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# Energy Consumption Prediction in Smart Homes using IoT and Machine Learning

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**Abstract:** This research paper presents an intelligent system for predicting energy consumption in smart homes using Internet of Things (IoT) and Machine Learning (ML) techniques. With the rapid growth of smart devices and automation, efficient energy management has become a critical challenge. The proposed system collects real-time data from IoT-enabled devices such as smart meters, temperature sensors, humidity sensors, and occupancy detectors. The collected data is pre-processed and analysed using machine learning algorithms including Random Forest, Support Vector Machine (SVM), and Linear Regression to forecast future energy consumption. The system not only predicts energy usage but also identifies consumption patterns to optimize energy efficiency and reduce wastage.

Experimental analysis shows that advanced ML models, particularly Random Forest, provide higher accuracy compared to traditional methods. The proposed approach can be effectively applied in smart homes, smart cities, and industrial environments to support sustainable and cost-efficient energy management.

**Keywords:** Internet of Things (IoT), Machine Learning, Energy Consumption Prediction, Smart Homes, Random Forest, Support Vector Machine (SVM), Linear Regression, Energy Efficiency, Smart Energy Management, Time-Series Forecasting.

## 1. INTRODUCTION

In recent years, the concept of smart homes has gained significant attention due to the increasing use of interconnected devices and automation technologies. A smart home consists of IoT-enabled devices such as smart meters, sensors, thermostats, and automated appliances that continuously generate large volumes of real-time data. This data provides valuable insights into energy consumption patterns and user behaviour.

However, with the growing number of connected devices, energy consumption has increased considerably, creating challenges in efficient energy management. Traditional energy monitoring systems mainly focus on tracking electricity usage but lack the ability to predict future consumption. As a result, they are less effective in reducing energy wastage and optimizing resource utilization.

The integration of IoT with Machine Learning (ML) offers a powerful solution to this problem. IoT devices enable continuous data collection, while ML algorithms analyse historical and realtime data to identify patterns and forecast future energy consumption. Predictive models allow users to make informed decisions, such as scheduling appliance usage during off-peak hours and reducing unnecessary energy consumption.

Various machine learning techniques have been used for energy prediction. Linear Regression provides a simple approach but is not suitable for complex datasets. Advanced models such as Random Forest and Support Vector Machine (SVM) offer improved accuracy, while deep learning models like Long Short Term Memory (LSTM) are highly effective for time-series forecasting.

This research aims to develop an efficient and scalable system for predicting energy consumption in smart homes using IoT and ML techniques. The proposed system focuses on real-time data processing, accurate prediction, and improved energy efficiency, contributing to sustainable development and smart energy management solutions.

  

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The main contribution of this research is the development of a real-time IoT-based energy prediction system using optimized machine learning models. The proposed approach improves prediction accuracy and helps in efficient energy management by analysing real-time data and identifying consumption pattern.

## 2.LITERATURE REVIEW

Various researchers have explored energy prediction using different techniques: Linear Regression is simple and easy to implement but performs poorly for complex datasets. Random Forest improves prediction accuracy by using multiple decision trees but requires higher computational power.
Support Vector Machine (SVM) provides better generalization but is slower for large datasets. Neural Networks and Deep Learning models (LSTM) are highly accurate for timeseries data but are complex and require large datasets.
Most existing systems focus only on monitoring energy usage rather than predicting it, which reduces their effectiveness in real-world applications.

## 3. METHODOLOGY

Data is collected using IoT sensors, pre-processed, and then used to train ML models such as Random Forest, SVM, and Linear Regression. The models are evaluated using MAE and RMSE. The proposed system follows a structured approach:
Step 1: Data Collection
IoT sensors collect real-time data such as: Energy consumption Temperature
Humidity
Occupancy
Step 2: Data Preprocessing
Removal of missing values
Noise reduction
Data normalization
Step 3: Feature Selection
Important features affecting energy consumption are selected to improve model performance. Step 4: Model Training
ML algorithms used:
Random Forest
SVM
Linear Regression
Step 5: Model Evaluation Performance is measured using:
MAE (Mean Absolute Error)
RMSE (Root Mean Square Error)

## 4.SYSTEM ARCHITECTURE

The system architecture consists of four main components:

- IoT Sensors Layer
- Collects real-time environmental and energy data
- Cloud Storage Layer
- Stores large volumes of data securely
- Machine Learning Layer
- Processes data and predicts energy consumption
- User Dashboard
- Displays results using graphs and reports

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## 5.RESULT

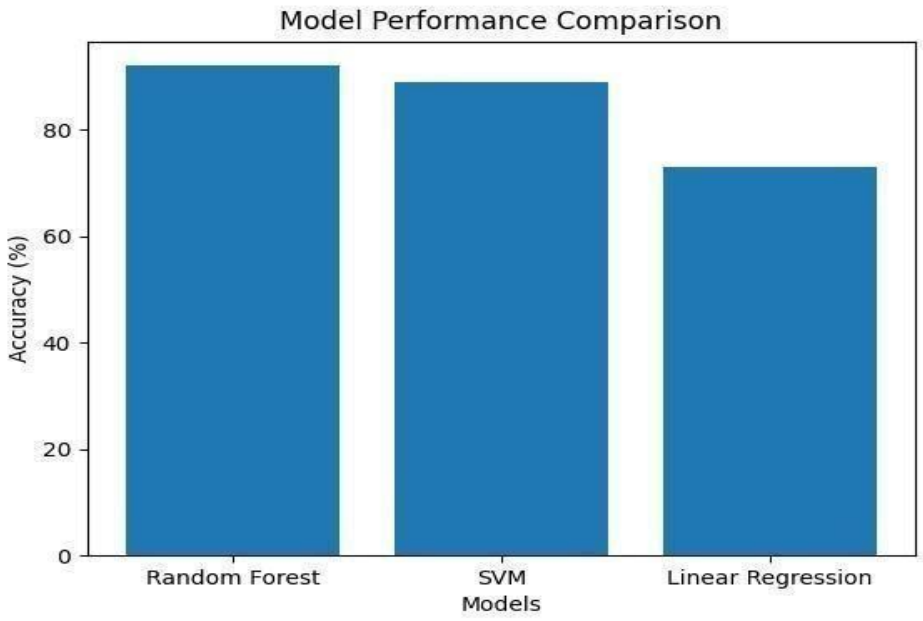
The system performance is evaluated using different ML models.

Random Forest shows the highest accuracy

SVM provides balanced performance

Linear Regression performs poorly for complex patterns

Graphical representation (bar graph) shows comparison of accuracy among models.

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## 6.PERFORM MODEL

| Model | Accuracy | Efficiency | Remarks |
|---|---|---|---|
| Random Forest | 92% | High | Best performance |
| SVM | 89% | Medium | Good balance |
| Linear Regression | 73% | Low | Less accurate |

Random Forest performs best due to its ensemble learning capability.

## 7.APPLICATIONS

This system can be applied in multiple domains:

- **Smart Homes** – Efficient energy usage
- **Smart Cities** – Large-scale energy optimization
- **Industrial Automation** – Reducing operational costs
- **Energy Management Systems** – Monitoring and forecasting

## 8.ADVANTAGES

- Reduces electricity consumption
- Improves energy efficiency
- Supports automation
- Provides real-time monitoring
- Helps in cost saving

## 9.LIMITATIONS

- High initial setup cost
- Requires stable internet connection
- Data privacy and security risks
- Complex model implementation

## 10.FUTURE SCOPE

Future improvements can include:

- Integration with renewable energy sources (solar, wind)
- Use of deep learning models like LSTM
- Edge computing for faster processing

## 11.CONCLUSION

The system effectively predicts energy consumption and improves smart home efficiency. Random Forest gives best accuracy. The proposed IoT and Machine Learning-based system provides an efficient solution for predicting energy consumption in smart homes. By analyzing real-time and historical data, the system helps reduce energy wastage and improves efficiency. Among the tested models, Random Forest provides the best performance. This system has great potential for future smart energy management solutions.

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