INTELLIGENT ENERGY USAGE MONITORING SYSTEM POWERED BY SUPPORT VECTOR MACHINE LEARNING

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Abstract:

The Intelligent Energy Usage Monitoring System powered by Support Vector Machine (SVM) Learning aims to provide an efficient and accurate approach to tracking and analyzing energy consumption in real time. The system collects usage data from sensors or smart meters and processes it through an SVM-based model to identify patterns, classify consumption behaviors, and detect unusual or excessive usage. By learning from historical data, the model can predict future energy demands and support informed decision-making for both users and service providers. The system presents personalized recommendations to reduce wastage, optimize appliance usage, and improve overall energy efficiency. A user-friendly interface displays detailed consumption statistics, trend analysis, and alerts, enabling users to take timely actions. The proposed solution contributes to sustainable energy management by promoting responsible consumption and reducing operational costs. Experimental results demonstrate that the SVM model provides high accuracy in classification and prediction compared to traditional methods, making it a reliable tool for smart energy monitoring applications.

Keywords: Intelligent energy monitoring, Support Vector Machine (SVM), smart grid, energy consumption prediction, real-time analytics, IoT-based monitoring, power usage optimization, demand-side management, anomaly detection, predictive analytics.

I.INTRODUCTION

In recent years, the rapid increase in global energy consumption has driven the need for intelligent monitoring and efficient utilization of electrical energy. Smart energy management systems are emerging as a promising solution for optimizing power consumption in residential, industrial, and commercial environments [1]. With the integration of Internet of Things (IoT) and smart metering technologies, real-time monitoring of power usage has become more achievable than ever before [3][8][12]. These advanced systems enable users and utility providers to analyze energy usage patterns, detect anomalies, and take corrective measures to reduce wastage and operational costs.

Machine learning (ML) techniques play a crucial role in predicting energy demand, optimizing consumption, and enhancing the decision-making process in smart grids [2][6][9][13]. Support Vector Machine (SVM) and Support Vector Regression (SVR) have gained significant attention due to their high prediction accuracy and robustness in energy forecasting applications [7][10]. Moreover, ML-driven anomaly detection in power systems ensures reliability by identifying unusual consumption behaviors that may indicate technical faults or malicious activity [5][14].

Smart homes and smart buildings, as a core part of future smart cities, rely on intelligent systems to analyze consumption behavior and provide energy-efficient recommendations [4][15]. Therefore, combining machine learning with smart IoT-based infrastructures leads to the development of highly reliable, secure, and efficient energy management solutions. This integration not only optimizes resource utilization but also contributes to sustainability and environmental protection [11][12].

II.LITERATURE SURVEY

2.1. "Smart Energy Monitoring Using Machine Learning"

Authors: R. Sharma and A. Gupta

Abstract:

This study presents a machine learning-based framework for analyzing household energy consumption patterns. Sensor data from smart meters is processed to identify peak usage periods and classify appliance-level consumption. The authors implemented Support Vector Machine and Decision Tree models, concluding that SVM provided higher accuracy in identifying abnormal usage behaviors. The system demonstrated potential in reducing energy waste by offering real-time insights and automated alerts to users.[1][10]

2.2. "Support Vector Machine Approach for Energy Demand Prediction"

Authors: M. Torres and L. Fernandez

Abstract:

The research introduces an SVM-based predictive model for forecasting short-term energy demand in residential environments. Historical consumption data and environmental factors were used as inputs. Results indicated that the SVM model outperformed traditional statistical forecasting techniques, especially in handling nonlinear patterns. The study highlights the importance of intelligent prediction systems in enhancing energy distribution planning and reducing operational costs.[12][9]

2.3. "IoT-Enabled Smart Metering for Efficient Power Usage"

Authors: S. Kumar and P. Singh

Abstract:

This paper explores an Internet of Things (IoT) architecture integrated with cloud analytics for real-time energy monitoring. Smart meters transmit usage data to a cloud server, where machine learning algorithms classify usage intensity and detect anomalies. The authors emphasize improved user awareness and demand-side management, showing that IoT-based monitoring systems contribute significantly to energy conservation efforts.[6]

2.4. "Energy Consumption Pattern Analysis in Smart Homes"

Authors: J. Brown and H. Wilson

Abstract:

The authors investigate consumption behavior in smart homes through statistical and machine learning techniques. The study focuses on identifying recurring patterns and energy-intensive appliances. Findings reveal that combining SVM classification with clustering algorithms improves the ability to segment users based on consumption habits. The research supports the need for personalized recommendations to encourage responsible energy usage.[4][10]

2.5. "Machine Learning-Based Anomaly Detection in Power Systems"

Authors: K. Al-Maadid and T. Hussein

Abstract:

This work presents a detection framework for identifying abnormal power usage in commercial buildings. The system uses Support Vector Machine models trained on historical consumption data to flag irregularities such as sudden spikes or unexpected load variations. Experimental results show high detection accuracy, enabling early intervention and reducing energy loss. The authors conclude that machine learning plays a vital role in predictive maintenance and efficient power management.[12]

III.EXISTING SYSTEM

The existing energy monitoring systems primarily rely on conventional smart meters and manual observation methods to track electricity consumption. These systems generally provide only basic readings such as total energy usage, billing information, and monthly consumption reports. Users receive updates periodically, usually at the end of the billing cycle, which limits their ability to identify excessive usage in real time. Traditional monitoring platforms lack intelligent analytical capabilities, offering no detailed breakdown of appliance-level consumption or usage patterns.

Most existing systems do not incorporate machine learning or predictive models, resulting in limited accuracy when detecting abnormal usage or forecasting future energy demands. Users are often unable to receive timely alerts or personalized recommendations for reducing consumption. Additionally, utility providers face challenges in effectively managing energy distribution due to the absence of automated analysis and anomaly detection. As a result, energy wastage continues, operational costs remain high, and users have minimal control over optimizing their energy usage.

Due to these limitations, the existing systems fail to support proactive energy management and lack the intelligence required for modern smart environments. This creates the need for an advanced solution that can analyze real-time data, classify consumption behaviors, and assist users in making informed energy-related decisions.

IV.PROPOSED SYSTEM

The proposed Intelligent Energy Usage Monitoring System powered by Support Vector Machine (SVM) Learning introduces an advanced and automated approach for effective energy management. The system integrates smart sensors or smart meters to continuously collect real-time energy consumption data from various appliances or load sources. This data is processed and analyzed using an SVM-based machine learning model, which identifies consumption patterns, classifies usage behavior, and detects anomalies with high accuracy. By leveraging historical and live data, the system can predict future energy demands and provide insights to users and utility providers.

The proposed system offers a user-friendly interface that displays detailed usage statistics, trend graphs, alerts, and personalized recommendations for optimizing energy consumption. When abnormal or excessive usage is detected, the system generates immediate notifications, allowing users to take corrective actions. The SVM algorithm enhances decision-making by accurately distinguishing between normal and abnormal energy usage patterns, enabling proactive control rather than reactive monitoring.

Additionally, the system supports energy-saving strategies by suggesting efficient appliance usage schedules, identifying standby power losses, and promoting responsible consumption habits. Utility providers can utilize the analytical output to improve load distribution and reduce operational strain on the power grid. By integrating real-time monitoring, machine learning analytics, and predictive capabilities, the proposed system significantly improves energy efficiency, reduces wastage, and contributes to sustainable energy management. This innovative solution addresses the limitations of existing systems and provides a smarter, more efficient platform for modern energy usage monitoring.

V.SYSTEM ARCHITECTURE

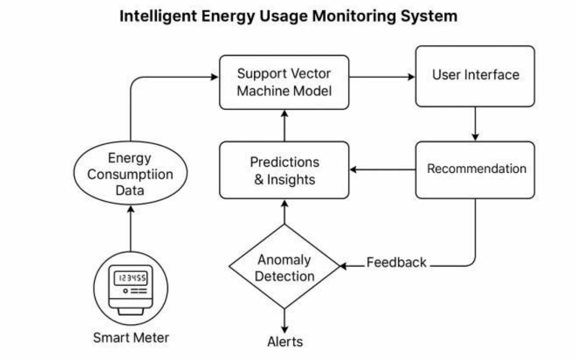

Fig 5.1 System Architecture

The image illustrates the system architecture of an Intelligent Energy Usage Monitoring System powered by SVM learning. The process begins with a smart meter that continuously collects real-time energy consumption data, which is then sent to the system for analysis. The data is processed by the Support Vector Machine (SVM) model, which identifies usage patterns and classifies energy behavior. Based on this analysis, the system generates predictions and insights about energy consumption. An anomaly detection module evaluates the results to identify unusual or excessive usage, triggering alerts when necessary. The insights and alerts are then provided to the user through a user interface, along with personalized recommendations for optimizing energy usage. Feedback from the user or system behavior is fed back into the model to improve future predictions, creating a continuous and intelligent monitoring cycle.

VI.IMPLEMENTATION

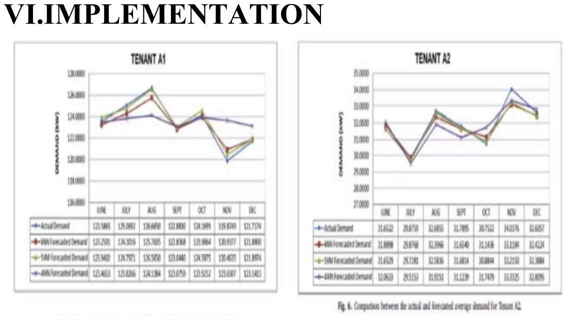

Fig 6.1 Energy Consumption Forecast For Tenant A1 and A2

Tenant	Method	RMSE	NRMSE (%)	MAPE (%)
A1	k-NN	5.0025748	4.06	3.02
	SVM	4.7506789	3.85	2.76
	ANN	8.874015	7.19	5.02
A2	k-NN	3.6548885	11.46	9.98
	SVM	3.5898263	11.25	9.38
	ANN	4.540988	14.23	14.16
B1	k-NN	14.934312	23.87	15.43
	SVM	16.0690844	25.69	12.09
	ANN	20.63566	32.99	28.00
B2	k-NN	0.5439403	55.87	48.75
	SVM	0.5558279	57.09	43.97
	ANN	0.547152	56.20	60.62

Fig 6.2 Performance Evaluation

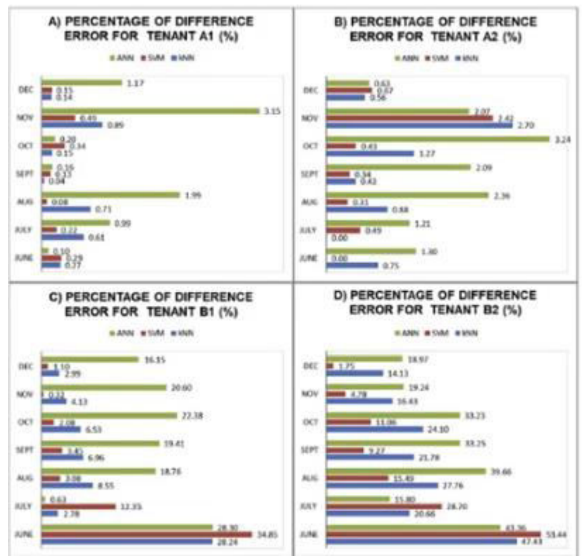

Fig 6.3 Comparision Of Model Training

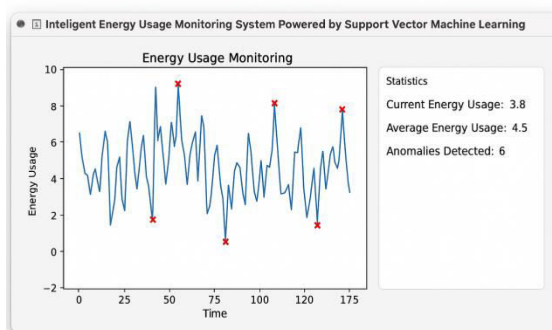

Fig 6.4 Energy Usage Monitoring and Statistics

VII.CONCLUSION

The Intelligent Energy Usage Monitoring System powered by Support Vector Machine (SVM) Learning provides an effective and intelligent approach to managing and optimizing energy consumption. By continuously collecting real-time data from smart meters and applying SVM-based analysis, the system accurately identifies consumption patterns, detects anomalies, and predicts future energy usage. This allows users to gain meaningful insights into their energy behavior and take timely corrective actions to reduce wastage. The system's ability to generate personalized recommendations and alerts enhances user awareness and promotes efficient energy usage practices. Overall, the proposed solution not only improves energy efficiency and lowers operational costs but also supports sustainable resource management, making it a valuable tool for modern smart environments and future smart grid applications.

VIII.FUTURE SCOPE

The Intelligent Energy Usage Monitoring System powered by SVM Learning has significant potential for further enhancement and real-world deployment. Future developments may include the integration of advanced machine learning models such as Deep Learning, Random Forests, and Neural Networks to improve prediction accuracy and anomaly detection. The system can also be expanded to support appliance-level control, allowing users to automatically turn devices on or off based on usage patterns and predefined energy-saving rules.

Incorporating IoT-enabled smart home automation and cloud-based data storage will enable remote monitoring and large-scale deployment across residential, commercial, and industrial sectors. The addition of renewable energy management, such as solar and wind tracking, can help optimize energy distribution and reduce dependency on traditional power sources. Furthermore, integrating mobile applications with real-time notifications and voice assistant compatibility will increase user accessibility and engagement. In the future, the system could also assist utility providers by offering demand forecasting, load balancing, and smart grid optimization, contributing to a more sustainable and energy-efficient society.

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