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Energy Monitoring and Prediction System using IOT and Machine Learning

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Abstract
The amalgamation of machine learning and the Internet of Things (IoT) within Home Energy Management Systems (HEMS) markedly improves predictive maintenance and diminishes energy consumption by facilitating real-time data processing, anomaly detection, and the implementation of optimized energy utilization strategies. This collaborative framework fosters the creation of sophisticated systems capable of forecasting equipment malfunctions and refining energy consumption behaviors, thereby promoting enhanced sustainability and financial savings. The subsequent sections elucidate the manner in which these technologies contribute to predictive maintenance and energy efficiency. The incorporation of IoT facilitates continuous observation and data aggregation, which is imperative for training machine learning models to accurately forecast maintenance requirements. Despite the considerable advantages presented by the integration of machine learning and IoT within HEMS, challenges pertaining to data privacy, security, and the necessity for robust infrastructure must be addressed to fully harness the potential of these technologies. The smart grid assumes a pivotal role in contemporary society and within our networks. Smart meters are integral to this framework. Smart meters provide instantaneous monitoring of reliable status, automated information collection, user engagement, and energy regulation. Additionally, they deliver real-time consumption metrics and enable power management. In instances where a customer's peak load demand surpasses the maximum threshold, the electricity supply to consumers will be disconnected through the implementation of an IoT-based system for HEMS. This paper introduces the utilization of smart meters in conjunction with IoT technology. This paper concentrates on predicting the electrical energy consumption of domestic appliances utilizing a machine learning paradigm in low-energy consumption residences within an apartment complex. Furthermore, this paper emphasizes a smart system that wirelessly profiles energy consumption by calculating the energy utilized by individual consumers.
Keywords: *Smart Grid, Intelligent Prediction Model, Internet of Things, Energy Management*

1. Introduction
The home monitoring and control systems can be characterized as devices that are realized through the implementation of the Internet of Things (IoT). Devices, automobiles, buildings, and other physical items that are equipped with electronic parts, software, sensors, actuators, and networking capabilities are all part of the interconnected network known as the Internet of Things. facilitate the collection and exchange of data among these entities. The home monitoring system is designed to oversee the access points of residential structures, specifically doors and windows, and provides notifications regarding any unauthorized entry through a data stream. This system is equipped with intrusion detection sensors that capture and transmit multiple images of the intruder to the user, irrespective of their location, via the Internet. The implementation of this system is achieved through the utilization of IoT, which encompasses the interconnection of machines through the Internet to enhance connectivity. This paper elucidates a cost-effective and adaptable home control and monitoring system that employs an embedded micro-web server, providing Internet Protocol (IP) connectivity for the remote access and management of devices and appliances. The proposed system does not necessitate a dedicated

server personal computer, in contrast to similar systems, and introduces an innovative communication protocol aimed at monitoring and regulating the home environment, extending beyond mere switching capabilities. Home automation pertains to the management of any or all electrical devices within a residential or commercial context. A plethora of distinct home automation systems is available on the market, each typically engineered and acquired for specific objectives. Notably, a significant challenge within this domain is the lack of interoperability and interconnectivity among these disparate systems. Various challenges must be addressed when designing a home automation system. Additionally, it is essential for the system to provide a user-friendly interface on the host side, facilitating the straightforward setup, monitoring, and control of devices. In intelligent home systems, the Internet is also utilized to guarantee remote operational control. For an extended period, the Internet has been extensively employed for activities such as web browsing, information retrieval, communication, file downloading, and software installation. With the swift advancements in technology, monitoring and controlling services have begun to be offered in conjunction with the Internet, serving as a medium for interaction with machinery and devices. The system may be implemented in diverse settings such as financial institutions, healthcare facilities, laboratories, and other advanced automated systems, significantly mitigating the risks associated with unauthorized access.

1.1. Existing System

The Design and Implementation of a Home Appliances Control System Utilizing Android Smartphones delineates a framework for remotely managing household appliances via an Android smartphone interface. A user engages with the smartphone interface by logging in and delicately pressing buttons to dispatch command messages, which are subsequently relayed to the Home Information Center through the Global System for Mobile Communications (GSM) network. The Peripheral Interface Controller (PIC) processor then interprets the designated command and regulates the appliance switches through wireless radio frequency techniques, ultimately facilitating remote management of household devices. The existing framework of our project does not incorporate the Internet of Things (IoT) paradigm for appliance control. This paradigm shift is imperative for contemporary technological advancements that enable device management from any geographical location. Therefore, we are transitioning to IoT technology as the proposed system in our project aimed at home automation.

1.2. Proposed System

The proposed framework developed for the enhancement of security measures and surveillance fundamentally comprises an Arduino module in conjunction with an array of sensors. The Node MCU is integrated with the internet utilizing IoT technology, thereby facilitating efficient home monitoring through various sensors. We have interfaced PIR, Vibration, Gas, and LDR sensors with the Node MCU to enable comprehensive home surveillance via IoT technology. The system permits the remote control of domestic electrical appliances, such as bulbs, fans, and motors, through the Internet of Things (IoT). The home monitoring system is equipped with sensors designed to detect unauthorized acces and to capture and transmit multiple images of the intruder to the user from any location via the internet. The implementation of the system is realized through the utilization of IoT, which embodies the interconnectedness of devices through the internet for enhanced connectivity. The paper presents a Home Energy Management System (HEMS) utilizing machine learning and IoT technologies to optimize energy consumption in residential settings. [1] It emphasizes the integration of smart meters for real-time monitoring and control of energy usage, enabling demand-side management. The research highlights the importance of predictive analysis and machine learning algorithms, such as ANN and reinforcement learning, in enhancing energy management strategies. [2] [3] The proposed system aims to reduce electricity costs while maintaining user comfort through effective load forecasting and intelligent decision-making. [4] [5]

2. Internet of Things

The paper describes a method for connecting a microcontroller to a Local Area Network (LAN) or the Internet, enabling it to function as a web server. It

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outlines a system designed to control home appliances remotely, utilizing personal computers, interface cards, and microcontroller control software. The microcontroller employed in the project is the Philips P89C51RD2BN, which facilitates the on/off control of home appliances, regulation of output power, and timing of usage. Additionally, the paper discusses the use of Wireless Sensor Network (WSN) technology for web-based environmental monitoring. The Internet of Things (IoT) is the network of physical objects, automobiles (often referred to as "connected devices" or "smart devices"), buildings, and other objects that have electronics, software, sensors, actuators, and network connectivity in order to collect and share data among themselves. Through the use of existing network infrastructure, the Internet of Things (IoT) enables remote sensing or control of objects, creating opportunities for a more direct integration of the physical world with computer-based systems, leading to increased efficiency, accuracy, and economic benefits as well as a decrease in the need for human intervention. When sensors and actuators are added to the Internet of Things, the technology is a specific example of the larger class of cyber-physical systems, which also comprises technologies like virtual power plants, smart grids,, and smart cities. Each object within this ecosystem is distinctly identifiable through its integrated computing system, yet possesses the capability to interoperate within the established Internet framework. Experts project that the IoT will comprise approximately 30 billion objects by the year 2020. Generally, the IoT is anticipated to provide sophisticated connectivity among devices, systems, and services that transcends traditional machine-to-machine (M2M) communications, encompassing a wide array of protocols, domains, and applications. The interconnection of these embedded devices (including smart objects) is anticipated to promote automation across nearly all sectors, while simultaneously facilitating advanced applications such as smart grids and extending into domains like smart cities. "Things," in the context of IoT, may denote a diverse array of devices including heart monitoring implants, biochip transponders utilized in agricultural animals, electric clams in marine environments, vehicles equipped with integrated sensors, and The Internet of Things (IoT) is the network of physical objects, automobiles (often referred to as "connected devices" or "smart devices"), buildings, and other objects that have electronics, software, sensors, actuators, and network connectivity in order to collect and share data among themselves. Through the use of existing network infrastructure, the Internet of Things (IoT) enables remote sensing or control of objects, creating opportunities for a more direct integration of the physical world with computer-based systems, leading to increased efficiency, accuracy, and economic benefits as well as a decrease in the need for human intervention. When sensors and actuators are added to the Internet of Things, the technology is a specific example of the larger class of cyber-physical systems, which also comprises technologies like virtual power plants, smart grids,. The IoT constitutes one of the foundational platforms of contemporary Smart Cities and Smart Energy Management Systems.

2.1.Steps in IOT Web Page Creation

2.1.1. Collect Data in a New Channel

The creation of a new channel to gather analyzed data is demonstrated in this example. You write data into your new channel after reading it from the public Thing Speak channel 12397-Weather Station. See Write Data to Channel and the API Reference for information on posting data from devices to a channel.

2.1.2. Create a Channel

Sign In to Thing Speak™ using your Math Works® Account, or create a new Math Works.
Click **Channels** > **My Channels**

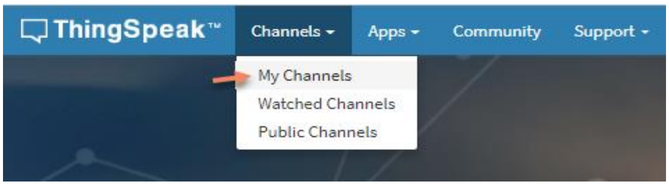

Figure 1 Channel Creation Block

- Click New Channel on the Channels page.
- Fields 1–3 have boxes next to them. Enter these values for the channel setting:
- Field 1: Temperature (F); Field 2: Humidity; Field 3: Dew Point Measurement; • Name: Dew Point Measurement

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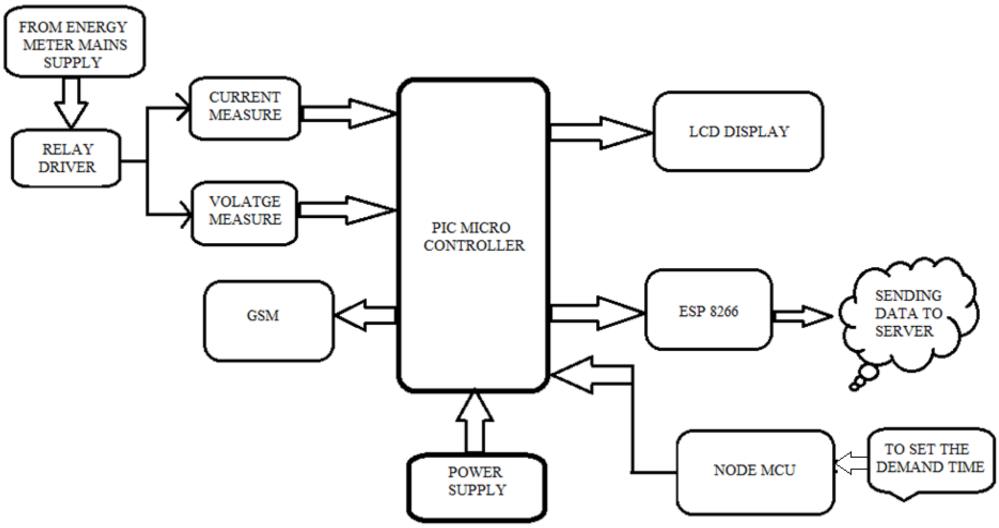

Figure 2 Proposed System Model

2.2.ESP8266 Wi-Fi Module

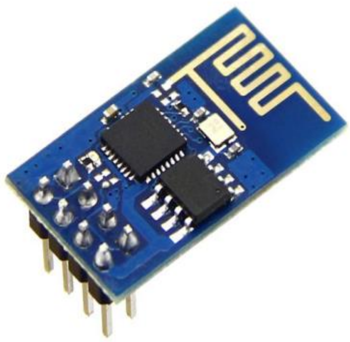

Figure 3 ESP8266 Module

Espressif developed the ESP8266, a Wi-Fi-enabled system on a chip (SoC) module. The development of embedded Internet of Things (IoT) applications is its primary purpose. The ESP8266 has the following features: 2.4 GHz Wi-Fi (802.11 b/g/n, supporting WPA/WPA2); general-purpose input/output (16 GPIO); serial communication protocol Inter-Integrated Circuit (I²C); analog-to-digital conversion (10-bit ADC); serial peripheral interface (SPI); I²S (Inter-IC Sound) interfaces with DMA (Direct Memory Access) (sharing pins with GPIO); UART (on dedicated pins, plus a transmit-only UART can be enabled on GPIO2); and pulse-width modulation (PWM). It uses an 80 MHz (or 160 MHz of versing overclocked) 32-bit RISC CPU based on the Tensilica Xtensa L106. It contains 96 KB of data Figure 1 shows Channel Creation Block, Figure 3 shows ESP8266 Module. RAM, 64 KB of instruction RAM, and 64 KB of boot ROM. Through SPI, external flash memory can be accessed. An inexpensive standalone wireless transceiver that can be utilized for end-point Internet of Things advancements is the ESP8266 module. A set of AT instructions must be used by the microcontroller in order to communicate with the ESP8266 module. The microcontroller uses a UART with a predetermined Baud rate to interact with the ESP8266-01 module. This chip is used by numerous third-party manufacturers to create various modules. Thus, the module has many pin availability options, like as The ESP-01 is a PCB trace antenna with eight pins, including two GPIO pins. (As seen in the figure above)ESP-03 comes with 14 pins, (7 GPIO pins) – Ceramic antenna. ESP-04 comes with 14 pins, (7 GPIO pins) – No ant [1-5]

2.3.Advantages

The suggested HEMS modifies energy consumption while reducing user comfort in a regulated manner. Furthermore, a measure of discomfort and a comfort model were suggested. The results of testing a prototype system in a simulated setting showed that heating system adjustment alone might result in savings of 16–19% in an extreme pricing scenario and 5% in a simulated month with primarily low price circumstances.

2.4.Applications

- Residential Applications
- Power House Monitoring
- Apartments

The sensor data is transmitted to the web browser for system monitoring following successful server connection. The webpage is displayed upon entering the IP address into the web browser. The web server conveys critical information regarding the status of home appliances that are remotely connected to the internet. Home automation enables the automation of tasks pertinent to security, wellbeing, and comfort through a smart system installed within a residence or building. In essence, it integrates technological advancements into the spatial design. A primary advantage of home automation systems is their contribution to energy efficiency. Figure 3 shows Flowchart. [6-11]

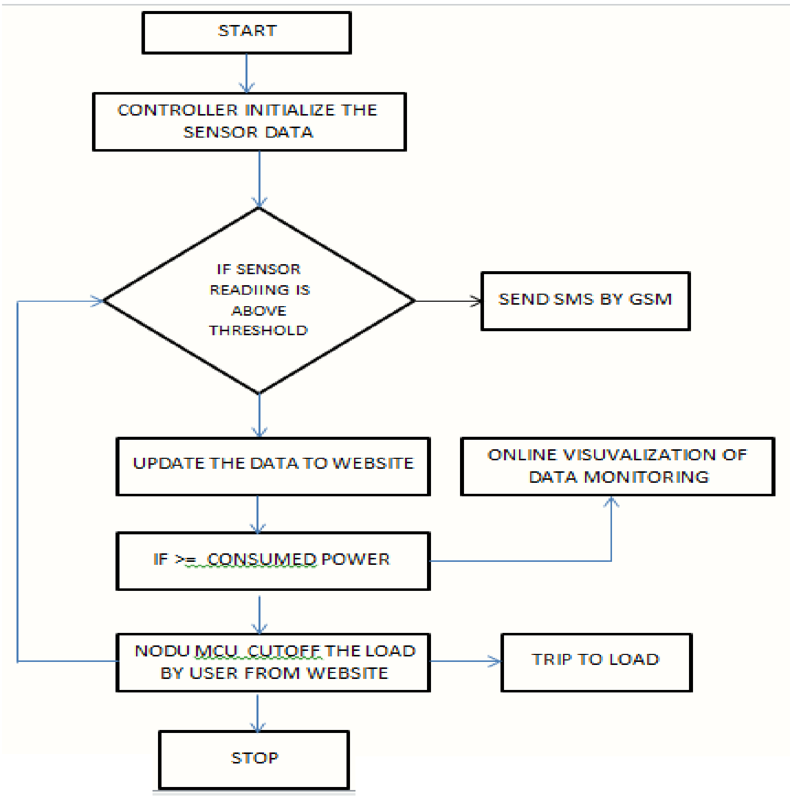

Figure 3 Flowchart

3. Discussions

To design a new algorithm with the proposed system because whatever we get the predictive data analysis take some time to analysis the overall system. The proposed work reviewed the home clients' energy management systems. It provided background information on smart home energy management system technologies, outlined the key elements, and conducted a comparative analysis of several technology approaches. Additionally, several of the flaws and problems with smart technologies, like their cost, implementation, and privacy concerns, have been examined, and a framework for future systems has been suggested.

4. Result

For residential smart houses to manage the DR and improve occupant comfort with reasonable electricity costs, accurate forecast in HEMS is crucial. This study examined the use of machine learning prediction methods in a variety of HEMS-related contexts. The analysis demonstrates how accurate load forecasting can successfully balance energy supply and demand in HEMS. Furthermore, precise household consumption forecasting greatly affects peak demand scheduling to guarantee steady power demand, which is critical for resource sustainability. Furthermore, by controlling the uncertainty and fluctuation issues, accurate PV energy prediction influences the control of the entire Smart MG. On the other hand, price prediction can save energy costs. Additionally, a HEMS model that was tuned using the best machine learning prediction techniques was suggested. In order to improve the overall economic experience and lifestyle of the residents, the model will assist in managing the energy consumption and offer recommendations to users based on the anticipated data. The model will eventually be prototyped. using multi-layer techniques and a multi-agent system simulation. The accuracy will be compared with similar models to evaluate its functionality and cost effectiveness. Figure 4 shows Hardware of the HEMS.

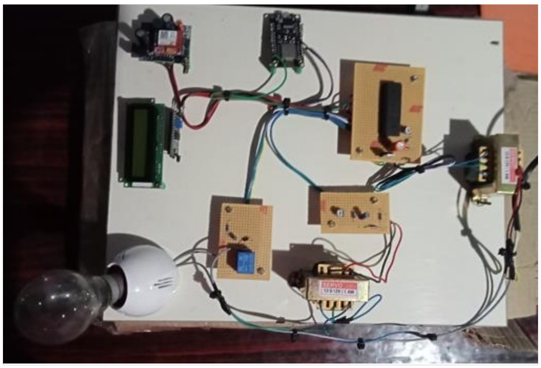

Figure 4 Hardware of the HEMS

Conclusion

The paper concludes that machine learning techniques are essential for developing efficient Home Energy Management Systems (HEMS) that can significantly reduce energy consumption in residential buildings. It emphasizes the importance of accurate load prediction for balancing energy demand and supply, which is crucial for maintaining stable power demand and resource sustainability. The study introduces an optimized HEMS model based on precise machine learning prediction algorithms, aimed at effectively managing energy demand and providing personalized recommendations to enhance residents' economic well-being and lifestyle. Future work includes prototyping the model using advanced techniques and conducting comparative analyses to assess functionality and cost-effectiveness.

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