamin D is essential for lung function and immune regulation, yet deficiency is common in COPD due to aging, low intake, corticosteroid use, and reduced storage, leading to increased inflammation and poorer treatment response. Genetic variations, particularly in vitamin D-binding protein (VDBP) and vitamin D metabolism genes, further influence susceptibility. This study aims to estimate vitamin D levels in COPD patients from Punjab and evaluate their association with disease risk and progression to support targeted therapeutic strategies.

159 PID-344: Career Pilot: AI-Powered Career Development and Placement Prepration Platform

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In the modern digital era, the rapid advancement of technology has significantly transformed the way students and job seekers prepare for their careers and placement opportunities. Despite the availability of various online platforms, many individuals still face challenges such as lack of proper guidance, inefficient resume building, limited access to relevant job opportunities, and inadequate preparation for interviews and aptitude tests. Traditional career development systems often fail to provide personalized recommendations and real-time feedback, which are essential for improving employability in a competitive job market. This research paper presents Career Pilot, an AI-powered web-based platform designed to assist users in career development and placement preparation. The system integrates multiple

functionalities such as resume analysis, job recommendation, mock tests, interview preparation, and performance evaluation into a single unified platform. By leveraging Artificial Intelligence and data analytics, the system provides personalized suggestions, identifies skill gaps, and enhances decision-making capabilities. The proposed system improves efficiency, reduces manual effort, and provides a structured approach to career preparation. The results demonstrate that AI-based career systems can significantly enhance user performance and employability. This research highlights the importance of intelligent automation in modern career development and provides a foundation for future advancements in AI-driven recruitment and learning systems.

160 PID-349: Energy-Efficient Asynchronous FIFO with Adaptive Buffer Scaling and Predictive Flow Control for High-Performance Multi-Rate DSP Architectures

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Multi-rate Digital Signal Processing (DSP) systems with very high performance need to be able to provide and accept data between heterogeneous clock domains, with the traditional asynchronous FIFO-based systems with constant buffer depth imposing undesirable power use and flow control inefficiencies. This paper suggests a predictive flow control with adaptive buffer scaling and asynchronous FIFO that is energy-efficient to overcome these constraints. There is reconfigurability of the architecture to 512-4096 entries of the buffers based on the real time occupancy and a proactive control by a predictive controller by use of 16-cycle traffic estimation window. It is designed with Verilog HDL and implemented in Xilinx Vivado and in the domain of 250 MHz write and 125 MHz read. Experimentation shows reduced dynamic power of 21.8 mW to 14.2 mW, shorter latency of 38 to 24 clock cycles and throughput of 1.92 Gsamples/s. The proposed architecture is better energy efficient and reduces overflow/underflow events and increases performance reliability by multi-rate DSP systems.

161 PID-359: Cybersecurity Challenges and Deep Learning–Based Foreign Object Detection in Wireless Power Transfer Systems

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This research paper examines the key cyber security challenges in Wireless Power Transfer (WPT) systems, focusing on both near-field and far-field technologies. WPT enables the transfer of electrical energy without physical connections using electromagnetic fields, resonant inductive coupling, or radio-frequency transmission. It is widely used in applications such as electric vehicle charging, medical implants, consumer electronics, industrial automation, and Internet of Things (IoT) devices. While WPT offers advantages like convenience, reduced maintenance, improved safety, and flexible design, its wireless nature introduces significant security risks. Unlike wired systems, WPT systems operate over open communication channels, making them vulnerable to various cyber attacks. These include spoofing, jamming, man-in-the-middle attacks, unauthorized access, energy theft, and data tampering. Attackers can exploit these vulnerabilities to disrupt power transfer, reduce efficiency, interfere with signals, or gain control over system operations. Such threats can compromise system reliability, user privacy, and safety, especially in critical applications like medical devices and EV charging. Additionally, WPT systems rely on communication protocols for

monitoring and control, which further increases their exposure to cyber threats. Weaknesses in software, firmware, or network connections can be exploited to manipulate system behavior or access sensitive data. As WPT systems become more integrated with IoT networks and smart grids, the complexity of securing them also increases, as attacks can spread across interconnected devices. Therefore, strong cyber security measures are essential to ensure safe, reliable, and efficient operation of WPT systems.