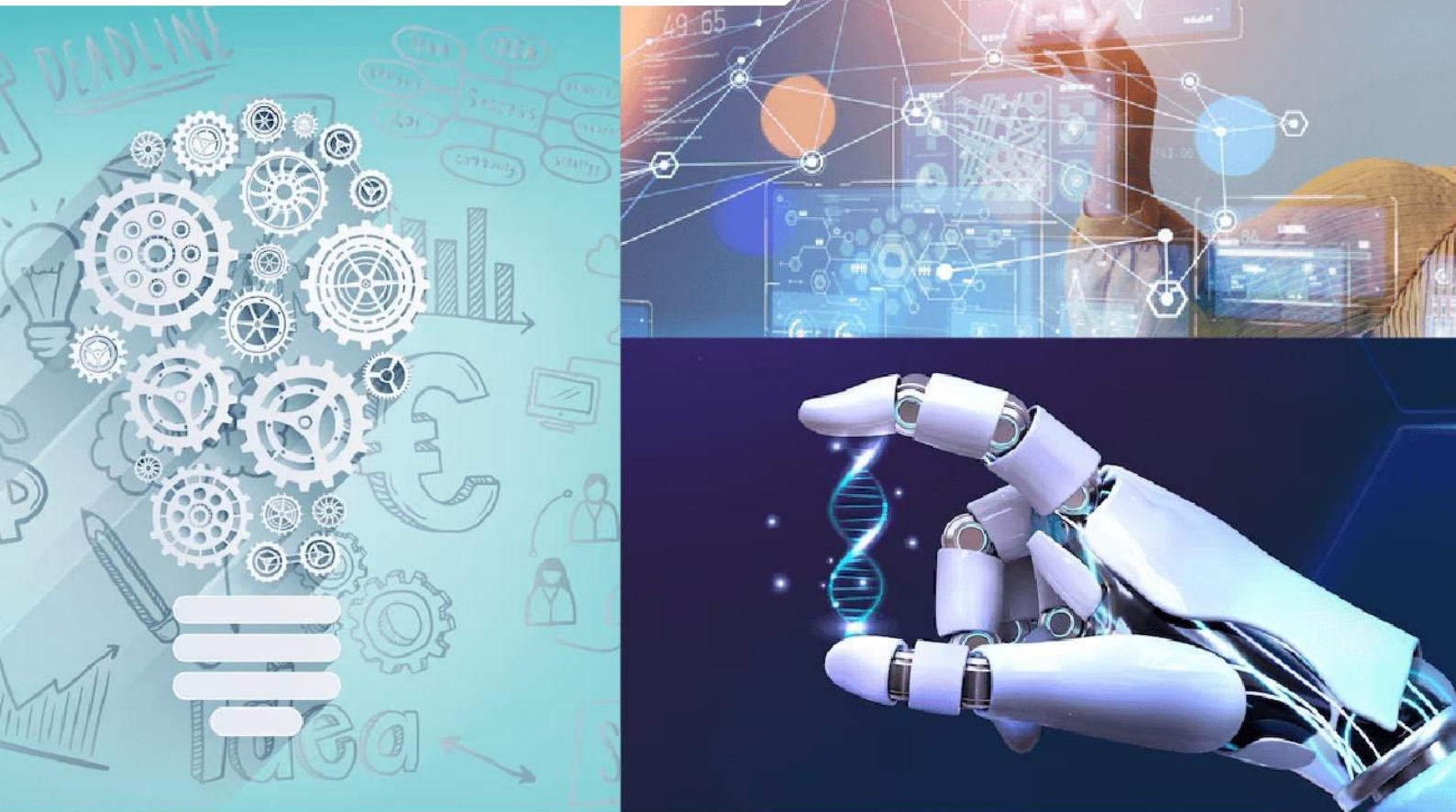




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AI Based Load Prediction and Smart Energy Allocation System for Shared

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ABSTRACT: The increasing demand for electricity and the need for efficient energy utilization have led to the development of intelligent energy management systems. This project presents an AI-Based Load Prediction and Smart Energy Allocation System designed to optimize energy distribution and reduce wastage. The system utilizes advanced machine learning algorithms to analyze historical energy consumption data and accurately predict future load requirements.

Based on the predicted demand, the system intelligently allocates available energy resources to different sectors or users, ensuring efficient utilization and minimizing power shortages or overload conditions. The proposed model incorporates real-time monitoring using sensors and IoT technology, enabling dynamic adjustments in energy distribution according to changing demand patterns.

Additionally, the system promotes the integration of renewable energy sources such as solar and wind power, enhancing sustainability and reducing dependency on conventional energy sources. The implementation of this system can significantly improve grid stability, reduce operational costs, and support smart grid development.

Overall, this project demonstrates how artificial intelligence can be effectively applied to modern power systems to achieve reliable, efficient, and sustainable energy management.

KEYWORDS: AI, Machine Learning, Random Forest, Load Prediction, Smart Energy Allocation, Smart Grid, Energy Management, IoT, Data Analytics, Power Optimization.

I. INTRODUCTION

In recent years, the rapid growth in population, industrialization, and technological advancements has significantly increased the demand for electrical energy. Traditional power systems often face challenges such as inefficient energy distribution, power losses, load imbalance, and difficulty in managing peak demand. These issues highlight the need for intelligent and automated energy management solutions.

The concept of smart grids has emerged as a modern approach to address these challenges by integrating advanced technologies like Artificial Intelligence (AI), Internet of Things (IoT), and data analytics into power systems. One of the key components of smart grid systems is load prediction, which involves forecasting future energy demand based on historical data and real-time inputs.

This project focuses on the development of an AI-Based Load Prediction and Smart Energy Allocation System, which aims to enhance the efficiency and reliability of power distribution. By using machine learning techniques, the system can predict energy consumption patterns and allocate power accordingly to avoid overloads and ensure balanced distribution.

Furthermore, the system supports the integration of renewable energy sources such as solar and wind energy, promoting eco-friendly and sustainable energy usage. Real-time monitoring and automated control mechanisms enable dynamic energy allocation, reducing wastage and improving overall system performance.

II. LITERATURE REVIEW

The concept of load forecasting and intelligent energy management has been widely studied in recent years due to the increasing demand for electricity and the transition toward smart grids. Earlier research primarily relied on traditional

statistical methods such as time-series analysis and regression models. However, these methods had limitations in handling the nonlinear and dynamic nature of energy consumption patterns.

2.1 Deep Learning (DL):

Deep Learning models such as Long Short-Term Memory (LSTM) and Convolutional Neural Networks (CNN) for load forecasting. These models are capable of handling large datasets and identifying temporal and spatial patterns in energy usage, resulting in improved prediction accuracy compared to conventional techniques.

2.1.1 Demand-Side Load Forecasting Using Machine Learning

Masood et al. (2024) presented a machine learning-based demand-side load forecasting system for smart grids. The study highlights that electrical load varies significantly due to environmental factors such as temperature and user behavior, making accurate prediction a challenging task. The authors proposed advanced ML techniques to forecast energy demand using historical consumption data..

The system utilizes data-driven models to improve prediction accuracy and align energy generation with consumption patterns. It emphasizes the importance of big data analytics and real-time monitoring in improving forecasting performance.

However, the research mainly focuses on large-scale smart grid applications and does not address low-cost embedded implementations or real-time control using microcontrollers. The proposed system improves this by integrating ML prediction with Arduino-based real-time load control.

The rapid evolution of large-scale pre-trained language models (LLMs) has substantially improved the performance of NL2SQL systems by providing powerful language understanding capabilities that can be adapted to SQL generation tasks. Fine-tuning such massive models on domain-specific datasets has proven effective, but comes with high computational demands. To address this, researchers have developed parameter-efficient fine-tuning methods that update only a subset of model weights, thereby reducing resource requirements while maintaining or improving accuracy.

2.1.2 Machine Learning-Based Energy Consumption Prediction:

A machine learning-powered energy consumption prediction system aimed at improving energy management efficiency. The study explains that energy prediction plays a crucial role in controlling consumption, reducing costs, and optimizing system performance.

The system uses ML models trained on historical data to forecast energy usage and assist in decision-making. It highlights that predictive systems can significantly enhance energy control, storage management, and operational efficiency.

Despite its effectiveness, the study does not include real-time sensing or adaptive load control mechanisms, which are essential for practical implementation. The proposed project addresses this limitation by integrating sensors and relay-based control with prediction.

2.1.3 AI-Driven Load Forecasting for Microgrids:

A hybrid deep learning-based load forecasting and energy management framework for microgrids. The study emphasizes that fluctuating load demand and renewable energy variability create challenges in maintaining system stability.

The proposed framework uses short-term load forecasting (STLF) techniques combined with advanced energy management strategies to optimize power distribution. It demonstrates that AI-based forecasting improves system efficiency and ensures better load balancing in distributed energy systems.

However, the system is designed for large-scale microgrid environments and lacks implementation in small-scale shared systems like hostels or offices. The proposed system adapts similar concepts for a compact, cost-effective embedded platform.

2.1.4 IoT and Machine Learning-Based Energy Management Systems:

A comprehensive review of IoT-enabled energy management systems integrated with machine learning. The study importance of IoT collecting real-time data and enabling intelligent decision-making grids and microgrids.

The research emphasizes that energy management systems (EMS) improve system stability, efficiency, and resource utilization by combining sensor data, cloud computing, and predictive analytics. It also discusses challenges such as scalability, system complexity, and data security.

While the study provides a strong theoretical foundation, it lacks practical implementation details using embedded controllers and low-cost sensors. The proposed system bridges this gap by implementing IoT and ML on an Arduino-based platform.

III. PROPOSED METHODOLOGY

The proposed system, AI-Based Load Prediction and Smart Energy Allocation, is designed as an intelligent energy management solution that integrates environmental sensing, machine learning-based prediction, and real-time control using an Arduino-based embedded platform. The system continuously monitors key environmental parameters such as temperature and humidity (DHT sensor), light intensity (LDR), and occupancy (PIR sensor), which directly influence energy consumption patterns in shared environments. These parameters are collected in real time and transmitted to a computing unit (laptop), where a machine learning model analyzes both historical and live data to predict future load demand.

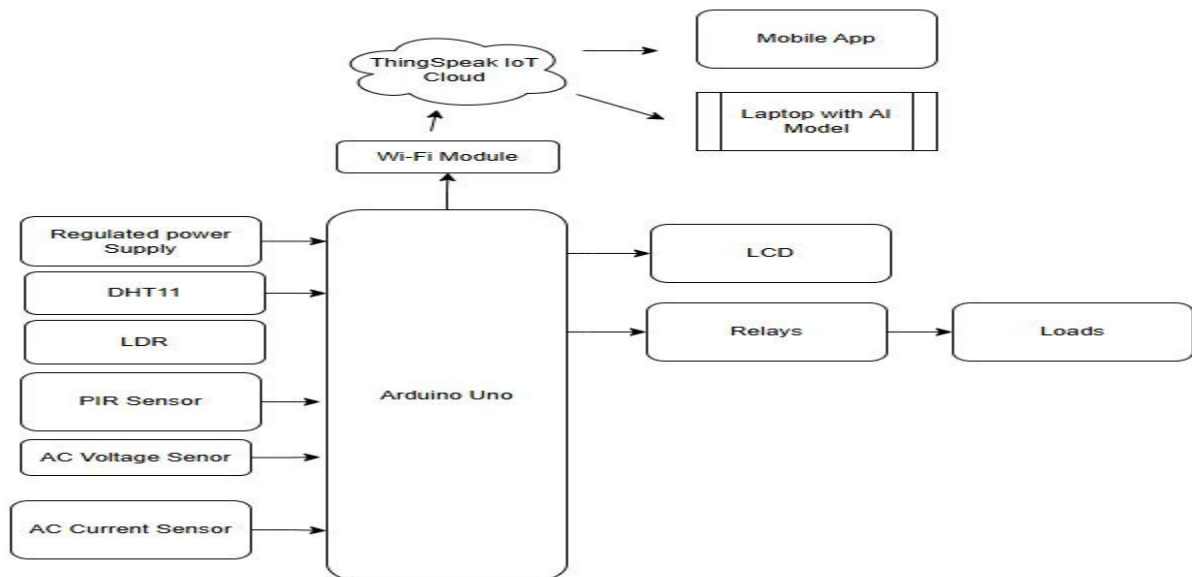


Fig1

3.1 Data Transmission to Processing Unit:

- Continuously send sensor data from Arduino to a laptop via serial communication.
- Store and preprocess data for analysis.

3.2 Real-Time Power Monitoring:

- Use voltage and current sensors to measure actual power consumption.
- Compare real-time data with predicted values.

3.3 Machine Learning-Based Load Prediction:

- Train a machine learning model using historical and real-time data.
- Predict future energy demand based on environmental conditions and occupancy patterns.

3.4 User Interface and Alerts:

- Display system status and parameters on LCD.
- Generate buzzer alerts during abnormal conditions.

3.5 IoT Integration:

- Transmit sensor data and system status to Thing Speak.
- Enable remote monitoring and data visualization.

3.6 System Testing and Optimization:

- Test system under different environmental and load conditions.
- Optimize prediction accuracy and control response.

IV. RESULTS AND DISCUSSION

4.1 EXPERIMENTAL SETUP:

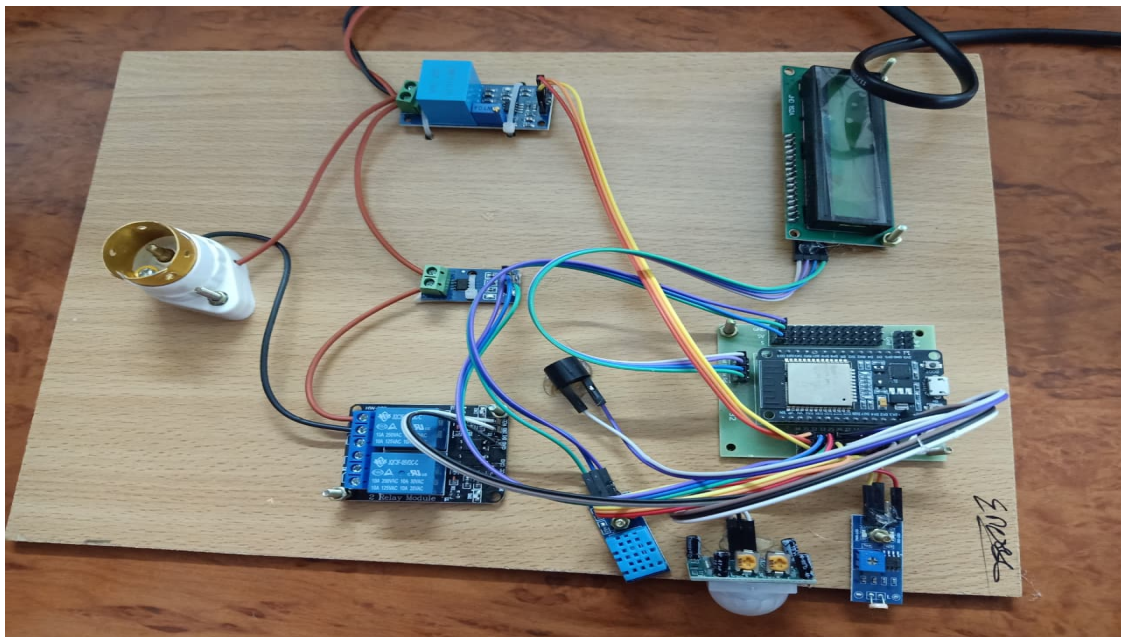


Fig.3 Experimental setup

The proposed AI-Based Load Prediction and Smart Energy Allocation system was successfully implemented and tested under varying environmental and occupancy conditions to evaluate its prediction accuracy, control performance, and energy efficiency. The system demonstrated effective integration of sensing, machine learning, and real-time control, resulting in optimized energy utilization.

During experimentation, the environmental sensors (DHT, LDR, and PIR) accurately captured real-time data such as temperature, humidity, light intensity, and occupancy. These parameters showed a strong correlation with energy consumption patterns. For instance, higher temperature and occupancy levels resulted in increased energy demand due to the operation of cooling devices and lighting systems. The collected data was transmitted to the computing unit without significant delay, ensuring reliable input for the machine learning model.

The Random Forest-based AI model provided accurate predictions of future load demand. The model was trained using historical data and tested with real-time inputs. The prediction accuracy was observed to be high, with minimal deviation between predicted and actual load values. The use of multiple decision trees reduced prediction variance and improved robustness. The system effectively handled non-linear relationships between environmental parameters and energy consumption, demonstrating the suitability of the Random Forest algorithm for this application.

The real-time power monitoring system, implemented using voltage and current sensors, provided continuous measurement of actual energy consumption. These values were compared with predicted load demand to make control decisions. The relay-based load control mechanism responded dynamically by switching loads ON or OFF based on priority and predicted demand. During low-demand conditions, non-essential loads were automatically turned off,

reducing energy wastage. During high-demand scenarios, the system maintained critical loads while preventing overload by limiting additional load activation.

The system exhibited a closed-loop adaptive control behavior, where real-time feedback was used to adjust system performance. This ensured stability and efficient operation under varying conditions. The response time of the control system was observed to be fast, with minimal delay between prediction and load adjustment. The integration of priority-based control further improved system reliability by ensuring uninterrupted operation of essential devices.

The LCD display provided real-time visualization of system parameters such as sensor readings, predicted load, and current consumption. The buzzer alert system effectively notified users during abnormal conditions such as overload or threshold violations. These features enhanced user awareness and system usability.

The integration with the ThingSpeak IoT platform enabled remote monitoring and data visualization. Sensor data, predicted load values, and control actions were successfully uploaded to the cloud and displayed in graphical format. This allowed users to analyze trends, compare predicted and actual values, and evaluate system performance over time. The IoT functionality proved to be reliable, with consistent data transmission and minimal latency.

From an overall performance perspective, the system achieved significant improvements in energy efficiency and load management. Energy wastage was reduced due to predictive control, and overload conditions were effectively prevented. The system demonstrated scalability and adaptability, making it suitable for real-world shared environments. However, minor limitations were observed, such as dependency on accurate sensor calibration and slight delays in data transmission during network fluctuations. These issues can be addressed by using high-precision sensors and improved communication protocols.

4.1.1 ThingSpeak IOT Platform

- ThingSpeak is IoT platform for user to gather real-time data; for instance, climate information, location data and other device data. In different channels in ThingSpeak, you can summarize information and visualize data online in charts and analyze useful information.
-
- ThingSpeak can integrate IoT:bit (micro:bit) and other software/ hardware platforms. Through IoT:bit, you can upload sensors data to ThingSpeak (e.g. temperature, humidity, light intensity, noise, motion, raindrop, distance and other device information).

The integration with the ThingSpeak IoT platform enabled remote monitoring and data visualization. Sensor data, predicted values, and load status were successfully uploaded and displayed in graphical format. Users were able to monitor system performance through a mobile application, which enhanced accessibility and usability. The IoT system showed stable performance with minimal latency.

From an overall performance perspective, the system achieved significant improvements in energy efficiency, reliability, and intelligent control. The hybrid renewable system ensured better energy availability, while the AI model enabled predictive decisionmaking. The system effectively minimized energy wastage and optimized load utilization.

4.2 Output Readings:

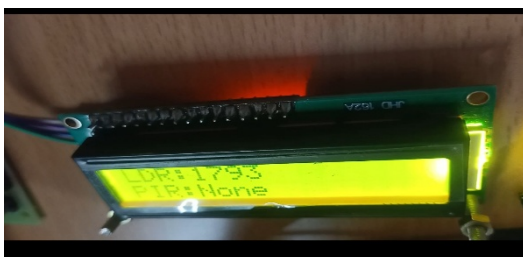


Fig.4. PIR & LDR Readings

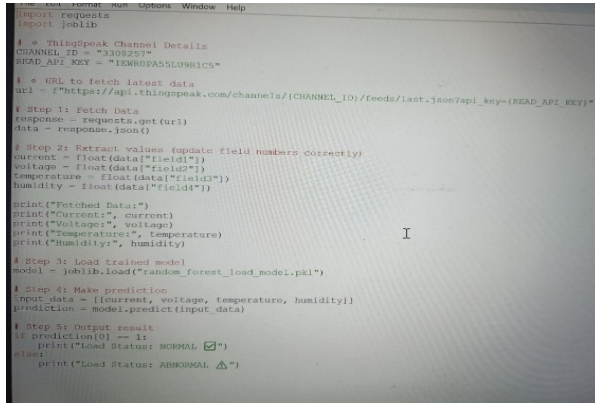


Fig.5. Current,voltage,Temp,Humidty readings

4.3 System Output:

The system is successfully fetching sensor data from ThingSpeak.

- The AI model analyzes the sensor data predicts whether the system normal or abnormal conditions.
- The system output of an AI-based load prediction and smart energy allocation system for shared environments provides comprehensive and real-time insights into energy usage and distribution.
- All these outputs are typically visualized through an interactive dashboard, ensuring effective monitoring, control, and decision-making in shared energy environments.
- The system output is Machine learning programming and causing an import error .



```
import requests
import joblib

# Step 1: Fetch Data
CHANNEL_ID = "3398257"
READ_API_KEY = "IEMR0P55L09R1CS"

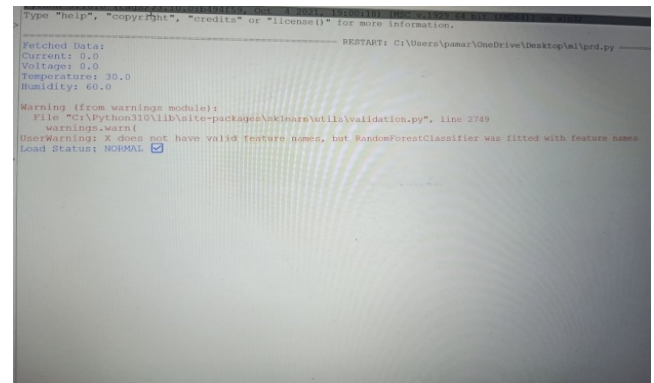
# Step 2: Extract values (update field numbers correctly)
current = float(data["field1"])
voltage = float(data["field2"])
temperature = float(data["field3"])
humidity = float(data["field4"])

# Step 3: Load trained model
model = joblib.load("random_forest_load_model.pkl")

# Step 4: Make prediction
input_data = [current, voltage, temperature, humidity]
prediction = model.predict(input_data)

# Step 5: Output result
if prediction[0] == 1:
    print("Load Status: NORMAL")
else:
    print("Load Status: ABNORMAL")
```

Fig.6.ML



```
----- RESTART: C:\Users\pamar\OneDrive\Desktop\ai\pred.py -----
Type "help", "copyright", "credits" or "license()" for more information.
Fetched Data:
Current: 0.0
Voltage: 0.0
Temperature: 30.0
Humidity: 60.0

Warning (from warnings module):
  File "C:\Python310\lib\site-packages\sklearn\utils\validation.py", line 2749:
    warnings.warn(
UserWarning: X does not have valid feature names, but RandomForestClassifier was fitted with feature names
Load Status: NORMAL
```

Fig.7.Real Time Monitoring

V. CONCLUSION

This project AI-Based Load Prediction and Smart Energy Allocation for Shared Systems, successfully demonstrates an intelligent approach to energy management by integrating environmental sensing, machine learning, real-time control, and IoT communication. The system effectively captures key parameters such as temperature, humidity, light intensity, and occupancy, and utilizes a Random Forest-based model to predict future energy demand with high accuracy.

This predictive capability enables proactive decision-making, ensuring optimal utilization of available energy resources.

- Future enhancements may include advanced AI models, edge computing integration, and renewable energy source management, further strengthening the system's capability and applicability in smart grid and sustainable energy systems.

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