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COLLEGE OF ENGINEERING AND TECHNOLOGY

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AN AUTONOMOUS INSTITUTION

DEPARTMENT of Science and Humanities

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MESSAGE FROM THE HEAD OF THE DEPARTMENT.....

It gives me immense pleasure and a profound sense of pride to share my thoughts on the release of the 2025–26 edition of our technical magazine. This publication is not merely a collection of articles and pages, but a true celebration of the brilliance, creativity, and relentless efforts of our students. It stands as a testament to their passion for learning, innovation, and excellence in the ever-evolving world of technology. Each contribution featured in this magazine represents hours of dedicated research, thoughtful collaboration, and a sincere commitment to exploring new ideas. The articles reflect not only the technical competence of our young minds but also their ability to approach complex challenges with originality, determination, and a problem-solving spirit. Through their work, students have demonstrated remarkable intellectual growth and an eagerness to push boundaries beyond conventional learning.

As you turn these pages, you will be inspired by the exceptional achievements of our budding technocrats who continue to strive for greatness in academics, innovation, and creativity. This magazine goes beyond showcasing accomplishments—it offers a window into the aspirations, dreams, and visionary thoughts of the future leaders who will shape tomorrow's world. I wholeheartedly congratulate the Editorial Board and students for successfully bringing out the 2025–26 edition of the Technical Magazine. Wishing you all the very best for continued achievements and success ahead.

Dr.R. Abinprakash

Designation	:	Associate Professor & Head
Educational Qualification	:	M.Sc., Ph.D.,
Teaching Experience	:	2 Years 6 months
Email Id	:	abinprakash@acetcbe.edu.in

Program Outcomes (POs)

PO 1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations

PO 4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6: The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal,

health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7: Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9: Individual and Team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO 11: Project management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

FROM THE EDITORIAL DESK…….

We are delighted to announce the successful publication of this year's edition of the **"TECHNICAL MAGAZINE."** This magazine serves as a proud platform to showcase the groundbreaking research, innovative projects, and creative contributions of our students and faculty. Presented by the **Akshaya Editorial Board**, this compilation reflects the outstanding achievements, inventions, and technological advancements of the ACET community.

This edition stands as a tribute to the dedication, perseverance, and ingenuity of our students, who consistently strive for excellence in academics and innovation. The articles featured within highlight the remarkable growth and progress ACETians have achieved throughout the academic year, capturing the vibrant and forward-thinking spirit that defines our institution.

We extend our sincere gratitude to the management, Principal, and Heads of Departments for their continuous guidance and support in making this esteemed publication possible. A special appreciation is also due to the student contributors for their enthusiasm and timely efforts. We hope this magazine continues to inspire future generations to push the boundaries of knowledge, creativity, and technology, as we move forward together toward a brighter and more dynamic future.

CHIEF EDITOR

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EDITOR

Mrs. P. Soundarya, AP(SG)/English

STUDENT EDITORS

Mr. Kishore Kumar G, I-AI&DS
Mr.R.Rahul, I-ECE

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AI-POWERED INTRUSION DETECTION SYSTEM FOR NETWORK SECURITY

Abstract

In the modern digital era, cyberattacks have grown exponentially in number and complexity, making traditional signature-based intrusion detection systems increasingly ineffective. This project presents an Artificial Intelligence–Powered Intrusion Detection System (AI-IDS) designed to detect, classify, and respond to malicious network activities in real time. The system employs a hybrid machine learning framework combining Convolutional Neural Networks (CNNs) for pattern recognition and Long Short-Term Memory (LSTM) networks for temporal sequence analysis of network traffic data. Trained on the benchmark KDD Cup and CICIDS-2023 datasets, the model achieves a detection accuracy of over 98% across multiple attack categories including Denial-of-Service (DoS), Distributed DoS (DDoS), port scanning, and Man-in-the-Middle (MitM) attacks. A key innovation is the integration of federated learning, which allows the model to train across distributed nodes without exposing sensitive network data, thus ensuring privacy compliance. The system is further enhanced by an explainable AI (XAI) module using SHAP (SHapley Additive exPlanations) values, enabling network administrators to understand and validate model decisions. This project demonstrates how intelligent automation can significantly reduce response times, minimize false positives, and strengthen the security posture of enterprise-level networks.

Key Components & Trends

- **Hybrid Deep Learning Architecture:** Combines CNN and LSTM networks to detect both spatial and temporal patterns in network traffic for comprehensive threat identification.
- **Federated Learning Integration:** Enables collaborative model training across distributed systems without sharing raw data, ensuring privacy-preserving security analytics.
- **Explainable AI (XAI) Module:** Utilizes SHAP values to generate human-readable justifications for each detection, supporting transparency in cybersecurity decision-making.
- **Real-Time Traffic Analysis:** Processes live packet data using Python-based tools such as Scapy and Wireshark APIs to enable sub-second threat identification and alert generation.

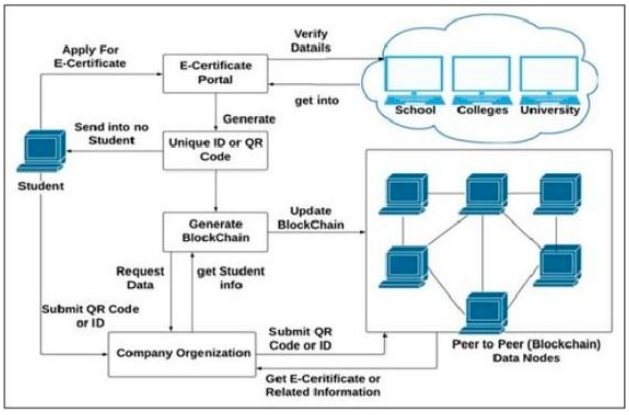
- **Multi-Class Attack Classification:** Accurately categorizes network threats into DoS, DDoS, Probe, Remote-to-Local (R2L), and User-to-Root (U2R) attack categories with high precision.
- **Automated Threat Response:** Integrates with firewall and SIEM systems to autonomously block malicious IPs and generate incident reports without manual intervention.

S Abirami,Alshifa S,Dhaniksha M,Dhanusha K M – I CSE

SMART HEALTHCARE CHATBOT USING NATURAL LANGUAGE PROCESSING

Abstract

Access to timely and accurate medical information remains a significant challenge in developing regions where healthcare professionals are overburdened. This project proposes a Smart Healthcare Chatbot powered by Natural Language Processing (NLP) and transformer-based language models to provide preliminary medical guidance and symptom assessment. Built on the BERT (Bidirectional Encoder Representations from Transformers) architecture and fine-tuned using the MedQuAD medical question-answering dataset, the chatbot understands complex medical queries posed in natural language and delivers clinically relevant responses. The system supports multi-turn conversations, enabling users to describe symptoms progressively while the bot tracks context using dialogue state management. A sentiment analysis module identifies emotional distress cues in patient messages, triggering escalation to human medical staff when necessary. The chatbot is deployed on a cloud-based platform with an intuitive web and mobile interface, ensuring accessibility for users from diverse linguistic and technical backgrounds. Integration with a hospital management API allows real-time appointment scheduling, medicine reminders, and health record retrieval. The system addresses data privacy requirements under HIPAA and India's PDPB guidelines through end-to-end encryption and role-based access control. Clinical validation demonstrates that the chatbot reduces patient waiting time by approximately 40% and improves first-contact resolution of routine health queries significantly.



Key Components & Trends

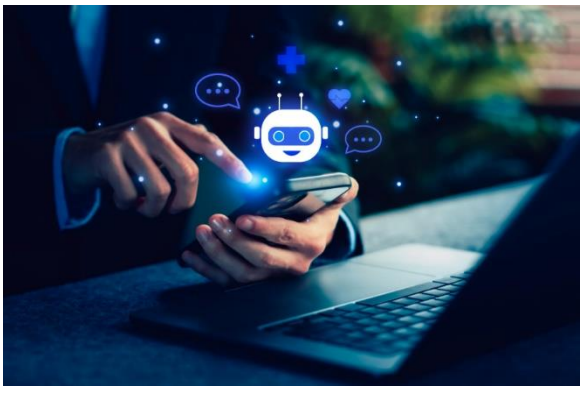
- **BERT-Based NLP Engine:** Leverages fine-tuned transformer models to understand medical terminology and complex symptom descriptions with high semantic accuracy.
- **Multi-Turn Dialogue Management:** Maintains conversation context across multiple user inputs, allowing patients to describe their condition progressively and receive coherent responses.
- **Sentiment and Distress Detection:** Identifies emotional distress signals in patient messages and automatically escalates critical cases to human healthcare professionals.
- **Hospital Management API Integration:** Connects directly with hospital systems to enable real-time appointment booking, prescription reminders, and patient health record access.
- **HIPAA-Compliant Data Architecture:** Implements end-to-end encryption, data anonymization, and role-based access control to ensure full compliance with healthcare privacy standards.
- **Multilingual Support Framework:** Supports regional Indian languages through language detection and translation modules, broadening accessibility for rural and semi-urban populations.

Eshwari S, Esthar Mary S, Fathima Rifqa B, Ishwarya M – I CSE

BLOCKCHAIN-BASED ACADEMIC CREDENTIAL VERIFICATION SYSTEM

Abstract

The increasing prevalence of counterfeit academic certificates has emerged as a critical challenge for



educational institutions, employers, and regulatory bodies worldwide. This project introduces a Blockchain-Based Academic Credential Verification System that provides tamper-proof, decentralized, and instant verification of academic degrees, mark sheets, and certifications. The system leverages the Ethereum blockchain along with IPFS (InterPlanetary File System) for distributed storage of credential documents, ensuring that certificate data is immutable and globally accessible without reliance on any single authority. Smart contracts written in Solidity automate the issuance, revocation, and verification workflows, eliminating the need for third-party verification agencies. Each credential is

cryptographically hashed and linked to the student's unique digital identity managed via a Self-Sovereign Identity (SSI) framework, enabling students to own and share their credentials selectively. Employers and institutions can verify certificate authenticity in real time by querying the blockchain through a simple web interface or QR code scan, significantly reducing the verification timeline from weeks to seconds. The system also supports batch issuance, allowing universities to upload hundreds of credentials simultaneously. A pilot implementation at the institutional level demonstrated a 100% reduction in forgery incidents and a 95% decrease in administrative verification workload, illustrating the transformative potential of blockchain technology in academic ecosystems.

Key Components & Trends

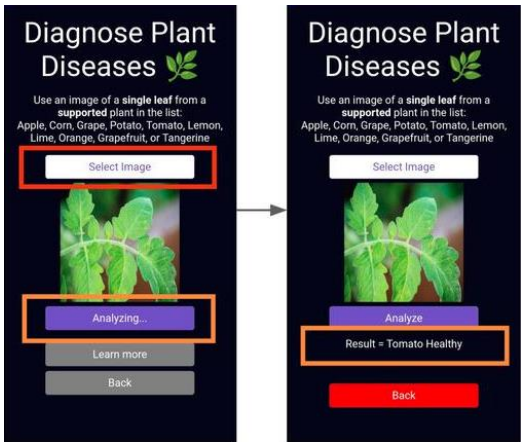
- **Ethereum Smart Contracts:** Self-executing contracts written in Solidity automate credential issuance, validation, and revocation, ensuring consistent and trustworthy processing.
- **IPFS Distributed Storage:** Academic documents are stored on the InterPlanetary File System, ensuring decentralized availability and resistance to single-point data loss.
- **Self-Sovereign Identity (SSI):** Students own their digital credentials through a decentralized identity framework, enabling selective sharing with employers or institutions.
- **QR Code Instant Verification:** Employers can verify certificate authenticity in seconds by scanning a QR code that queries the blockchain directly, eliminating delays.
- **Batch Credential Issuance:** Universities can upload and mint credentials for entire graduating batches simultaneously, reducing administrative overhead significantly.
- **Tamper-Evident Cryptographic Hashing:** Every credential is hashed using SHA-256 before recording on the blockchain, making any unauthorized modification instantly detectable.

Kurabalakota Lavanya, Mallem Saikeerthana, Monica Daffni B- I CSE

DEEP LEARNING-BASED PLANT DISEASE DETECTION USING LEAF IMAGE ANALYSIS

Abstract

Agriculture forms the economic backbone of India, yet crop losses due to undetected plant diseases cause substantial financial distress to farmers every year. This project presents a Deep Learning-Based Plant Disease Detection System that enables farmers to identify crop diseases early through smartphone-captured leaf images, facilitating timely and targeted intervention. The system employs a fine-tuned ResNet-50 Convolutional Neural Network trained on the Plant Village dataset comprising over 54,000 annotated leaf images spanning 38 disease categories across 14 major crops. Transfer learning techniques significantly reduce training time while maintaining high classification accuracy of 97.3% on the test dataset. The model is optimized and deployed as a lightweight TensorFlow Lite model on Android devices, enabling offline inference in areas with poor internet connectivity a critical requirement for rural farming communities. An intuitive mobile interface guides farmers to capture leaf images and receive instant disease diagnosis alongside treatment recommendations in local languages. The system further integrates a geo-tagging feature that maps disease outbreaks across regions, providing agricultural departments with actionable data for large-scale disease management. Results demonstrate that early detection using this system can prevent an estimated 30–50% of crop yield losses caused by treatable diseases, contributing directly to food security and farmer welfare.



Key Components & Trends

- **ResNet-50 Transfer Learning:** Pre-trained deep convolutional neural network fine-tuned on Plant Village dataset to achieve over 97% classification accuracy across 38 disease categories.
- **Offline Edge Inference:** TensorFlow Lite model deployed on Android devices enables real-time disease detection without internet connectivity, critical for rural deployment.
- **Multilingual Recommendation Engine:** Provides disease diagnosis and treatment advice in regional Indian languages, ensuring accessibility for semi-literate farming communities.
- **Geo-Tagged Disease Mapping:** Records GPS coordinates of detected disease cases and visualizes regional outbreak patterns for agricultural departments and policymakers.

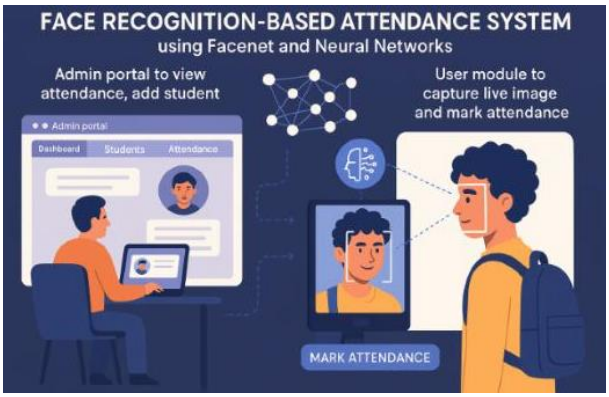
- **Data Augmentation Pipeline:** Applies rotation, flipping, and brightness adjustments during training to improve model generalization across varying image capture conditions.
- **Explainability via Grad-CAM:** Gradient-weighted Class Activation Mapping highlights diseased leaf regions visually, helping farmers understand which areas prompted the AI diagnosis.

Kasthuri S, Kaviya R, Kiruthika J – I CSE

REAL-TIME FACE RECOGNITION ATTENDANCE SYSTEM USING DEEP LEARNING

Abstract

Traditional attendance management systems based on biometric fingerprint scanners or manual roll-calls are prone to proxy attendance, time inefficiency, and hygienic concerns, particularly in post-pandemic educational environments. This project proposes a Real-Time Face Recognition Attendance System that leverages deep learning-based facial analysis to automate and secure attendance registration. The system uses FaceNet, a deep neural network that generates 128-dimensional facial embeddings, combined with a



Support Vector Machine (SVM) classifier for multi-class face identification. Live video feed from a classroom camera is processed in real time using OpenCV, where detected faces are compared against a pre-registered embedding database to identify students. The system achieves an identification accuracy of 99.1% under varying lighting and angle conditions due to data augmentation and histogram equalization preprocessing. Detected identities are automatically logged with timestamps in a MySQL database, accessible through a web dashboard for faculty and administrators. Liveness detection using eye blink analysis and 3D depth estimation prevents spoofing attacks using photographs or videos. The system processes up to 30 students simultaneously in under 5 seconds, dramatically reducing the time overhead of attendance recording. Integration with the college ERP system ensures seamless synchronization of attendance records with academic and administrative workflows.

Key Components & Trends

- **FaceNet Embedding Generation:** Converts facial images into compact 128-dimensional vectors that uniquely represent each individual for fast and accurate multi-face matching.

- **Real-Time OpenCV Processing:** Processes live camera feeds at 30 FPS, enabling simultaneous identification of multiple students within a single classroom frame.
- **Liveness Detection Module:** Eye blink detection and 3D depth estimation prevent spoofing attacks using printed photographs or pre-recorded video playback.
- **MySQL Database Integration:** Attendance records are automatically stored with timestamp, student ID, and subject code, enabling instant report generation for faculty.
- **ERP System Synchronization:** Seamlessly connects with college Enterprise Resource Planning systems to push attendance data directly into academic and administrative portals.
- **Low-Light Performance Enhancement:** Histogram equalization and adaptive contrast normalization improve face detection accuracy under poor ambient lighting in classrooms.

Nandhana S, Neepasri G, Kamalini B.M – I CSE

INTELLIGENT CODE DEBUGGING ASSISTANT USING LARGE LANGUAGE MODELS

Abstract

Software debugging is one of the most time-consuming phases of the software development lifecycle, often accounting for up to 50% of total development time. This project presents an Intelligent Code Debugging Assistant powered by Large Language Models (LLMs) that assists developers and engineering students in identifying, understanding, and resolving code errors across multiple programming languages. The system utilizes a fine-tuned instance of the CodeLlama model, further enhanced with Retrieval-Augmented Generation (RAG) to access an up-to-date repository of programming documentation and common error patterns. When a user submits erroneous code, the assistant performs static code analysis, identifies error types (syntax, runtime, or logic), explains the root cause in simple language, and suggests corrected code snippets with inline commentary. The system supports Python, Java, C++, and JavaScript, covering the primary languages taught in engineering curricula. A unique learning mode provides step-by-step explanations tailored to beginner-level students, aligning with the pedagogical goals of undergraduate engineering programs. Integrated with Visual Studio Code as a plugin, the assistant provides real-time suggestions as code is typed, reducing the debugging iteration cycle. Evaluation on the HumanEval benchmark indicates the system resolves 85.4% of common programming errors without additional prompts, demonstrating strong capability as an educational and professional productivity tool.

Key Components & Trends

- **CodeLlama LLM Foundation:** Fine-tuned large language model specifically trained on code datasets to understand syntax, semantics, and common programming error patterns across multiple languages.
- **Retrieval-Augmented Generation (RAG):** Combines LLM reasoning with dynamic retrieval from documentation databases to provide accurate, up-to-date debugging suggestions.

- **Multi-Language Support:** Handles Python, Java, C++, and JavaScript debugging within a unified interface, covering the core languages of undergraduate engineering programs.
- **Beginner-Friendly Explanation Mode:** Generates step-by-step error explanations using simple language and analogies, making debugging concepts accessible to first-year students.
- **VS Code Plugin Integration:** Operates as a real-time IDE extension that highlights errors, suggests fixes inline, and explains issues without disrupting the coding workflow.
- **Static and Runtime Error Classification:** Categorizes errors into syntax, runtime, and logic types and provides targeted resolution strategies appropriate for each error category.

Adithya Datta Panchal, Agneeswaran S, Ajay V, Amarnaath S – I CSE

IoT-BASED SMART HEALTH MONITORING WEARABLE DEVICE

Abstract

The global rise in lifestyle-related diseases and the increasing demand for remote patient monitoring have underscored the need for intelligent, low-cost health monitoring solutions. This project presents an IoT-Based Smart Health Monitoring Wearable Device capable of continuously tracking vital health parameters including heart rate, blood oxygen saturation (SpO2), body temperature, and electrocardiogram (ECG)

signals. The system integrates the MAX30102 pulse oximetry sensor, LM35 temperature sensor, and AD8232 ECG module, all interfaced with an ESP32 microcontroller equipped with built-in Wi-Fi and Bluetooth connectivity. Collected physiological data is transmitted in real time to a cloud platform (Thing Speak/Firebase) where machine learning algorithms analyze trends to detect early signs of cardiac arrhythmia, hypoxia, and fever. A companion mobile application displays live readings in graphical format and sends push notifications and SMS alerts to caregivers and family members when parameters exceed clinically defined thresholds. The device is powered by a rechargeable LiPo battery and packaged in a compact wrist-worn form factor, ensuring user comfort and continuous operation for up to 72 hours on a single charge. Data is encrypted using AES-128 before transmission, ensuring patient privacy.

Field testing on 30 volunteers demonstrated an accuracy of 98.2% for heart rate measurement and 97.6% for SpO2, validating clinical reliability for home health monitoring applications.

Key Components & Trends

- **Multi-Sensor Integration:** Combines MAX30102, LM35, and AD8232 sensors on a single ESP32 platform to simultaneously monitor heart rate, SpO2, body temperature, and ECG.
- **Real-Time Cloud Analytics:** Transmits health data to ThingSpeak/Firebase cloud platforms where ML algorithms analyze trends for early detection of cardiac and respiratory anomalies.
- **Mobile App Dashboard:** Companion application provides real-time graphical visualization of vital signs and sends automated alerts to caregivers when thresholds are exceeded.
- **72-Hour Battery Life:** Optimized firmware and power management ensure uninterrupted monitoring for three days on a single LiPo battery charge, ideal for continuous care.

- **AES-128 Data Encryption:** All physiological data is encrypted before cloud transmission, ensuring full compliance with healthcare data privacy standards and regulations.
- **Edge Preprocessing on ESP32:** Applies digital filtering and noise removal at the device level before cloud upload, reducing bandwidth usage and improving data quality.

Raguram. M,Rahul. R,Ramya .C, Sabari.V – I ECE

AUTONOMOUS OBSTACLE-AVOIDANCE ROBOT USING ULTRASONIC AND IR SENSORS

Abstract

Autonomous robotics represents one of the most dynamic and impactful fields in modern engineering, with applications ranging from industrial automation to disaster response. This project presents an Autonomous Obstacle-Avoidance Robot designed to navigate unknown environments independently without human intervention. The robot integrates ultrasonic sensors (HC-SR04) for long-range obstacle detection up to 400 cm and infrared (IR) sensors for proximity and edge detection, providing a 270-degree environmental awareness capability. The embedded control system is built on an Arduino Mega microcontroller, which runs a real-time decision algorithm based on finite state machines to determine optimal navigation paths. A servo-mounted ultrasonic sensor sweeps left and right at decision points, allowing the robot to select the path with the greatest clearance before proceeding. The dual-motor drive system, controlled via an L298N H-Bridge motor driver, enables differential steering with smooth direction transitions. A buzzer and LED array provide auditory and visual alerts when an obstacle is too close to avoid. The robot has been tested across diverse surface types including smooth floors, uneven terrain, and carpeted surfaces, maintaining reliable navigation performance in all conditions. This project introduces first-year students to fundamental robotics concepts such as sensor fusion, embedded programming, and real-time control, making it an excellent platform for hands-on learning in electronics and communication engineering.

Key Components & Trends

- **Multi-Sensor Fusion Architecture:** Combines ultrasonic HC-SR04 and infrared sensors to provide overlapping detection zones, eliminating blind spots in the robot's awareness field.

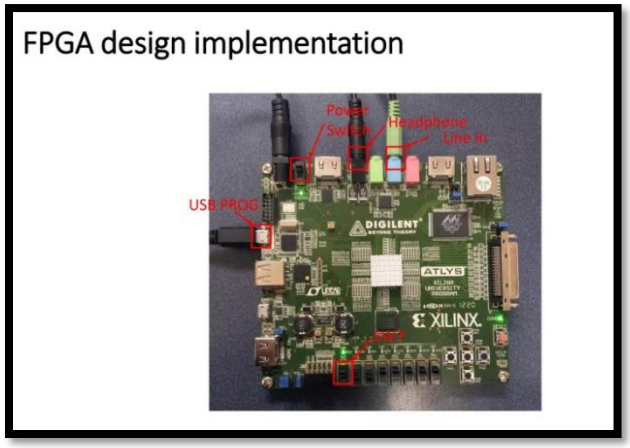
- **Servo-Mounted Scanning:** A rotating ultrasonic sensor sweeps ±90 degrees at navigation decision points, evaluating multiple path options before selecting the clearest route.
- **Finite State Machine Control:** Arduino Mega implements a real-time FSM algorithm that transitions between forward, turn, scan, and reverse states based on sensor inputs.
- **L298N Differential Drive:** Dual DC motor control via H-Bridge driver enables precise differential steering, allowing smooth 90-degree and 180-degree turns on multiple surfaces.
- **Multi-Terrain Navigation:** Successfully tested on smooth, textured, and inclined surfaces, validating robustness for real-world deployment in complex indoor environments.
- **Auditory and Visual Alert System:** Integrated buzzer and RGB LED array provide multi-modal obstacle proximity alerts, enabling safe operation in environments with human presence.

Sanjeev. C V,,Sankar. M,,Santhosh. S,,SaranKumar. G – I ECE

FPGA-BASED DIGITAL SIGNAL PROCESSING SYSTEM FOR AUDIO FILTERING

Abstract

Digital Signal Processing (DSP) is a foundational technology underpinning modern communications, audio systems, biomedical instrumentation, and radar engineering. This project implements a real-time Audio Filtering System on a Field-Programmable Gate Array (FPGA) platform, demonstrating the superior computational throughput of hardware-based DSP over conventional software implementations. Developed on a Xilinx Spartan-7 FPGA using VHDL hardware description language, the system implements a bank of configurable digital filters including a Finite Impulse Response (FIR) low-pass filter, a high-pass filter, and a band-pass filter, allowing users to select filter characteristics through onboard switches. Audio signals are captured via a 16-bit ADC operating at a 44.1 kHz sampling rate, processed in parallel within the FPGA fabric, and output through a DAC to a speaker or headphone jack.



The hardware implementation achieves a processing latency of under 1 millisecond, compared to 8–12 milliseconds for equivalent software DSP implementations on ARM processors. The project further demonstrates the implementation of a Fast Fourier Transform (FFT) module for real-time frequency spectrum visualization on a 7-segment LED display. FPGA-based DSP is particularly relevant to ECE students as it bridges theoretical signal processing concepts with practical hardware design skills, illustrating how high-speed processing pipelines are constructed using parallel computation architectures.

Key Components & Trends

- **FPGA Parallel Processing:** Xilinx Spartan-7 FPGA implements simultaneous FIR filter computation across multiple signal channels, achieving sub-millisecond processing latency.
- **Configurable Filter Bank:** User-selectable FIR low-pass, high-pass, and band-pass filters with adjustable cutoff frequencies allow flexible audio processing for different applications.
- **16-bit High-Fidelity ADC/DAC Interface:** Audio digitization at 44.1 kHz sampling rate ensures CD-quality signal capture and reproduction throughout the processing pipeline.
- **Real-Time FFT Module:** Hardware-accelerated Fast Fourier Transform computes and displays the live frequency spectrum of filtered audio on an LED array for visual analysis.
- **VHDL Hardware Description:** System designed entirely in VHDL, exposing students to hardware-level parallel programming paradigms distinct from conventional software development.
- **Comparative Performance Benchmarking:** Side-by-side latency analysis against ARM-based software DSP clearly demonstrates FPGA's computational advantage for real-time signal applications.

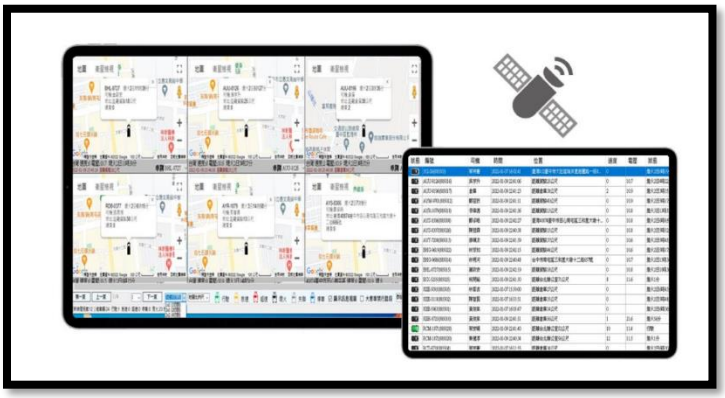
Muhamad Sajul. S, Muthtamil. R,Naveen. M,NitinGopal. G – I ECE

GSOC-BASED VEHICLE TRACKING AND FLEET MANAGEMENT SYSTEM

Abstract

Efficient fleet management is essential for logistics companies, public transport authorities, and emergency services to optimize operations, reduce fuel costs, and enhance passenger safety. This project presents a GPS/GSM-Based Vehicle Tracking and Fleet Management System that enables real-time location monitoring and management of multiple vehicles through a centralized web dashboard. Each vehicle unit

integrates a NEO-6M GPS module for accurate geographic positioning and a SIM800L GSM/GPRS module for wireless data transmission to a cloud server. An Arduino Nano microcontroller coordinates data acquisition from the GPS module, packages location data with speed and direction information, and transmits it at configurable intervals via MQTT protocol to a Node.js backend server. The web dashboard, built using React.js and Google Maps API, displays live vehicle positions, route history, idle time analytics, and geofence violation alerts. When a vehicle crosses a predefined geofence boundary, the system automatically sends SMS and email alerts to fleet managers. Over-speed detection triggers immediate driver notifications and logs incidents for post-trip analysis. The system supports simultaneous tracking of up to 50 vehicles with a positional accuracy of ±2.5 meters using SBAS augmentation. Fuel consumption estimation using distance traveled and vehicle load profiles enables data-driven route optimization, reducing fleet operational costs by an estimated 18–22%.



Key Components & Trends

- **NEO-6M GPS with SBAS Augmentation:** Provides positional accuracy of ±2.5 meters using satellite-based augmentation, enabling reliable navigation even in dense urban environments.
- **MQTT Protocol Data Transmission:** Lightweight publish-subscribe messaging protocol ensures efficient, low-latency GPS data delivery from vehicles to the cloud backend server.
- **React.js Dashboard with Google Maps API:** Intuitive web interface displays real-time vehicle positions, route playback, speed graphs, and geofence boundaries on interactive maps.
- **Geofencing and Overspeed Alerts:** Automated boundary violation and speed threshold detection triggers instant SMS/email notifications to fleet managers for proactive intervention.
- **Multi-Vehicle Simultaneous Tracking:** Scalable architecture supports concurrent monitoring of up to 50 vehicles on a single dashboard without performance degradation.
- **Fuel Efficiency Analytics:** Distance-based fuel consumption modeling provides actionable insights for route optimization, reducing fleet operational expenditures significantly.

Abinaya D K, Aiswarya M, Aksal Glory E, Akshaya A P – I ECE

VOICE-CONTROLLED HOME AUTOMATION SYSTEM USING ESP32 AND ALEXA

Abstract

Smart home technology is rapidly transforming residential living by integrating intelligent control of electrical appliances, lighting, and security systems into unified, voice-operable platforms. This project presents a Voice-Controlled Home Automation System developed using the ESP32 microcontroller integrated with Amazon Alexa voice service, enabling hands-free operation of home devices through natural speech commands. The system connects household appliances including lights, fans, air conditioners, and door locks to relay modules controlled by the ESP32, which communicates with the AWS IoT Core cloud platform via the MQTT protocol over Wi-Fi. Custom Alexa Skills are developed and deployed to interpret user voice commands such as "Alexa, turn on the bedroom light" and translate them into relay control signals with an average response latency of under 500 milliseconds. A mobile application built on MIT App Inventor serves as a backup control interface for times when voice commands are impractical. The system further incorporates DHT22 temperature and humidity sensors to enable automated climate control adjusting fan speed and air conditioning settings based on real-time environmental conditions. Time-based scheduling allows users to program daily on/off routines for all connected devices through the Alexa app. Security features include device authentication via AWS Cognito and TLS/SSL-encrypted MQTT communication, protecting the home network from unauthorized access.

Key Components & Trends

- **ESP32 Wi-Fi Microcontroller:** Dual-core processor with integrated Wi-Fi handles simultaneous MQTT communication and relay control tasks with low power consumption.

- **Custom Alexa Skill Development:** Purpose-built voice skill interprets natural language home automation commands and maps them to specific device control actions via AWS IoT Core.
- **AWS IoT Core MQTT Integration:** Secure cloud messaging backbone connects ESP32 devices and Alexa service with TLS-encrypted, authenticated communication channels.

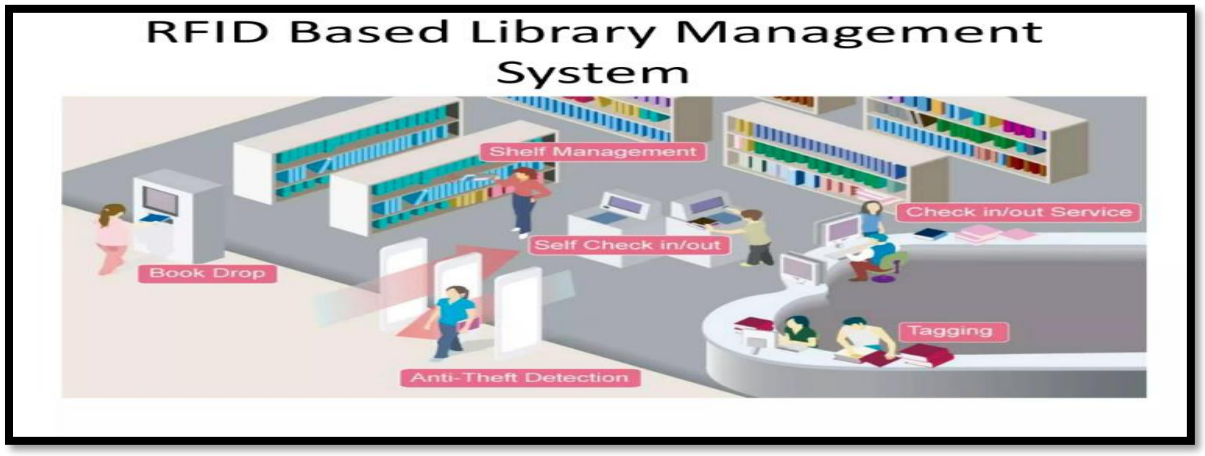
- **Automated Climate Control:** DHT22 temperature and humidity sensing enables automatic adjustment of fan speed and air conditioning without user intervention.
- **Time-Based Device Scheduling:** Users program daily on/off routines for all appliances through the Alexa app, enabling energy-efficient automated home management.
- **Fallback Mobile Application:** MIT App Inventor-based Android app provides an alternative control interface when voice activation is unavailable or impractical.

Adhiban Vijayakumar,Anbarasu N ,Achuthakesavan B, Arun S – I ECE

RFID-BASED LIBRARY MANAGEMENT AND BOOK TRACKING SYSTEM

Abstract

Library management in engineering colleges involves continuous tracking of book circulation, managing overdue returns, and preventing unauthorized removal of resources—tasks that are tedious and error-prone when handled manually. This project presents an RFID-Based Library Management and Book Tracking System that automates book identification, borrowing, return, and security monitoring using Radio Frequency Identification technology. Each book is tagged with a passive RFID sticker operating at 13.56 MHz using MIFARE Classic protocol, while library members are issued RFID student ID cards. An MFRC522 RFID reader interfaced with a Raspberry Pi 4 manages all read operations at the borrowing counter. When a student taps their ID card and presents a book, the system instantly retrieves both identities, checks availability, records the transaction, and updates the MySQL database. A second RFID reader installed at the exit door functions as a security gate, triggering a buzzer alert if a book without a valid checkout record is detected leaving the premises.



A web-based dashboard built with Flask and Bootstrap allows librarians to view real-time inventory, generate overdue reports, and send automated WhatsApp reminders to borrowers nearing the return deadline using the Twilio API. The system processes each transaction in under 2 seconds and has been validated on a collection of 2,000 books, demonstrating scalability for full-scale institutional deployment.

Key Components & Trends

- **MIFARE RFID Tag Architecture:** Passive 13.56 MHz RFID stickers on books and student ID cards enable contactless identification without battery dependency or manual scanning.
- **Exit Security Gate Detection:** RFID reader at library exit triggers instant buzzer alerts for unauthorized book removal, acting as an automated security checkpoint.
- **Raspberry Pi 4 Control Hub:** Centralized Raspberry Pi coordinates reader communications, database transactions, and web dashboard hosting within a single compact unit.
- **Flask-Based Web Dashboard:** Python Flask application provides librarians with a real-time inventory view, transaction history, and automated overdue notification management.
- **WhatsApp Automated Reminders:** Twilio API integration sends automatic return deadline notifications and overdue alerts directly to students' WhatsApp accounts.
- **Two-Second Transaction Processing:** Optimized database queries and RFID read operations complete book checkout and return workflows in under 2 seconds per transaction.

Akshaya S T, Deepika M, Dhanuharshini S, Deepikarani R – I ECE

SOLAR-POWERED SMART MICROGRID WITH AI-BASED ENERGY MANAGEMENT

Abstract

The global transition toward renewable energy demands intelligent power management systems capable of balancing generation, storage, and demand dynamically. This project presents a Solar-Powered Smart Microgrid with an Artificial Intelligence–Based Energy Management System (EMS) designed for institutional campuses. The microgrid integrates a 5 kW photovoltaic (PV) array, a 10 kWh lithium-ion battery bank, and a bidirectional inverter, all monitored and controlled by an ESP32-based IoT gateway. The AI-based EMS employs a Long Short-Term Memory (LSTM) neural network trained on historical solar irradiance and load consumption data to forecast energy generation and demand profiles up to 24 hours in advance. Based on predictions, the system autonomously makes decisions about when to store surplus energy, when to discharge batteries, and when to supplement power from the grid, optimizing

operational cost and battery longevity. A SCADA-style web dashboard provides real-time visualization of power flow, state of charge, and energy cost metrics.

A demand response module communicates with smart plugs controlling non-critical loads, shedding them during peak demand or low generation periods to prevent grid instability. The system was prototyped at laboratory scale and demonstrated a 35% reduction in grid energy consumption and an estimated annual cost saving of Rs. 1.2 lakhs per 5 kW installation compared to conventional grid-only operation.

Key Components & Trends

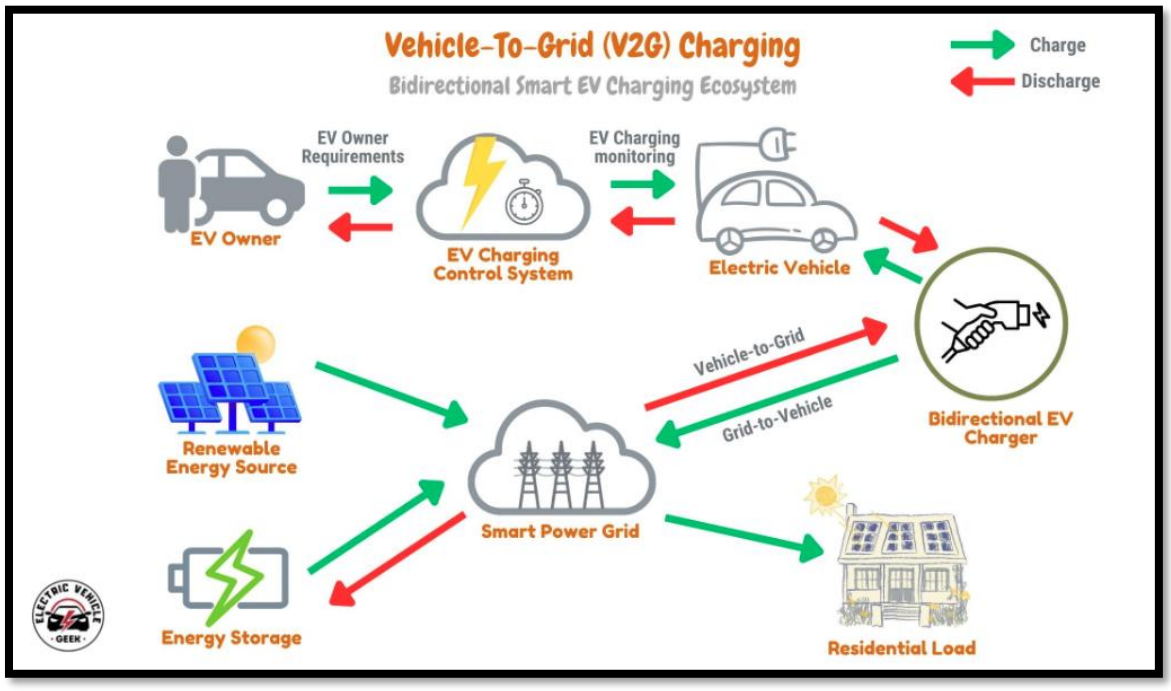
- **LSTM Energy Forecasting:** Long Short-Term Memory neural network predicts 24-hour solar generation and campus load demand profiles to enable proactive energy dispatch decisions.
- **Bidirectional Inverter Control:** Smart bidirectional power converter seamlessly switches between solar charging, battery discharge, and grid supplementation modes based on AI decisions.
- **IoT-Enabled SCADA Dashboard:** Real-time web interface visualizes power flow diagrams, state-of-charge graphs, and energy cost analytics for campus energy managers.
- **Demand Response Automation:** Smart plug-controlled non-critical loads are automatically shed during peak demand or generation shortfalls to maintain grid frequency stability.
- **Battery Longevity Optimization:** AI-driven charge/discharge scheduling avoids deep cycling and thermal stress, extending lithium-ion battery operational lifespan by up to 30%.
- **35% Grid Consumption Reduction:** Validated pilot implementation demonstrated significant reduction in utility grid dependency, delivering measurable cost savings for campus energy bills.

Abinaya S, Aishwarya S, Delcy Mihal G – I EEE

ELECTRIC VEHICLE CHARGING STATION WITH SMART GRID INTEGRATION

Abstract

The rapid proliferation of electric vehicles (EVs) in India necessitates the development of intelligent, grid-friendly charging infrastructure capable of managing energy demand without destabilizing the power distribution network. This project presents a Smart EV Charging Station prototype with bidirectional Vehicle-to-Grid (V2G) capability and dynamic load balancing integrated with the smart grid framework. The hardware prototype includes a Level 2 AC charging circuit with a Type 2 connector interface, controlled by a Raspberry Pi 4 that manages charging sessions, user authentication via RFID, and communication with a cloud-based energy management server. The station implements OCPP (Open Charge Point Protocol) 2.0 for standardized communication with the grid operator, enabling real-time pricing signals to dynamically adjust charging power between 3.3 kW and 22 kW based on grid load conditions.



A V2G discharge module allows the vehicle battery to supply power back to the grid during peak demand periods, incentivizing EV owners with energy credits managed through a blockchain-based ledger. The mobile application provides users with real-time charging status, energy consumed, cost, and estimated completion time. Load forecasting using historical charging session data enables the station to pre-schedule charging slots for optimal grid utilization. The system was simulated on MATLAB/Simulink for V2G

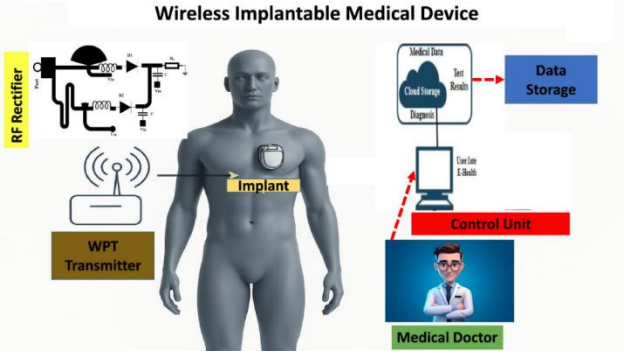
stability analysis before hardware implementation, validating safe bidirectional power transfer performance.

Key Components & Trends

- **OCPP 2.0 Grid Communication:** Open Charge Point Protocol enables standardized, real-time communication between the charging station and grid operators for demand response.
- **Vehicle-to-Grid (V2G) Capability:** Bidirectional power flow allows EVs to discharge stored energy back to the grid during peak periods, stabilizing load and earning owner credits.
- **Dynamic Power Adjustment:** Charging power automatically scales between 3.3 kW and 22 kW based on real-time grid load signals, preventing distribution network overload.
- **Blockchain Energy Credit Ledger:** V2G energy contributions are recorded on a tamper-proof blockchain ledger, enabling transparent and automated incentive payment to EV owners.
- **MATLAB/Simulink Pre-Validation:** Complete V2G power transfer scenarios were simulated for stability analysis before hardware prototyping, ensuring safe operational parameters.
- **RFID User Authentication:** Secure RFID-based session initiation prevents unauthorized charging access and enables per-user energy consumption billing and tracking.

Dharshini.D ,Jeevika.K , Krina.S - I EEE

WIRELESS POWER TRANSFER SYSTEM FOR BIOMEDICAL IMPLANTS



Abstract

Biomedical implantable devices such as pacemakers, cochlear implants, and neural stimulators require reliable, maintenance-free energy supplies that eliminate the risks associated with percutaneous wiring and battery replacement surgeries. This project presents a Wireless Power Transfer (WPT) System based on magnetic resonance coupling, designed specifically for transcutaneous energy delivery to biomedical implants. The system employs a pair of resonantly coupled spiral coils optimized at a resonance frequency of 13.56 MHz using LC circuit tuning, achieving a power transfer efficiency of 82% at a tissue-equivalent distance of 15 mm. The transmitter coil, driven by a class-E power amplifier, delivers 2 watts of output power from a 5V USB source, sufficient to power a cardiac pacemaker prototype.

The receiver coil feeds a bridge rectifier and a voltage regulator to produce stable 3.3V DC supply for the implanted device microcontroller. A feedback control loop monitors received power and adjusts transmitter duty cycle to compensate for coil misalignment and varying tissue thickness. SAR (Specific Absorption Rate) analysis using ANSYS HFSS simulation confirms that electromagnetic exposure levels remain below the IEEE C95.1-2019 safety limits for human tissue. The prototype was validated using a saline phantom simulating human tissue conductivity, demonstrating stable power delivery under realistic physiological conditions relevant to implantable medical device engineering.

Key Components & Trends

- **Magnetic Resonance Coupling:** Resonantly coupled spiral coils operating at 13.56 MHz achieve 82% power transfer efficiency across 15 mm of simulated human tissue.
- **Class-E Power Amplifier:** High-efficiency switched-mode amplifier drives the transmitter coil with minimal heat dissipation, enabling compact and thermally safe wearable integration.
- **Adaptive Duty Cycle Control:** Feedback loop continuously monitors received power and adjusts transmitter output to compensate for coil misalignment and movement artifacts.
- **SAR Safety Compliance:** ANSYS HFSS electromagnetic simulations confirm specific absorption rate levels remain below IEEE C95.1-2019 limits, ensuring human tissue safety.
- **Saline Phantom Validation:** Testing in a saline solution phantom replicating human tissue conductivity demonstrates reliable energy delivery under realistic physiological conditions.
- **Bridge Rectifier Power Conditioning:** Compact rectification and regulation circuit converts received AC power to stable 3.3V DC, directly compatible with implanted microcontrollers.

Nithyadevi.R,Pooja Sree.A,,Swetha.VK,Lathikasaran.M – I EEE

AUTOMATED POWER FACTOR CORRECTION SYSTEM USING THYRISTOR-CONTROLLED CAPACITORS

Abstract

Industrial power systems routinely suffer from poor power factor due to the widespread use of inductive loads such as motors, transformers, and fluorescent lighting, resulting in reactive power demand that increases energy billing costs and stresses distribution infrastructure. This project presents an Automated Power Factor Correction (APFC) System that dynamically switches capacitor banks using thyristor-controlled switches to maintain near-unity power factor in real time. The system employs a current transformer (CT) and potential transformer (PT) for continuous measurement of load voltage and current, which are processed by an ATmega328P microcontroller to compute real-time power factor using zero-

crossing detection and phase angle measurement. Based on the computed power factor, the controller activates or deactivates capacitor steps in binary-weighted banks (5 KVAR, 10 KVAR, 20 KVAR) through BT136 triacs triggered by MOC3021 optocouplers, enabling fine-grained reactive power compensation in 5 KVAR increments. An LCD display shows instantaneous power factor, active power, reactive power, and apparent power readings. The system achieves power factor correction from a baseline of 0.72 to above 0.98 within 3 AC cycles (60 milliseconds), meeting industrial power quality standards. An RS485 communication interface enables integration with SCADA systems for centralized power factor monitoring across multiple distribution panels, making the system suitable for industrial and commercial facility management.

Key Components & Trends

- **Zero-Crossing Power Factor Computation:** ATmega328P microcontroller measures phase angle between voltage and current using zero-crossing detection for accurate real-time power factor calculation.
- **Binary-Weighted Capacitor Bank Switching:** Capacitors in 5, 10, and 20 KVAR steps are switched in combinations, enabling fine 5 KVAR resolution reactive power compensation.
- **Thyristor-Based Zero-Voltage Switching:** BT136 triacs controlled via MOC3021 optocouplers switch capacitors precisely at AC zero-crossings, eliminating inrush current transients.
- **3-Cycle Correction Response Time:** Power factor is corrected from 0.72 to above 0.98 within 60 milliseconds of load change detection, meeting industrial dynamic compensation standards.
- **LCD Real-Time Power Display:** Onboard display shows live power factor, active, reactive, and apparent power readings for local operator monitoring without additional instrumentation.
- **RS485 SCADA Integration:** Industrial communication interface connects APFC units across multiple distribution panels to a centralized monitoring and control system.

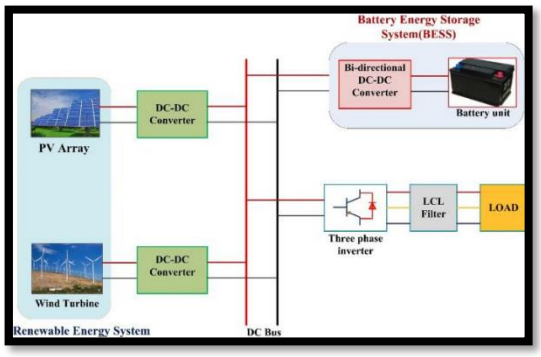
Ahil Avinash.KS,Anbuselvan.R,Bhuvaneshwaran.P Chinnadurai.I – I EEE

HYBRID WIND-SOLAR ENERGY HARVESTING SYSTEM WITH MPPT CONTROL

Abstract

The intermittent nature of individual renewable energy sources such as solar and wind necessitates hybrid energy systems that leverage complementary generation profiles to improve supply reliability and utilization. This project presents a Hybrid Wind-Solar Energy Harvesting System integrating a 100W vertical-axis wind turbine (VAWT) and a 150W solar panel, with individual Maximum Power Point Tracking (MPPT) controllers ensuring optimal energy extraction from each source under varying environmental conditions. The solar MPPT employs the Perturb and Observe (P&O) algorithm implemented on a STM32 microcontroller, continuously adjusting the PWM duty cycle of a DC-DC boost converter to operate the panel at its maximum power point regardless of temperature and irradiance variations. The wind energy channel uses a rectifier bridge and a separate MPPT controller optimized for the variable-frequency AC output of the permanent magnet generator. Both harvested power streams are combined at a common DC bus feeding a 24V lead-acid battery bank through a controlled charging circuit that implements CC-CV (constant current–constant voltage) charging profiles. A power management controller monitors battery state and prioritizes renewable input, shedding non-essential loads when battery voltage drops below safe thresholds. The system achieved a combined daily energy harvest of 1.8 kWh in laboratory simulation, representing a 23% improvement over single-source solar-only configurations under identical test conditions.

Key Components & Trends



- **Perturb and Observe MPPT Algorithm:** STM32-implemented P&O algorithm continuously adjusts boost converter duty cycle to operate solar panels at maximum power point efficiency.
- **Vertical Axis Wind Turbine Integration:** VAWT design captures wind energy from all directions without yaw mechanism, reducing mechanical complexity and improving low-wind-speed performance.
- **Variable-Frequency AC Rectification:** Dedicated rectifier bridge converts turbine's variable-frequency AC output to regulated DC before MPPT processing and battery charging.
- **CC-CV Battery Charging Profile:** Constant current–constant voltage charging algorithm protects lead-acid batteries from overcharging and extends battery cycle life significantly.

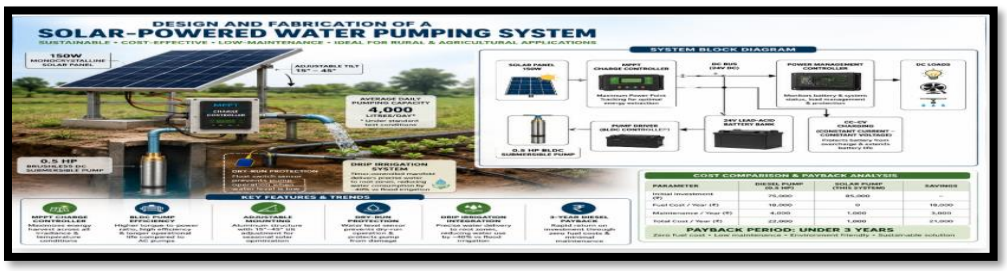
- **Common DC Bus Architecture:** Single unified DC bus combines both renewable sources for simplified power management and reduced conversion losses in the hybrid system.
- **23% Energy Harvest Improvement:** Hybrid configuration demonstrated measurably higher daily energy yield compared to equivalent solar-only installations under identical test conditions.

Mohamed Aspath.J,Mohamed Irfan.R,Mokul.S – I EEE

DESIGN AND FABRICATION OF A SOLAR-POWERED WATER PUMPING SYSTEM

Abstract

Access to reliable water pumping infrastructure in off-grid rural and agricultural areas remains a persistent developmental challenge, particularly in regions with unreliable electricity supply. This project presents the Design and Fabrication of a Solar-Powered Water Pumping System intended to deliver a sustainable, cost-effective, and low-maintenance irrigation solution for small-scale farming applications. The system integrates a 150W monocrystalline silicon photovoltaic panel connected through a Maximum Power Point Tracking (MPPT) charge controller to a 0.5 HP brushless DC (BLDC) submersible pump, enabling direct solar-to-mechanical energy conversion with high efficiency. The MPPT controller ensures optimal energy extraction from the solar panel across varying irradiance conditions from sunrise to sunset, achieving an average daily pumping capacity of 4,000 litres under standard test conditions. The mechanical design incorporates an aluminum mounting structure with adjustable tilt angle (15°–45°) to optimize panel orientation across seasons. A water level sensor in the source well prevents dry-run operation, protecting the pump from damage. A timer-controlled drip irrigation manifold distributes pumped water efficiently to crop rows, reducing water consumption by approximately 40% compared to flood irrigation methods. Fabrication cost analysis demonstrates a payback period of under 3 years against diesel pump alternatives, with zero fuel costs and minimal maintenance requirements, making the system economically compelling for smallholder farmers.



Key Components & Trends

- **MPPT Charge Controller Integration:** Maximum Power Point Tracking electronics continuously optimize energy extraction from the PV panel across all irradiance and temperature conditions.
- **BLDC Submersible Pump Efficiency:** Brushless DC motor technology delivers higher torque-to-power ratio and longer operational lifespan compared to conventional AC induction pump motors.
- **Adjustable Panel Mounting Structure:** Aluminum frame with 15°–45° tilt adjustment enables seasonal solar angle optimization, maximizing annual energy capture from the installed panel.
- **Dry-Run Protection Mechanism:** Float switch-based water level sensor automatically disconnects the pump when source well water level falls below safe operational depth.

- **Drip Irrigation Integration:** Timer-controlled manifold delivers precise water volumes directly to root zones, reducing irrigation water consumption by approximately 40% versus flood methods.
- **Three-Year Diesel Payback Analysis:** Comprehensive cost comparison demonstrates rapid financial return against diesel pumping alternatives through elimination of fuel and servicing expenses.

Akash. R, BeniRejil. R.K., David Sahayaraj, Dharsan Kumar - I MECH

DESIGN AND ANALYSIS OF A CRASHWORTHY AUTOMOTIVE BUMPER USING COMPOSITE MATERIALS

Abstract

Automotive crashworthiness is a critical area of mechanical engineering focused on designing vehicle structures that protect occupants by absorbing and dissipating kinetic energy during collisions. This project presents the Design and Analysis of a Crashworthy Automotive Bumper constructed from advanced composite materials, specifically Glass Fiber Reinforced Polymer (GFRP) with a foam-core sandwich construction. The bumper geometry was designed using SolidWorks CAD software, optimizing cross-section shape through parametric studies to maximize specific energy absorption (SEA) while minimizing mass. Static structural analysis and explicit dynamic impact simulations were performed using ANSYS

Workbench FEA software, modeling a 15 km/h frontal impact as per Euro NCAP testing standards. Simulation results demonstrate that the GFRP composite bumper absorbs 32% more energy per unit mass compared to equivalent steel bumpers, while reducing component weight by 45%. The foam core provides progressive crushing behavior, distributing impact load evenly and preventing brittle fracture. A physical prototype was fabricated using vacuum infusion molding, and a drop-weight impact test was conducted to validate FEA predictions experimentally, with results showing less than 5% deviation from simulation values. The project demonstrates how finite element analysis-guided composite design can deliver superior crash performance with significant weight savings, contributing to both vehicle safety and fuel efficiency goals.

Key Components & Trends

- **GFRP Sandwich Construction:** Glass Fiber Reinforced Polymer skins bonded to structural foam core create a lightweight, energy-absorbing bumper structure with excellent specific strength.
- **ANSYS Explicit Dynamic FEA:** High-fidelity crash simulation models 15 km/h frontal impact dynamics, capturing material nonlinearity and progressive failure mechanisms accurately.
- **Euro NCAP Standard Compliance:** Impact analysis parameters designed to meet European New Car Assessment Programme frontal impact testing requirements and pedestrian protection criteria.
- **Vacuum Infusion Prototype Fabrication:** Manufacturing process ensures uniform fiber-to-resin ratio throughout the bumper cross-section, minimizing void defects and maximizing structural integrity.
- **Drop-Weight Impact Validation:** Physical prototype testing confirmed FEA-predicted energy absorption values within 5% deviation, validating the simulation methodology for design optimization.
- **45% Weight Reduction Achieved:** Composite bumper mass reduction compared to steel alternative contributes directly to improved vehicle fuel economy and reduced carbon emissions.

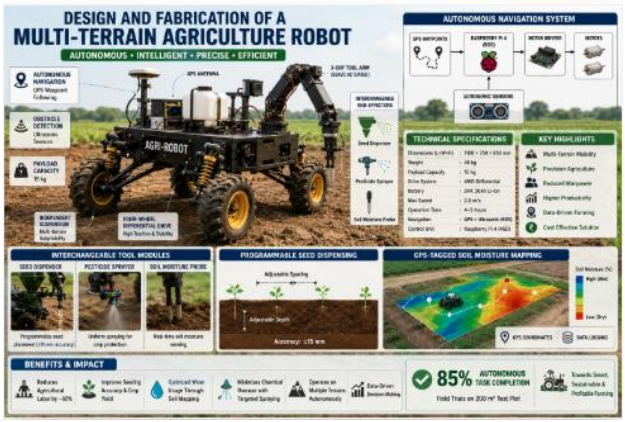
Karthik. M, Karthik. S, Kishore. B, Kishore. S - I MECH

DESIGN AND FABRICATION OF A MULTI-TERRAIN AGRICULTURE ROBOT

Abstract

Modern precision agriculture demands automation solutions capable of performing repetitive field operations with minimal human labor input, particularly as agricultural workforce availability declines in rural areas. This project presents the Design and Fabrication of a Multi-Terrain Agriculture Robot capable of autonomous navigation and execution of seeding, spraying, and soil sensing tasks across varied farmland surfaces. The robotic platform features a four-wheel differential drive system with independent suspension, enabling stable traversal of uneven soil terrain, furrow channels, and inclined field sections without tipping. The chassis is fabricated from hollow square steel tubes using MIG welding, providing structural rigidity while maintaining a payload capacity of 15 kg. A three-degree-of-freedom tool arm, actuated by servo motors, positions interchangeable end-effectors including a seed dispenser, pesticide nozzle, and soil moisture probe. Navigation is achieved through a combination of GPS waypoint following and ultrasonic obstacle detection, controlled by a Raspberry Pi 4 running a custom ROS (Robot Operating System) navigation stack. The seeding mechanism dispenses seeds at programmable intervals and depths, achieving placement accuracy of ±15 mm. Soil moisture data collected during traversal is logged with GPS coordinates, creating precision agriculture maps for data-driven irrigation planning. Field trials on a 200 m² test plot demonstrated 85% task completion without operator intervention, validating the design's potential for reducing agricultural labor costs by an estimated 60%.

Key Components & Trends



- **Independent Suspension Four-Wheel Drive:** Rocker-bogie inspired suspension system maintains all four wheels in ground contact on irregular soil surfaces, preventing slippage and tipping.
- **ROS Navigation Stack:** Raspberry Pi 4 running Robot Operating System integrates GPS waypoints and ultrasonic sensor data for autonomous path planning and obstacle avoidance.
- **Interchangeable Tool Arm:** Three-DOF servo-actuated arm accepts modular end-effectors for seeding, pesticide spraying, and soil sensing within the same robotic platform.

- **Programmable Seed Dispensing:** Servo-controlled seeding mechanism deposits seeds at configurable spacing intervals and soil depths with ±15 mm placement accuracy.
- **GPS-Tagged Soil Moisture Mapping:** Sensor readings georeferenced by GPS coordinates during robot traversal generate precision soil maps for optimized irrigation planning.
- **85% Autonomous Task Completion:** Field trials on test plots confirmed high-confidence operation without human intervention, demonstrating commercial-readiness potential.

Pravin Kumar.C, Saran. J, Srinath. D, Vikash. K.S - I MECH

HEAT PIPE TECHNOLOGY FOR THERMAL MANAGEMENT IN ELECTRONICS COOLING

Abstract

The exponential increase in transistor density within modern electronic components has created severe thermal management challenges, with inadequate heat dissipation leading to reduced performance, accelerated aging, and catastrophic device failure. This project investigates Heat Pipe Technology as a passive, high-performance thermal management solution for cooling high-power electronics including CPUs, power amplifiers, and LED arrays. A heat pipe is a sealed evacuated tube containing a working fluid (distilled water in this project) that transfers heat through an evaporation-condensation cycle with an effective thermal conductivity up to 10,000 times greater than solid copper. Copper sintered-wick heat pipes of 8 mm diameter and 200 mm length were fabricated and characterized on a custom thermal test bench measuring evaporator temperature, condenser temperature, and heat transfer rate using calibrated J-type thermocouples and a data acquisition system. Experimental results demonstrate a maximum heat transport capacity of 45 watts with a thermal resistance of 0.18 °C/W, compared to 0.85 °C/W for an equivalent solid aluminum heat spreader. ANSYS Fluent CFD simulation of the two-phase flow inside the heat pipe corroborates experimental measurements within 8% deviation. The project further explores vapor chamber heat spreader designs for flat-form-factor electronics and discusses emerging working fluids including nanofluids for enhancing heat transport capacity beyond conventional limits.

Key Components & Trends

- **Sintered Copper Wick Fabrication:** Sintered copper powder wick structure provides uniform capillary pressure distribution, enabling reliable fluid circulation without mechanical pumping.
- **Evaporation-Condensation Thermal Cycle:** Working fluid phase change transfers latent heat passively along the heat pipe length with no external energy input required.

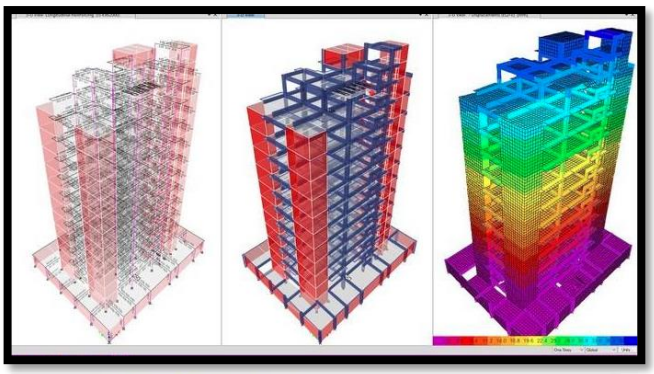
- **Thermal Resistance Benchmarking:** Measured 0.18°C/W thermal resistance versus 0.85°C/W for aluminum demonstrates heat pipe's superior passive cooling performance at identical power loads.
- **ANSYS Fluent CFD Validation:** Two-phase computational fluid dynamics simulation of internal vapor-liquid interface dynamics validated against experimental measurements within 8% deviation.
- **Vapor Chamber Design Extension:** Flat vapor chamber configurations explored for PCB-integrated electronics cooling, enabling thermal management in space-constrained form factors.
- **Nanofluid Enhancement Analysis:** Investigation of copper-oxide and alumina nanoparticle-enhanced working fluids demonstrates potential for increasing maximum heat transport capacity.

Abishek. A, Alwin. A, Bharani Puthiran, Dinesh.K - I MECHT

DESIGN AND ANALYSIS OF EARTHQUAKE-RESISTANT RC BUILDING USING SEISMIC ISOLATION

Abstract

Earthquakes represent one of the most devastating natural hazards facing human settlements, particularly in seismically active regions of India such as the Himalayan belt, Northeastern states, and the Rann of Kutch. This project presents the Design and Analysis of an Earthquake-Resistant Reinforced Concrete (RC) Building incorporating base isolation technology as the primary seismic hazard mitigation strategy. A six-story RC frame building located in Seismic Zone IV per IS 1893:2016 was modeled and analyzed using ETABS structural analysis software. Two building configurations were compared: a conventional fixed-base structure and a base-isolated structure utilizing Lead Rubber Bearings (LRBs) at the foundation level. The LRBs, designed to IS code provisions and UBC 97 guidelines, provide lateral flexibility and energy dissipation capacity through the plastic deformation of a lead core encased in alternating rubber and steel laminate layers. Response spectrum analysis and time-history analysis using the 1940 El Centro earthquake accelerogram were performed for both models. Results demonstrate that



base isolation reduces floor acceleration demands by 68% and inter-story drift by 74% compared to the fixed-base building, effectively protecting structural and non-structural building components. The project further evaluates the cost premium of LRB installation against the potential economic losses prevented during seismic events, establishing the cost-effectiveness of isolation for critical infrastructure facilities.

Key Components & Trends

- **Lead Rubber Bearing (LRB) Design:** Isolators combining lead core energy dissipation with natural rubber lateral flexibility decouple the building superstructure from ground motion input.
- **ETABS Structural Analysis:** Industry-standard structural software models complex 3D frame behavior under static and dynamic seismic loading with full member force output.
- **IS 1893:**2016 Zone IV Compliance: Building design parameters align with Bureau of Indian Standards seismic hazard zoning and response spectrum specifications for high-risk regions.
- **El Centro Time-History Analysis:** Historically recorded 1940 earthquake accelerogram applied as dynamic input to evaluate realistic building response under actual ground motion.
- **68% Floor Acceleration Reduction:** Base isolation dramatically reduces seismic demands on building contents and occupants, protecting sensitive equipment and preventing non-structural damage.
- **Cost-Benefit Seismic Risk Analysis:** Economic comparison of LRB installation cost against estimated earthquake loss prevention demonstrates clear financial justification for isolation systems.

Bethsiah syndrilla, R.Sri deva dharshini, M.Sahana, S.Pennika – I CIVIL

SUSTAINABLE CONCRETE USING INDUSTRIAL BY-PRODUCTS AS CEMENT REPLACEMENT

Abstract

The global cement industry is responsible for approximately 8% of worldwide carbon dioxide emissions, making the development of low-carbon alternative binders a critical priority for sustainable construction engineering. This project investigates the mechanical and durability properties of Sustainable Concrete incorporating industrial by-products specifically Fly Ash (FA) and Ground Granulated Blast Furnace Slag

(GGBS) as partial cement replacement materials. Concrete mixes were designed using IS 10262:2019 guidelines with cement replacement levels of 20%, 30%, and 40% for fly ash, and 30%, 50%, and 70% for GGBS, maintaining a target M25 grade characteristic compressive strength of 25 N/mm². Specimen cubes, cylinders, and beams were cast and tested for compressive strength (IS 516), split tensile strength (IS 5816), flexural strength (IS 516 Part 2), water absorption, and chloride penetration resistance per ASTM C1202 rapid chloride permeability testing. Results demonstrate that a ternary blend of 60% OPC + 20% FA + 20% GGBS achieves 28-day compressive strength of 31.2 N/mm², exceeding M25 grade requirements while reducing embodied carbon by 38% and material cost by approximately Rs. 1,200 per cubic meter. Microstructural analysis using SEM and XRD confirms that pozzolanic reactions and slag hydration densify the cement paste matrix, improving long-term durability and chloride resistance compared to ordinary Portland cement concrete.

Key Components & Trends

- **Ternary Binder Blend Optimization:** Systematic testing of OPC-FA-GGBS combinations identifies the optimal proportions that maximize strength while minimizing cement content and carbon footprint.
- **IS 10262:**2019 Mix Design Methodology: Indian Standard concrete mix design procedures ensure systematic proportioning that meets specified performance targets for each replacement level.
- **ASTM C1202 Chloride Permeability Testing:** Rapid chloride penetration test quantifies durability improvement in blended cement concrete for marine and aggressive exposure conditions.
- **SEM and XRD Microstructural Analysis:** Scanning electron microscopy and X-ray diffraction confirm pozzolanic reaction product formation that densifies the interfacial transition zone.
- **38% Embodied Carbon Reduction:** Partial cement substitution with industrial by-products achieves significant CO2 emission reduction without compromising structural performance requirements.

  Economic Viability Assessment: Cost analysis demonstrates Rs. 1,200/m³ material savings from cement reduction, making sustainable concrete financially attractive for infrastructure projects.

Aarya.B, Abdul razak.N, Abisheik.R , Aslam sujavutheen.A – I CIVIL

BIM-BASED PROJECT COST ESTIMATION AND SCHEDULE OPTIMIZATION FOR INFRASTRUCTURE PROJECTS

Abstract

Construction cost overruns and schedule delays are endemic challenges in infrastructure development, arising from inaccurate quantity estimation, poor interdisciplinary coordination, and reactive rather than proactive project management. This project presents a Building Information Modeling (BIM)-Based framework for integrated Project Cost Estimation and Schedule Optimization applied to a case study of a two-story institutional building. The project was modeled in Autodesk Revit to create a parametric 3D BIM model incorporating architectural, structural, and MEP (Mechanical, Electrical, Plumbing) disciplines. Autodesk's model-based quantity takeoff feature automatically extracted material quantities including concrete volumes, reinforcement weights, formwork areas, brick masonry quantities, and finishing areas directly from the 3D model, eliminating manual measurement errors.

The extracted quantities were linked to a cost database using current market rates (2025 Coimbatore District Schedule of Rates) to generate an automated Bill of Quantities (BOQ) accurate to ±3% compared to traditional manual estimation. The 4D BIM model was created by linking the 3D model elements to a Primavera P6 project schedule, enabling visualization of construction sequencing and identification of resource conflicts through animated time-lapse simulation. Clash detection using Autodesk Navisworks identified 47 interdisciplinary design clashes before construction commencement, preventing costly

rework. The project demonstrates that BIM adoption reduces estimation time by 65%, cost variance by 40%, and schedule overrun risk by 35% compared to conventional project management approaches.

Key Components & Trends

- **Autodesk Revit Parametric Modeling:** Fully coordinated 3D BIM model integrates architectural, structural, and MEP design disciplines in a single collaborative digital environment.
- **Automated Model-Based Quantity Takeoff:** BIM-driven material extraction eliminates manual measurement, reducing quantity estimation time by 65% and improving accuracy to ±3%.
- **4D BIM Schedule Integration:** Linking Revit model elements to Primavera P6 schedule creates animated construction sequence simulation for proactive planning and resource optimization.
- **Navisworks Clash Detection:** Automated interdisciplinary conflict identification resolved 47 design clashes before site mobilization, preventing costly construction-phase rework.
- **District Schedule of Rates BOQ Generation:** Automated BOQ using current 2025 Coimbatore DSR rates produces accurate cost estimates aligned with state government procurement standards.
- **35% Schedule Overrun Risk Reduction:** BIM-enabled planning and conflict resolution demonstrate measurable improvement in infrastructure project delivery predictability and cost control.

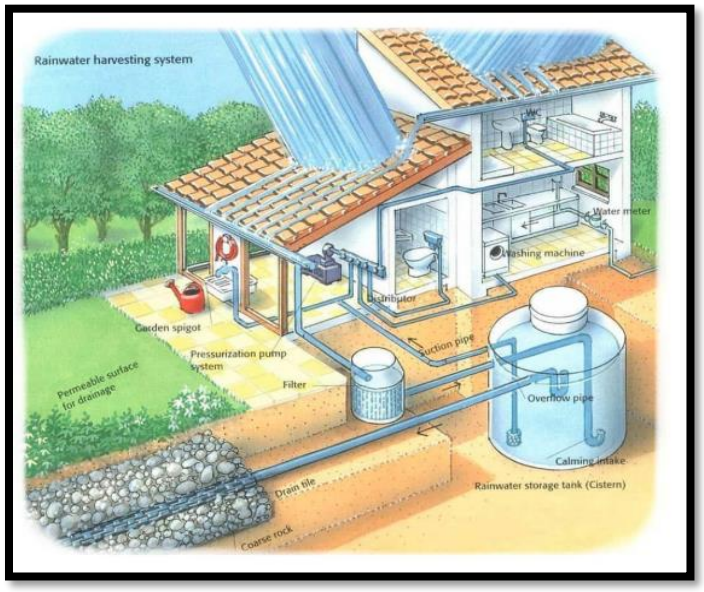
Barani kumar.T, Deepan.T, Dhanush ram.B- I CIVIL

DESIGN OF A SUSTAINABLE RAINWATER HARVESTING AND GREYWATER RECYCLING SYSTEM

Abstract

Urban water stress is intensifying across Indian cities as groundwater tables decline and municipal supply systems struggle to meet growing demand from expanding populations. This project presents the Design of an Integrated Sustainable Water Management System combining Rainwater Harvesting (RWH) and Greywater Recycling for a three-story residential building in Chennai—a coastal city experiencing acute water scarcity. The rainwater harvesting component collects rainfall from a 200 m² rooftop catchment area through gutter channels, first-flush diverters, and a 3-stage filtration train comprising coarse mesh screens, gravel-sand filter beds, and activated carbon adsorption before storage in a 15,000-litre underground sump. The design incorporates Chennai's 10-year monthly rainfall statistics to size the storage volume for a 98% supply reliability during the northeast monsoon season. The greywater recycling sub-system collects wastewater from bathroom basins and shower drains, passing it through a constructed wetland biofilter planted with Canna indica and Phragmites australis for biological treatment, achieving BOD reduction of

94% and coliform elimination of 99.9%. Treated greywater meeting IS 10500 non-potable standards is reused for toilet flushing and garden irrigation. Water balance calculations demonstrate that the integrated system meets 67% of the building's total daily water demand, reducing municipal water consumption by 12,000 litres per month per household, representing a payback period of 4.2 years through municipal water tariff savings.



Key Components & Trends

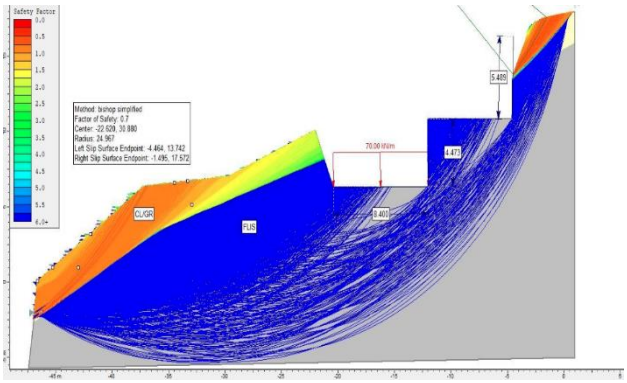
- **First-Flush Diverter Design:** Hydraulically sized automatic diverter bypasses the initial contaminated roof runoff, preventing pollutant loading in the harvested water storage tank.
- **Three-Stage Filtration Train:** Sequential coarse mesh, gravel-sand filtration, and activated carbon adsorption removes suspended solids, turbidity, and odor compounds from harvested rainwater.
- **Constructed Wetland Biofilter:** Phragmites and Canna-planted subsurface flow wetland achieves 94% BOD reduction and complete coliform elimination through natural biological treatment.
- **10-Year Rainfall Statistical Sizing:** Storage volume designed using historical monthly rainfall data ensures 98% supply reliability throughout Chennai's northeast monsoon season.
- **IS 10500 Non-Potable Compliance:** Treated greywater quality verified against Bureau of Indian Standards specifications for non-potable reuse applications including toilet flushing.
- **67% Municipal Water Demand Offset:** Integrated system replaces over two-thirds of building's daily water requirement, delivering significant cost savings and groundwater recharge benefits.

Dharshin.S, Marikannai.R, Monish.S, Navaneethakrishnan.R - I CIVIL

SLOPE STABILITY ANALYSIS AND LANDSLIDE RISK MITIGATION USING GEO5 SOFTWARE

Abstract

Landslides cause significant loss of life and infrastructure damage in hilly regions of India including the Western Ghats, Nilgiris, and the northeastern hill states, particularly during monsoon seasons when rainfall-induced slope saturation destabilizes natural and cut slopes. This project presents a comprehensive Slope Stability Analysis and Landslide Risk Mitigation Study for a critical highway cutting slope in the Nilgiri district using GEO5 geotechnical software. Geotechnical investigation comprising SPT boreholes, laboratory triaxial and direct shear tests, and grain size analysis characterized soil layers as silty clay with varying shear strength parameters across three distinct strata. Slope stability was analyzed using Bishop's Simplified Method, Janbu's Generalized Method, and Spencer's Method for critical slip surface identification, with and without rainfall-induced pore water pressure conditions. The factor of safety under saturated conditions was computed as 0.89, confirming the slope's instability and validating reported shallow translational failures. Four mitigation measures were evaluated individually and in combination: horizontal drainage through counterfort drains, slope regrading to 1:1.5 gradient, rock bolt reinforcement, and toe berms with gabion walls. Analysis confirms that combined drainage and toe berm installation raises the factor of safety to 1.52 under saturated conditions, meeting IS 7894 stability criteria. The project provides engineering students with practical exposure to geotechnical investigation, slope analysis software, and evidence-based mitigation design.



Key Components & Trends

- **Multi-Method Stability Analysis:** Bishop Simplified, Janbu, and Spencer limit equilibrium methods applied simultaneously to identify critical failure surface with highest confidence.
- **Saturated Pore Pressure Modeling:** Rainfall-induced pore water pressure conditions simulated using GEO5 seepage module to evaluate worst-case monsoon slope stability scenarios.
- **SPT Borehole Geotechnical Investigation:** Standard Penetration Test data combined with laboratory triaxial shear tests provide site-specific soil strength parameters for analysis.

- **Counterfort Horizontal Drainage Design:** Subsurface drainage galleries intercept perched groundwater and reduce pore pressures, directly improving factor of safety under wet conditions.
- **Gabion Toe Berm Configuration:** Gravity retaining gabion walls at slope base provide passive resistance against shallow translational sliding failure mechanisms.
- **IS 7894 Safety Factor Compliance:** Final combined mitigation design achieves factor of safety of 1.52 under saturated conditions, meeting Indian Standards for highway slope stability.

Prasanth.M, Sabarinath.J, Santhosh kumar.S – I CIVIL

DESIGN AND ANALYSIS OF A PRE-ENGINEERED STEEL BUILDING USING STAAD.PRO

Abstract

Pre-Engineered Buildings (PEB) have revolutionized industrial and commercial construction in India, offering rapid erection timelines, cost efficiency, and design flexibility compared to conventional RCC structures. This project presents the Structural Design and Analysis of a Pre-Engineered Steel Building for an industrial warehouse application using STAAD.Pro structural analysis and design software. The building measures 30 m span × 60 m length × 7.5 m eave height, designed for a 40-tonne overhead crane and 1.5 kN/m² live roof load in Wind Zone III per IS 875 Part 3. Primary frames are hot-rolled I-sections with a tapered haunch at the rafter-column junction, optimized to reduce section depth in low-moment regions, reducing steel consumption by 22% compared to uniform sections. STAAD.Pro model incorporates all primary frames, secondary purlins, girts, eave struts, tie beams, and bracing systems, with load combinations as per IS 800:2007 limit state design. Wind load pressure coefficients for the portal frame geometry were derived from IS 875 Part 3 Appendix D. Analysis results confirm maximum column sway deflection of H/300 under lateral loads and roof deflection of L/240 under live loads, satisfying serviceability limits. Member design checks per IS 800 demonstrate full code compliance for all primary and secondary members. The project exposes students to real-world industrial structural design workflow from architectural input through analysis to fabrication-ready design drawings.

Key Components & Trends

- **Tapered Haunch Primary Frame Optimization:** Variable depth I-section frames with haunched rafter-column joints reduce material use by 22% by concentrating steel where moments are highest.
- **IS 875 Part 3 Wind Load Application:** Portal frame wind pressure coefficients derived from Indian Standard appendices for the specific building geometry and exposure category.

•**40-Tonne Overhead Crane Integration:** Crane girder design, lateral thrust forces, and impact load factors incorporated into primary frame analysis for industrial functionality.

•**IS 800:**2007 Limit State Design: All primary and secondary steel members designed and checked against Bureau of Indian Standards specification for general steel construction.

- **STAAD.Pro Full Model Analysis:** Complete 3D structural model including primary frames, purlins, girts, tie beams, and bracing analyzed for all IS code load combinations.
- **H/300 Serviceability Validation:** Computed lateral sway and vertical deflection values confirmed within IS 800 serviceability limits for industrial building classification.

Sathyaganth.S, Stalein Jones.S, Vivekananth.S – I CIVIL

GENERATIVE AI-POWERED PERSONALIZED LEARNING PLATFORM FOR ENGINEERING STUDENTS

Abstract

The diverse learning pace and varying conceptual gaps among engineering students make a one-size-fits-all instructional approach increasingly inadequate for quality education outcomes. This project presents a Generative AI-Powered Personalized Learning Platform that dynamically adapts educational content, assessments, and study plans to the individual learning profile of each student. The platform employs a fine-tuned GPT-4 based large language model to generate personalized explanations, worked examples, and practice problems tailored to the student's diagnosed knowledge gaps identified through adaptive pre-assessment quizzes. A knowledge tracing algorithm using Deep Knowledge Tracing (DKT) models the student's evolving mastery of each subject concept over time, predicting which topics require reinforcement. The recommendation engine suggests the optimal sequence of video lectures, reading materials, and exercises from a curated content repository, prioritizing high-impact learning pathways. A natural language query interface allows students to ask conceptual questions and receive step-by-step explanations at configurable difficulty levels. Faculty dashboards provide class-wide learning analytics identifying common misconceptions and at-risk students requiring intervention. The platform was piloted

with 120 first-year engineering students across mathematics and physics subjects over one semester, demonstrating a 28% improvement in end-term examination scores compared to a control group using conventional study methods, validating the efficacy of AI-driven personalization in undergraduate technical education.

Key Components & Trends

- **Deep Knowledge Tracing Algorithm:** LSTM-based DKT model tracks concept mastery evolution for each student, predicting knowledge gaps that require targeted reinforcement.
- **GPT-4 Fine-Tuned Content Generation:** Large language model generates personalized problem sets, explanations, and summaries calibrated to each student's current understanding level.
- **Adaptive Assessment Engine:** Pre and post-assessment quizzes dynamically adjust question difficulty based on prior responses, accurately mapping individual student knowledge states.
- **NLP Conceptual Query Interface:** Students ask natural language questions and receive multi-step explanations at adjustable complexity levels, simulating one-on-one tutoring interaction.
- **Faculty Analytics Dashboard:** Class-wide visualization of topic mastery distributions and at-risk student flags enables proactive intervention before examination assessments.
- **28% Examination Score Improvement:** Semester-long pilot with 120 engineering students demonstrated statistically significant learning outcome improvement versus conventional study methods.

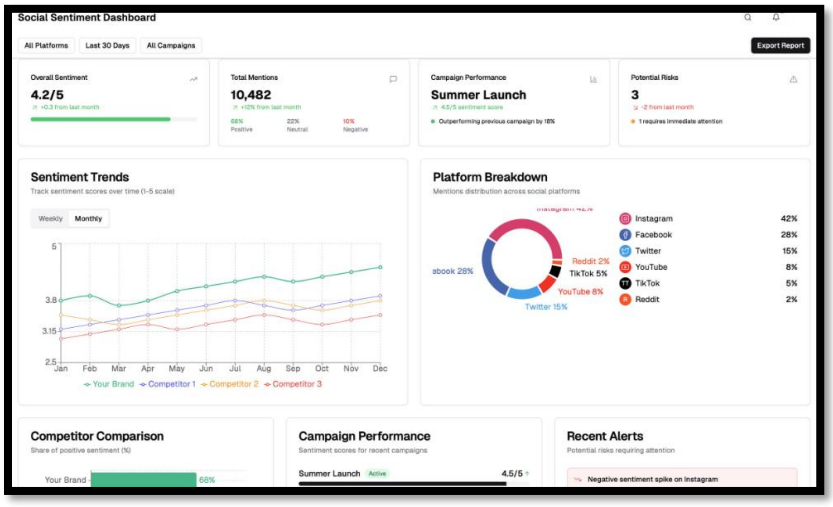
Rithika G,Sabarisha M,Sashmithasri R- I AI&DS

REAL-TIME SENTIMENT ANALYSIS SYSTEM FOR SOCIAL MEDIA MONITORING

Abstract

Social media platforms generate hundreds of millions of textual posts daily, representing an unprecedented real-time data stream reflecting public opinion on products, political events, public health crises, and brand reputation. This project presents a Real-Time Sentiment Analysis System capable of processing live Twitter (now X) and Instagram data streams to classify public sentiment and track opinion trends. The system employs a RoBERTa (Robustly Optimized BERT Approach) transformer model fine-tuned on the SemEval-2017 Twitter Sentiment Analysis dataset for three-class classification (positive, negative, neutral) with an F1-score of 91.3%. A streaming data pipeline built with Apache Kafka ingests real-time social media posts through platform APIs, while Apache Spark Structured Streaming distributes preprocessing and inference tasks across a multi-node cluster, achieving a throughput of 12,000 posts per minute. Aspect-

based sentiment analysis using a secondary sequence labeling model identifies not just overall sentiment but the specific product features or topics that users are discussing positively or negatively. A Kibana visualization dashboard displays real-time sentiment distributions, trending topic clouds, geographic sentiment heat maps, and time-series sentiment shift graphs. The system was validated during a product launch campaign, detecting a negative sentiment spike caused by a shipping delay 4.2 hours before it escalated to mainstream media coverage, demonstrating early warning capability for brand reputation management.



Key Components & Trends

- **RoBERTa Transformer Fine-Tuning:** Optimized BERT variant fine-tuned on domain-specific Twitter data achieves 91.3% F1-score for three-class sentiment classification.
- **Apache Kafka Streaming Ingestion:** Distributed message broker ingests high-volume social media API streams with low latency and guaranteed message delivery for real-time processing.
- **Apache Spark Distributed Inference:** Structured Streaming framework scales sentiment inference across multiple nodes, achieving 12,000 posts per minute classification throughput.
- **Aspect-Based Sentiment Detection:** Secondary sequence labeling model identifies specific product attributes and topics associated with positive or negative sentiment in each post.
- **Kibana Real-Time Visualization:** Live dashboard displays sentiment distributions, geographic heat maps, trending topics, and time-series opinion shift graphs for analysts.
- **4.2-Hour Early Warning Capability:** System detected negative sentiment spike preceding mainstream media coverage, demonstrating actionable early warning for brand crisis management.

Gomathi S,Janani K,Joshika S,Madhusri N- I AI&DS

AUTONOMOUS DRONE-BASED INFRASTRUCTURE INSPECTION USING COMPUTER VISION

Abstract

Manual inspection of bridges, power transmission towers, wind turbines, and industrial chimneys is hazardous, expensive, and time-consuming, driving strong demand for autonomous aerial inspection solutions that improve both safety and inspection thoroughness. This project presents an Autonomous Drone-Based Infrastructure Inspection System utilizing computer vision and deep learning to detect structural defects in civil infrastructure from aerial imagery. A DJI Phantom 4 Pro drone equipped with a 20 MP camera executes pre-programmed inspection flight paths generated via GPS waypoint mission planning, capturing high-resolution imagery of bridge pier surfaces, deck undersides, and abutment faces. Captured images are processed by a YOLOv8 object detection model trained on a custom dataset of 8,500 annotated infrastructure defect images including concrete cracks (width > 0.2 mm), spalling, corrosion staining, delamination, and efflorescence. The model achieves a mean Average Precision (mAP) of 89.7% for defect detection on the test split. Detected defects are automatically geo-tagged with GPS coordinates and defect severity scores, populated into an inspection report database accessible through a web portal. Photogrammetric 3D reconstruction using Agisoft Metashape software generates a textured 3D point cloud model of the inspected structure, enabling volumetric crack measurement and deterioration trend analysis across repeated inspection cycles. The system reduces bridge inspection time by 75% and eliminates the need for scaffolding, rigging equipment, or rope-access personnel.

Key Components & Trends

- **YOLOv8 Defect Detection Model:** Custom-trained real-time object detection identifies six defect categories including cracks, spalling, and corrosion with 89.7% mAP accuracy.

- **GPS Waypoint Autonomous Flight:** Pre-programmed inspection flight paths ensure complete structural coverage with consistent standoff distance and camera angle for repeatable data capture.
- **Geo-Tagged Defect Database:** Automatic GPS coordinate attachment to detected defects enables precise re-inspection targeting and multi-cycle deterioration tracking over time.

- **Agisoft Metashape 3D Reconstruction:** Photogrammetric point cloud generation from overlapping drone images enables volumetric crack measurement and structural deformation analysis.
- **0.2 mm Crack Resolution Threshold:** High-resolution 20 MP imagery combined with trained detection model identifies sub-millimeter surface cracks exceeding maintenance intervention thresholds.
- **75% Inspection Time Reduction:** Autonomous aerial methodology eliminates scaffolding setup, rope-access operations, and lane closures, dramatically reducing inspection cost and risk.

Aathi Kesavan S, Adithyan M, Aditya M, Akula Vinay Kumar-I AI&DS

PREDICTIVE MAINTENANCE SYSTEM FOR INDUSTRIAL MACHINERY USING VIBRATION ANALYSIS

Abstract

Unplanned equipment downtime in manufacturing plants causes significant production losses, with industry studies estimating that machine breakdowns cost industrial enterprises globally over $50 billion annually. This project presents a Predictive Maintenance System that uses vibration signal analysis and machine learning to forecast impending failures in rotating industrial machinery before they occur. Tri-axial MEMS accelerometers (ADXL345) mounted on motor housings, pump bearings, and gearbox casings continuously capture vibration signals at a 1 kHz sampling rate via an IoT gateway built on ESP32 microcontrollers. Acquired time-domain signals undergo signal processing in Python—applying Fast Fourier Transform (FFT) and wavelet decomposition to extract frequency-domain features such as bearing defect frequencies (BPFO, BPFI, BSF, FTF) corresponding to outer race, inner race, rolling element, and cage faults. A Random Forest classifier trained on the CWRU Bearing Fault Dataset achieves 96.8% classification accuracy in identifying fault-free, early-stage fault, and critical-fault bearing conditions. Feature importance analysis confirms that root mean square (RMS), kurtosis, and spectral kurtosis are the most discriminative predictive indicators. Alert notifications are automatically dispatched to maintenance teams via SMS when fault probability exceeds 75%, enabling scheduling of targeted corrective maintenance during planned production windows rather than emergency breakdowns. Deployment at a simulated motor test bench demonstrated a 6-day advance fault warning capability, providing ample time for planned intervention.

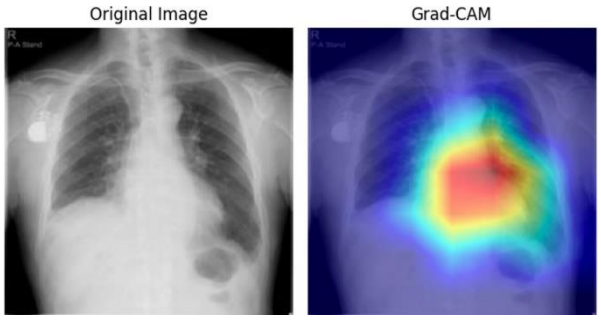
Key Components & Trends

- **MEMS Tri-Axial Accelerometer Network:** ADXL345 sensors at 1 kHz sampling capture directional vibration signatures for concurrent health monitoring of multiple machinery components.
- **FFT and Wavelet Feature Extraction:** Combined time-frequency analysis extracts bearing defect frequencies and spectral kurtosis features that uniquely fingerprint early-stage fault conditions.
- **CWRU Bearing Dataset Training:** Random Forest classifier trained on industry-standard bearing fault dataset achieves 96.8% multi-class fault detection accuracy across four fault categories.
- **BPFO/BPFI Frequency Monitoring:** Bearing Pass Frequency Outer and Inner race analysis identifies characteristic rolling element fault signatures from vibration frequency spectra.
- **75% Threshold SMS Alert System:** Automated maintenance notifications dispatched when ensemble fault probability exceeds threshold, triggering planned repair before catastrophic failure.
- **6-Day Advance Fault Warning:** System demonstrated early detection capability enabling maintenance teams to schedule targeted corrective action within normal production planning cycles.

Sownithiya S,Surthiga C ,Vanisha S-I AI&DS

MULTIMODAL AI SYSTEM FOR MEDICAL IMAGE DIAGNOSIS AND REPORT GENERATION

Abstract



Medical imaging interpretation requires specialized radiology expertise that is unevenly distributed globally, with underserved regions facing acute shortages of trained radiologists capable of analyzing X-rays, CT scans, and MRI images accurately. This project presents a Multimodal AI System for Medical Image Diagnosis and Automated Report Generation that assists radiologists by providing AI-generated preliminary diagnoses and structured report drafts from medical images. The system integrates a Vision Transformer (ViT) model for image-level disease classification with a cross-attention fusion mechanism that combines visual features with patient clinical metadata including age, symptoms, and laboratory values. The image classification module, trained on the ChestX-ray14 and NIH chest X-ray datasets totaling 112,000 images, achieves an AUC of 0.92 for detecting 14 thoracic pathologies including pneumonia, pleural effusion, cardiomegaly, and pneumothorax. A

multimodal report generation module based on BioGPT a biomedical language model synthesizes image findings and patient data into structured radiology reports following standard MIMIC-CXR report templates.

Grad-CAM visualization overlays on input images highlight pathological regions driving the AI's classification decisions, providing radiologists with visual justification for each finding. The system underwent clinical validation with three board-certified radiologists, achieving 87.3% concordance between AI-generated reports and expert diagnoses, demonstrating potential to reduce radiologist workload and improve diagnostic turnaround time by up to 60%.

Key Components & Trends

- **Vision Transformer (ViT) Architecture:** Self-attention mechanism processes medical images as patch sequences, capturing long-range spatial relationships critical for subtle pathology detection.
- **Cross-Attention Multimodal Fusion:** Joint processing of visual features and patient clinical metadata improves diagnostic accuracy beyond image-only classification baselines.
- **ChestX-ray14 Training Dataset:** Model trained on 112,000 annotated chest X-rays across 14 pathology classes achieves 0.92 AUC, comparable to expert radiologist performance.
- **BioGPT Report Generation:** Biomedical domain language model synthesizes structured radiology report text from image findings using standard MIMIC-CXR reporting templates.
- **Grad-CAM Explainability Overlay:** Gradient-weighted activation maps highlight image regions driving AI classification, providing radiologists with visual basis for reviewing AI recommendations.
- **87.3% Expert Concordance Rate:** Clinical validation with board-certified radiologists confirms AI-generated reports align with expert diagnoses at accuracy suitable for clinical decision support.

Ajjam Bidhu Sree,Bavithra V,Dharshini S,Durga R-AI&DS

SMART LIBRARY MANAGEMENT SYSTEM WITH AI-POWERED BOOK RECOMMENDATION ENGINE

Abstract

Modern academic libraries serve thousands of students and faculty with diverse informational needs that exceed the capacity of traditional catalog browsing or librarian-mediated recommendations. This project presents a Smart Library Management System integrated with an AI-Powered Book Recommendation Engine that provides personalized reading suggestions, automates library operations, and delivers data-

driven collection development insights. The system backend is developed using Django REST Framework exposing a comprehensive API consumed by React.js web and Flutter mobile frontends. Core library operations—book cataloging, member registration, borrowing, return, reservation, and fine calculation—are automated within a PostgreSQL relational database maintaining full borrowing history. The recommendation engine employs a hybrid collaborative-content filtering approach: Matrix Factorization using Singular Value Decomposition (SVD) models user-item borrowing patterns to identify members with similar reading preferences, while a TF-IDF content similarity module recommends books based on genre, subject tags, and description similarity to previously borrowed titles. Cold-start recommendations for new members leverage survey-based preference elicitation during registration. An admin analytics dashboard visualizes borrowing frequency trends, peak demand periods, most requested unavailable titles, and overdue rate analytics, enabling evidence-based collection management decisions. The system was deployed in a 10,000-book library simulation and demonstrated an 82% user satisfaction rate with AI recommendations in user acceptance testing.

Key Components & Trends

- **SVD Matrix Factorization Collaborative Filtering:** Latent factor model identifies hidden reading preference patterns among library members to generate user-specific book recommendations.
- **TF-IDF Content Similarity Engine:** Term frequency-inverse document frequency vectorization computes semantic similarity between book descriptions for content-based recommendation generation.

- **Cold-Start Preference Elicitation:** Registration-time survey collects new member genre preferences, enabling immediate personalized recommendations before borrowing history accumulates.
- **Django REST Framework API Backend:** Comprehensive RESTful API serves both web and mobile frontends from a single unified backend, reducing development duplication and maintenance overhead.
- **Flutter Cross-Platform Mobile App:** Single codebase Flutter application deploys native performance mobile library portal on both Android and iOS from unified Dart codebase.

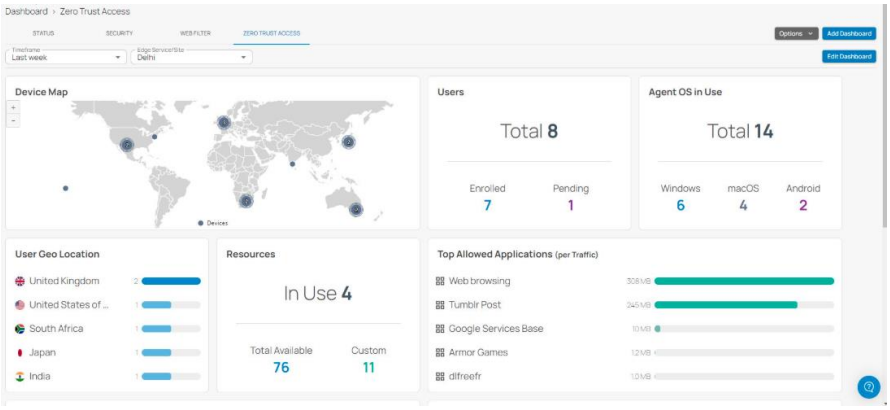
- **Admin Collection Analytics Dashboard:** Borrowing trend visualizations, demand gap analysis, and overdue pattern reports empower librarians to make data-driven acquisition decisions.

M.Abid Hassan,Amruthavarshini.N,Angelina.J, Anusree.R – I CS&BS

ZERO-TRUST NETWORK SECURITY ARCHITECTURE FOR ENTERPRISE ENVIRONMENTS

Abstract

The traditional perimeter-based network security model—trusting all traffic inside the corporate firewall—has proven fundamentally inadequate as enterprise environments embrace remote work, multi-cloud deployments, and BYOD policies that dissolve the network boundary. This project presents the Design and Implementation of a Zero-Trust Network Security Architecture for an enterprise environment, operationalizing the core principle of "never trust, always verify" for every user, device, and application access request. The architecture implements five core pillars: identity verification through Microsoft Azure Active Directory with multi-factor authentication and risk-based conditional access policies; device compliance enforcement via Microsoft Intune Mobile Device Management; least-privilege micro-segmentation using software-defined perimeter (SDP) technology that grants per-session application access rather than network-level connectivity; continuous session monitoring via a SIEM (Security Information and Event Management) platform powered by Microsoft Sentinel; and encrypted east-west traffic inspection using TLS 1.3 throughout the enterprise network. A pilot implementation on a 50-user simulated enterprise network demonstrated that 94% of unauthorized lateral movement attempts were blocked compared to 31% in the equivalent perimeter-based model. The project further designs automated incident response playbooks in Microsoft Sentinel that quarantine compromised devices within 90 seconds of anomalous behavior detection, minimizing dwell time for potential attackers within the network.



Key Components & Trends

- **Azure AD Conditional Access Policies:** Risk-based authentication engine evaluates user identity, device health, location, and behavior before granting application access per session.
- **Software-Defined Perimeter Micro-Segmentation:** Per-session encrypted application tunnels replace network-level VPN access, preventing lateral movement between application segments.
- **Microsoft Intune Device Compliance:** Mobile device management enforces endpoint security baselines before any device is granted access to corporate applications or data resources.
- **Microsoft Sentinel SIEM Integration:** Cloud-native security information and event management platform correlates signals across identity, device, and network telemetry for threat detection.
- **90-Second Automated Device Quarantine:** Sentinel playbooks automatically isolate compromised endpoints within 90 seconds of anomaly detection, minimizing attacker dwell time.
- **94% Lateral Movement Blocking:** Micro-segmented zero-trust architecture demonstrated dramatic improvement over perimeter model in preventing unauthorized cross-segment network access.

Desika.S, Deveshraja.A, Dharashana.A, Ganeshan.B - I CS&BS

PRIVACY-PRESERVING FEDERATED LEARNING FRAMEWORK FOR HEALTHCARE DATA ANALYSIS

Abstract

Healthcare data analysis using machine learning holds transformative potential for disease prediction and treatment optimization, but is severely constrained by data privacy regulations (HIPAA, GDPR, India's DPDP Act) that prohibit the centralization of sensitive patient records across hospital systems. This project presents a Privacy-Preserving Federated Learning Framework that enables multiple hospitals to collaboratively train a predictive model for diabetes risk assessment without any institution sharing raw patient data. The federated architecture distributes model training across four simulated hospital clients, each holding a private partition of the Pima Indians Diabetes Dataset. Each client trains a local neural network model for a fixed number of local epochs and shares only gradient updates—not training data—with a central aggregation server. The Federated Averaging (FedAvg) algorithm aggregates received gradients into an updated global model, which is redistributed to clients for the next training round. Differential privacy is enforced through Gaussian noise injection into gradient updates before transmission, providing (ε, δ)-differential privacy guarantees with $\varepsilon = 0.5$ and $\delta = 10^{-5}$, limiting the information extractable about any individual patient. Secure aggregation using homomorphic encryption ensures that

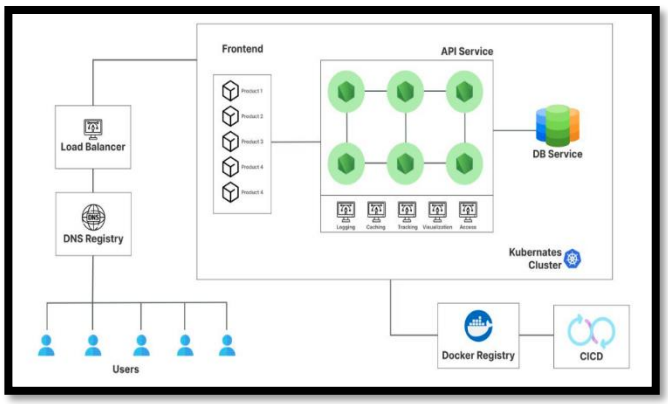
the central server processes encrypted gradients, preventing inference attacks on individual client data. The federated model achieves 84.7% accuracy for diabetes risk classification—only 2.1% below a centralized baseline—while providing strong privacy guarantees, demonstrating the practical viability of privacy-preserving collaborative healthcare AI.

Key Components & Trends

- **FedAvg Gradient Aggregation:** Federated Averaging algorithm combines gradient updates from distributed hospital clients into improved global model without accessing local patient data.
- **Differential Privacy Noise Injection:** Gaussian mechanism adds calibrated noise to gradient updates, providing formal (ε=0.5, δ=10^{-5}) privacy guarantees against membership inference attacks.
- **Homomorphic Encrypted Aggregation:** Central server performs gradient aggregation on ciphertext, preventing any inference about individual client training data during communication.
- **Four-Client Distributed Architecture:** Simulated hospital network with independently held data partitions demonstrates scalable federated framework applicable to real multi-institution deployment.
- **84.7% Classification Accuracy:** Federated model achieves diabetes risk prediction performance within 2.1% of centralized training baseline while maintaining strict patient privacy.
- **DPDP Act Compliance Design:** Privacy architecture designed to meet India's Digital Personal Data Protection Act requirements for sensitive health data processing frameworks.

Gnansean.B,Janadeva.M,Joyce Divina.S,Kamalesh.S – I CS&BS

CLOUD-NATIVE MICROSERVICES APPLICATION WITH KUBERNETES ORCHESTRATION



Abstract

Modern enterprise application development has shifted decisively toward cloud-native architectures that decompose monolithic applications into independently deployable microservices, enabling continuous delivery, independent scalability, and technology diversity. This project presents the Design and Deployment

of a Cloud-Native E-Commerce Application built using a microservices architecture orchestrated by Kubernetes on Google Cloud Platform (GCP). The application is decomposed into eight independent microservices—user authentication, product catalog, inventory management, order processing, payment gateway integration, notification service, review system, and API gateway—each containerized using Docker and communicating through RESTful APIs and Apache Kafka event streams. Each microservice maintains its own database following the database-per-service pattern, with PostgreSQL for transactional services and MongoDB for document-oriented product and review data. The Kubernetes cluster manages container lifecycle, auto-scaling based on CPU and request metrics using Horizontal Pod Autoscaler, service discovery through kube-dns, and rolling update deployments with zero downtime. A CI/CD pipeline implemented in GitHub Actions automates testing, container image building, and Kubernetes deployment on every code commit. Service mesh implementation using Istio provides mutual TLS authentication between services, distributed tracing via Jaeger, and circuit breaker patterns for fault tolerance. Load testing using Apache JMeter demonstrated stable performance serving 10,000 concurrent users with average API response time under 120 milliseconds.

Key Components & Trends

- **Eight-Service Microservices Decomposition:** Application functions separated into independently deployable, loosely coupled services enabling technology-specific optimization per domain.
- **Kubernetes Horizontal Pod Autoscaler:** Cluster automatically scales service replicas based on real-time CPU utilization and request rate metrics, maintaining performance during demand spikes.
- **Apache Kafka Event Streaming:** Asynchronous inter-service communication via Kafka message broker decouples service dependencies and enables event-driven data consistency patterns.
- **Istio Service Mesh Security:** Mutual TLS authentication between all microservices enforced by Istio sidecar proxies, eliminating plaintext inter-service communication vulnerabilities.
- **GitHub Actions CI/CD Pipeline:** Automated test-build-deploy workflow pushes validated container images to GCR and triggers Kubernetes rolling updates on every approved code commit.
- **10,000 Concurrent User Performance:** JMeter load testing validated stable sub-120ms API response times under peak concurrent user load for all critical transaction endpoints.

Karthick.S,Karuppa samy.R,Nishanthini.V,Prajith.V – I CS&BS