IoT Based Smart Energy Monitoring System For Home Appliances Using Machine Learning Algorithm

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Abstract- *Advancement in IoT based application has become the state-of-the art technology among the researcher due to the availability of Internet everywhere. The benefit of the Internet of Things (IoT) and connected nodes has been on a steep incline in recent years. Inefficient energy use has been a major issue globally. Residential energy consumption has been on a steady increase due to the growing population as well as a lack of awareness within households regarding proper energy utilization that causes significant amount of energy wastage. The emergence of Internet-of-Things(IoT) is a consequence and convergence of several key technologies such as real-time analytics, machine learning, sensors and embedded system.*

The proposed system consists of a set of sensors that monitor the energy consumption of various home appliances, a microcontroller unit that collects the sensor data and sends it to a cloud server, and a machine learning algorithm that analyses the data to predict future energy consumption. The system can also be used to alert users when energy usage exceeds a certain threshold based on the predicted energy consumption. This system demonstrates the potential of IoT-based smart energy monitoring systems in reducing energy waste and promoting energy efficiency.

Keywords- Machine Learning, Energy Monitoring, Relay, Wi-Fi module (ESP8266),PIC Controller, GSM module.

I. INTRODUCTION

Electricity is a source of energy which is non-recyclable, thus it must be utilized cautiously for it to be sustainable. Inefficient energy use has been a major issue globally, as a large percentage of current energy sources are generated using fossil fuels. Inefficient energy usage habits within households such as keeping unused appliances turned on, lowering air conditioner temperature to 16°C etc. results in energy wastage. Therefore, it is essential to monitor and optimize energy usage to promote energy efficiency and sustainability. One of the solutions to a growing urban population and household energy consumption is a smart energy monitoring and management system that utilize Internet of Things (IoT) technology.

Internet of Things (IoT) is a network of physical devices which are embedded with certain type of electronics which enable these devices/objects to connect and communicate with each other by exchanging data.IoT devices play a critical role in collecting and transmitting data related to energy consumption, production, and distribution. Smart energy metering systems will mainly assist empower customers with data to track, handle and regulate the use of energy, optimize efficiency and decrease the loss of energy. These features can help visualize these data better to the average household and in theory, help them manage their energy more efficiently. This system shall send the data to the assigned cloud when it is connected to the Wi-Fi router. The user simply can access the cloud on the device, and hence monitor the appliance energy consumption for the required amount of time. However, the most existing energy monitoring systems lack the element of CIoT with machine learning that enables the manipulation of data from users' energy habits.

Cognitive IoT(CIoT)refers to the application of intelligence in IoT, uses a new computing paradigm called Cognitive Computing which is essentially the convergence of IoT with machine learning.This paper proposes an IoT-based smart energy monitoring system for home appliances which implement machine learning algorithm like linear regression to predict future energy consumption level.To use linear regression for energy consumption prediction, historical energy data is collected and used to train the algorithm. Once the algorithm has been trained, it can be used to predict future energy consumption based on previous energy consumption pattern.

This allows energy providers to better manage their resources and plan for future demand. Such systems can help individuals and organizations monitor their energy usage,

identify energy-intensive appliances, and optimize energy usage to reduce waste and save costs.

II. SYSTEM ANALYSIS

The machine learning algorithm uses historical data to identify patterns in energy usage and to predict future energy consumption based on previous energy consumption. The predicted energy consumption can be used to identify energy-intensive appliances and to optimize energy usage by scheduling non-critical loads during off-peak hours. The system can also be used to alert users when energy usage exceeds a certain threshold and to recommend energy-saving measures based on the predicted energy consumption. The system can provide a user interface that displays real-time energy consumption data and loaded again for analysing for optimizing energy usage. Regular maintenance and updates to the system are required to ensure the accuracy and effectiveness of the machine learning algorithm and the sensors. Hence by analysing large amounts of data in real-time, these algorithms can help users optimize energy usage, reduce waste, and improve efficiency.

III. PROPOSED METHODOLOGY

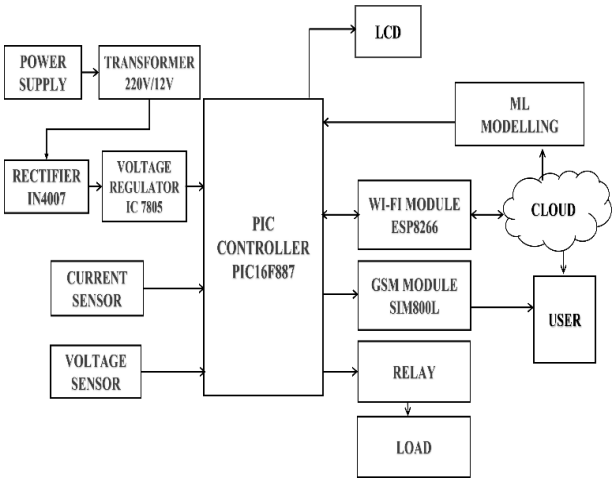

Figure 1: BLOCK DIAGRAM

PIC Microcontroller (PIC16F887) is powered by power supply. It is connected with Wi-fi module (ESP8266), GSM module (SIM800L) and LCD display. Day by day, Current, voltage, power, unit, cost and day are observed at LCD display interfaced with PIC controller. Future energy consumption is predicted using machine learning model like Linear Regression and set as a energy limit for appliances. If the energy usage crosses the set limit, the cloud server will send an alert to the user through the mobile application and moreover appliances are turned off through the relay.

The actual power consumption is again passed to the ML modelling for prediction and energy limit changes to the newest value. Overall, the use of machine learning algorithms can greatly enhance the capabilities of an IoT-based smart energy monitoring system. Hence the system can adjust energy usage based on the predictions made by the models, optimizing energy usage and reducing waste.

IV. SYSTEM DESIGN

In proposed concept,PIC Controller(PIC16F887),Wi-fi module(ESP8266),GSM module(SIM800L)and LCD are being used. The PIC Controller interfaces with the energy monitoring sensors and other hardware components, such as relays, to control the energy usage of the system. The microcontroller also manages the communication between the IoT platform and the sensors.The Wi-Fi module is used for wireless communication between the system and the IoT platform. The module connects to a Wi-Fi network and sends data from the energy monitoring sensors to the cloud server. The GSM module is used for sending SMS alerts to the user in case of any abnormal energy usage patterns detected by the system. It can also be used as a backup communication method if the Wi-Fi network is not available. Microcontroller manages the operation of the system, while the Wi-Fi and the GSM modules enable wireless communication with the IoT platform and the user.

V. EXPERIMENTAL SETUP

A power supply unit is required to provide the appropriate voltage supply. This unit consists of transformer, rectifier, filter and a regulator.230V AC power supply is stepped down to 12V by the Transformer. 12V AC is converted into 12V DC by rectifier IN4007 which in turn converted to 5V by two voltage regulator IC7805. One is to supply for GSM module (SIM800L). Another one is given to PIC Microcontroller (PIC16F887). Program is mounted into the PIC. The PIC16F87 controller is powered +5Vfrom the power supply board. It is connected with Wi-Fi module, GSM module and LCD.

Current and voltage analog signals are received through ADC port of PIC and corresponding power, units and cost are calculated and displayed through LCD connected with PIC. When the energy consumption is lesser than the predicted value, Current, voltage, power, unit, cost and day will get displayed in the LCD display. These data also shared to cloud through Wi-Fi module. The data stored in the cloud can be accessed by user using mobile. When crossing of predicted value, SMS alerts will be send to the user through GSM module and also observed at LCD display. Simultaneously,

PIC turn OFF the Appliances through relay 5V/250W.After incorporating appropriate changes, user can again turn ON the appliances using mobile.

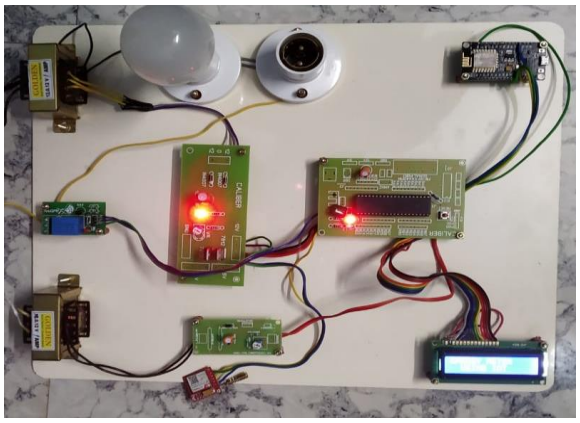

Figure 2 : Snapshot of Proposed Hardwarekit

S.NO`	PARAMETERS	EXISTING SYSTEM	PROPOSED SYTEM
1.	Controller	MSP430F6736	PIC16F887
2.	Operating voltage range	1.8V-3.6V	2.0V-5.5V
3.	Accuracy	65%	80.79%
4.	User Energy consumption Pattern	Not Analysed	Analysed

Table1: Comparison of proposed system with existing system.

VI. RESULT AND DISCUSSION

The results of the IoT-based smart energy monitoring system using machine learning algorithms can be evaluated based on its ability to accurately predict energy consumption patterns, optimize energy usage in real-time, and reduce waste. At normal condition, parameters like current,voltage,units consumed, cost and day are displayed in the LCD (Figure:3&4) and also stored in cloud through Wi-fi Router for future analysis. When current exceeds beyond the predicted amount of 391W of first 5 days, LCD indicates power off signal (Figure:5) and this signal also received through mobile via GSM. The following results and discussions can be observed:

Figure 3: Current, Voltage, Power, Day reading

Figure 4 :Units consumed and Cost incurred

Figure 5:Power off signal

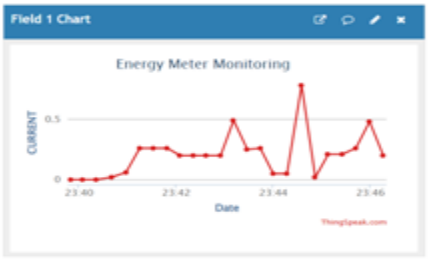

Figure 6: Variation of Current w.r.t Time

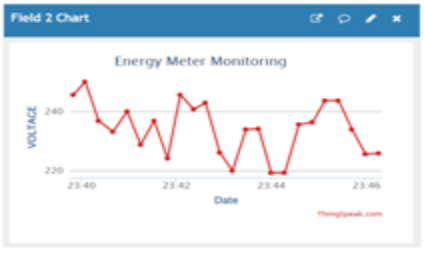

Figure 7: Variation of Voltage w.r.t Time

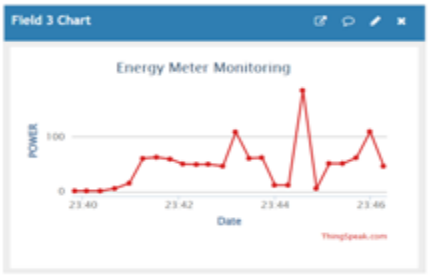

Figure 8: Variation of Power w.r.t Time

Energy consumption prediction: The machine learning models trained on historical data were able to accurately predict energy consumption patterns in real-time. This allowed the system to adjust energy usage based on the predictions made by the models, optimizing energy usage and reducing waste.

Anomaly detection: The machine learning algorithms were able to detect anomalies in energy consumption patterns, such as sudden spikes or drops in usage. This allowed users to identify potential issues with their equipment or systems and take corrective action.

Optimization of energy usage: The machine learning models were able to optimize energy usage in real-time based on the data collected from the sensors. For example, the system could adjust heating and cooling systems based on occupancy data or optimize lighting based on ambient light levels.

Overall, the results of the IoT-based smart energy monitoring system using machine learning algorithms showed that it was effective in predicting energy consumption patterns, optimizing energy usage in real-time, and reducing waste. By analyzing large amounts of data in real-time, the system was able to help users optimize their energy usage, reduce waste, and improve energy efficiency. The system also helped users identify potential issues with their equipment or systems and take corrective action, further improving the overall efficiency of the system.

VII. FUTURE SCOPE

The future scope of the IoT-based smart energy monitoring system using machine learning algorithms is significant. Since it helps us in many ways, such as analysing large chunks of data, data extractions, interpretations, etc, it can quickly adapt to future technologies. The integration of advanced data analytics techniques, renewable energy sources, and smart grid systems will further improve the efficiency and sustainability of the system. The integration with home automation systems and the development of a more user-friendly interface will also increase the accessibility and usability of the system for users.

VIII. CONCLUSION

Proper energy utilisation is needed in this era where population is expected to increase exponentially, and global warming is already showing its effect. The IoT-based smart energy monitoring system using machine learning algorithms is a promising solution for optimizing energy usage, reducing waste, and improving energy efficiency.By using machine learning algorithms to analyse large amounts of data in real-time, the system can predict energy consumption patterns, detect anomalies, and optimize energy usage in real-time. It enables us to utilize the technology to save energy which is one of the best ways to meet the increasing energy demand. The system also provides users with the ability to monitor their energy consumption and adjust energy usage settings based on their needs.

REFERENCES

[1] Olteanu, G. Oprina, N. Tapus and S. Zeisberg, “Enabling Mobile Devices for Home Automation Using ZigBee,”19th International Conference on Control Systems and Computer Science, Bucharest, 2013, pp. 189-195.

[2] E. D. NgangueNdih and S. Cherkaoui, "On Enhancing Technology Coexistence in the IoT Era: ZigBee and 802.11 Case," in IEEE Access, vol. 4, pp. 1835-1844,2016.

[3] A.L. Hanees and M. M. M. Mufassirin, “Development of IoT Based Smart Energy Meter Reading and Monitoring System”, 7th International Symposium 2017 (IntSym2017)- SEUSL, 2018.

[4] Mesquita, J., Guimarães, D., Pereira, C., Santos, F., & Almeida, L. (2018, September). Assessing the ESP8266 Wi-Fi module for the Internet of Things. In 2018 IEEE 23rd International Conference on Emerging Technologies and Factory Automation (ETFA) (Vol. 1, pp.784-791). IEEE.

[5] EvtimPeytchev, MihailLyaskov, KostadinPopovski, GrishaSpasov,“Home Energy Monitoring System based on Open Source Software andHardware” International Conference on Computer Systems and Technologies - CompSysTech’16.

[6] Qiang, T., Guangling, G., Lina, C., & Han, W. (2018, October).Nodemcu-based Low-cost Smart Home Node Design. In IOP Conference Series: Materials Science and Engineering (Vol. 435, No. 1, p. 012013). IOP Publishing.

[7] Kodali, R. K., & Mahesh, K. S. (2017, September).Low cost implementation of smart home automation. In Advances in Computing, Communications and Informatics (ICACCI), 2017 International Conference on (pp. 461-466). IEEE.

[8] Singh, H., Pallagani, V., Khandelwal, V., &Venkanna, U. (2018, March). IoT based smart home automation system using sensor node.In 2018 4th International Conference on Recent Advances in Information Technology (RAIT) (pp. 1-5). IEEE.

[9] Sharma, M. L., Sachin, K., &Nipuri, M. (2017). SMART HOME SYSTEM USING IOT. International Research Journal of Engineering and Technology, 4(11), 1108-1112.

[10] Jinsoo Han, Chang-Sic Choi, Wan-Ki Park, Ilwoo Lee, and Sang-Ha Kim. "Smart home energy management system including renewable energy based on ZigBee and PLC" IEEE Transactions on Consumer Electronics, Vol. 60, No. 2, May 2014.

[11] X. Fan, B. Qiu, Y. Liu, H. Zhu, and B. Han, "Energy visualization for smart home," Energy Procedia, vol. 105, pp. 2545–2548, 2017.