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The Internet of Things and Artificial Intelligence-Based Recommendation System for Automating Homes

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Abstract: Automation techniques for the home are becoming more popular as a result of the simplicity with which equipment and appliances may be controlled by speech or centered on physical activity by the use of sensors. Research suggests that introducing smartness to small businesses and regular users may be expensive and that there has to be an easier, more transparent, and more simple way to connect and manage equipment with mobile apps. Sensors and the Internet of Things (IoT) have enabled the rapid development of several electrical appliance prototypes into marketable final products. In this information time, there are not enough data-driven strategies for making the most of ceiling fans in homes and businesses. As a further advantage, Artificial Intelligence (AI) algorithms applied to data may help us uncover patterns that reflect appliance use and spot shifts in our daily routine. As a result, this study suggests a method to promote specific programs to those who have smart homes via the usage of IoT and AI. With the resident's permission, the dataset includes information on the fans in their bedroom, living room, and lounge. A wide variety of experts, including data scientists, environmentalists, fan makers, architects, and social scientists, may benefit from this information. Monthly averages of temperature and humidity, energy used, hours of use per day or month, and monthly/weekly summaries are all available for analysis.

Keywords: *Internet of things, artificial intelligence, convolutional neural network, automatic homes.*

1. Introduction

A strategy for managing energy consumption at home that seeks to achieve optimum levels of all used energies. The charging and discharging of EVs, as well as the usage of distributed generation and energy storage, are all taken into consideration. The hems may adjust to new rates and the amount of energy used by the home automatically. The scheduling algorithm Hem and its underlying structure are explained. Technologies such as the "smart grid," "demand response," "smart homes," "new energy production," "energy storage," and others are discussed. Scheduling and using power consumption devices and energy sources efficiently is also explored and addressed concerning the hems and other potential future development pathways. A hems design is provided based on the current state of the art in metering technology [1]. A home information management terminal stores data and manages household schedules. By making strategic purchases from the grid and generating electricity using photovoltaics, an optimal simulation model for scheduling a new home energy management system may be developed. The potential role of AI in the hems is also considered. In today's world, improving energy efficiency is a tool that is utilized to combat some of the most significant problems facing the global community, including, but not limited to, issues relating to energy security, air pollution, climate change, and economic crises [2]. Alternatives that improve energy efficiency have the potential to maximize the amount of energy that is used while simultaneously lowering the number of greenhouse gases that are emitted, which in turn makes a beneficial contribution to the protection of natural ecosystems and the well-being of humans. Additionally, options that are more energy efficient can offset the economic consequences at the place of employment. Because of the recent upward trend in energy consumption, particularly in the residential sector, energy efficiency has been a topic of intense interest in studies all over the globe. As a result of this, organizations and governments all over the globe are suggesting steps for energy conservation intending to decrease the inconveniences that are associated with energy [3].

The IoT is a network of objects, including cars, household appliances, and other objects, that are equipped with electronics, software, sensors, actuators, and networking to connect, gather, and share data. Smart automobiles, smart lightbulbs, and smart thermostats are a few examples of these devices. The IoT presently plays a key role in the monitoring and managing of equipment. Additionally, it uses a remote system to calculate the data obtained and manages the controls in line with the results. [4]. Applications that are based on the IoT are gaining a lot of traction in this age. To transfer gathered data and create

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management choices depends on the output from the server, these devices rely on communication, which may take place through “Bluetooth, Wi-Fi, ZigBee, light-fidelity (Li-Fi), near field communication (NFC), radio frequency identification (RFID), and Z-Wave”. The IoT is a change that gives businesses the ability to raise their organizational productivity. This provides businesses with a higher level of protection against potential threats [5].

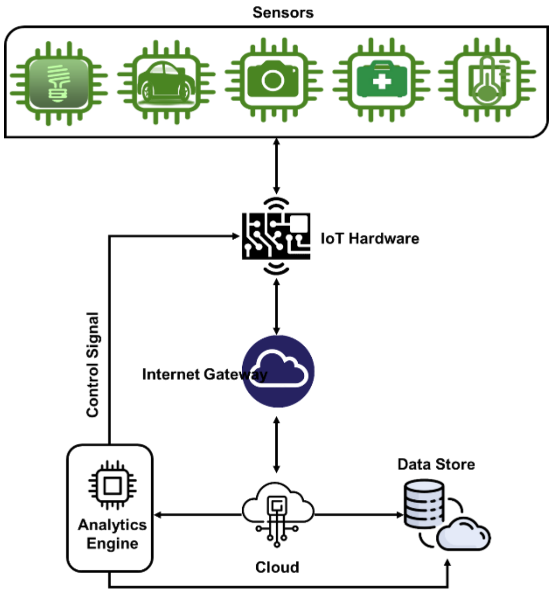

Fig. 1. Architecture of IoT

The overall architecture of the IoT is presented in figure 1; it includes sensors associated with the cloud through various channels of transmission and communication, including “wireless networks, satellite networks, Wi-Fi, Bluetooth, a wide area network (WAN), and a low-power wide-area network”. Sensor data is sent from the attached gadgets to a cloud server for retrieval and processing. The cloud server then transmits control signals downstream to the linked devices. A “no-structured query language (No-SQL) database” is used by the cloud, which can be a remote server, or a cloud service, to store and manage large amounts of real-time data [6]. Through an internet gateway, Depending on the IoT hardware, the relevant control signal is provided to effect change in the real world. The IoT allows for a tolerable degree of variation in temperature readings from home heating and cooling systems. Improved quality of life and more automation are only two of the many potential outcomes of using IoT in conjunction with a 5G network. Recent research shows that always-connected devices can real-time information on behavior and environmental conditions and digest it swiftly, leading to improved operations management and enhanced automated decision-making. AI agents like Google Assistant and Amazon Alexa may be used to manage automated home systems in real-time. High-speed network connection allows generic automation systems to make decisions and make adjustments in real-time [7].

The research aims to provide smart solutions to track the environmental status concerning the user-preferred speed of the fan using IoT-AI-based fans for usage in homes and businesses. Smart functioning in a manually controlled fan is made possible by data collection. This dataset will allow for the study of fan usage patterns across rooms, allowing for the growth of smart features including a bedroom fan that is set to automatically go to sleep mode to regulate the speed of the fan based on surrounding while sleeping, and a feature that reduces fan speed in the living room during mealtimes based on historical data. In addition, the information may be used to study appliance performance concerning seasonal and climatic differences in different regions.

The paper is organized in the manner described below. A comprehensive examination of the most current contributed home automation methods is presented in Section 2. The suggested smart automation approach is fully described in Section 3. The outcomes of the implementation are shown in Section 4 along with a commentary. The paper's main contributions are discussed in Section 5, along with the potential for future improvements to the suggested program.

2. Related work

An Internet of Things program for managing and keeping tabs on connected dwellings was deployed in [8]. In particular, the program provides a safety net by letting users observe and operate domotic devices using their hands or voices. Using App Inventor and Android Studio, we were able to create this useful app. An energy-shedding algorithm and a smart home energy management system architecture were presented in [9]. This project relied on grid management, control systems, house management systems, and domotic gadgets that communicate wirelessly with one another. In [10], a smart home design was used to propose a protocol for WSN optimization. This layout separates the inside and outside spaces, with the two communicating through a central hub. A smartphone gives the user complete access to their house at all times. To implement and validate the system, we employed the SQLite database system. A framework for modelling IoT applications was given in [11], which may be used to generate systems for home security that are both reliable and economical to run. The study [12] presented a cyber-physical smart house system that minimizes energy consumption. The technology watches the elderly to help them keep their homes' energy use down by using cloud big data and computation. Furthermore, this study offered a smart multimedia-enabled middleware assistant for monitoring domotic devices, visualizing energy-efficient operations, exchanging multimedia messages, and controlling domotic devices using hand gestures. To save power, the model momentarily turned off certain devices whose characteristics overlapped with those of others. Based on the premise that the IoT has the potential to significantly advance many different types of technology, including but not limited to "e-government, environmental control, military applications, infrastructure maintenance, manufacturing applications, energy management, health monitoring, smart homes, and transportation systems" [13] proposes analyzing a home automation framework.

3. Proposed Methodology

The goal of home automation is to improve the convenience of use, comfort, energy efficiency, and safety by providing homeowners with the ability to automate and manage various parts of their houses from a distant location. Users can manage and monitor the gadgets, appliances, and systems in their homes, even when they are not there, by using a centralized control system or mobile apps. Home automation systems have the potential to become more intelligent, adaptable, and efficient if they make use of the technologies described. CNNs are an example of a form of deep learning model that works particularly well for image processing and other computer vision applications. CNNs are useful tools for performing tasks like object detection when used in the context of home automation. For instance, surveillance cameras that are outfitted with CNNs can recognize and categorize the people or things they are looking at. This paves the way for automatic reactions such as the sending of warnings or the activation of certain actions based on particular patterns.

The convolution layer serves as CNN's central processing unit, performing all necessary convolutional operations. The kernel/filter (matrix) in this layer is responsible for the actual convolution. Until the complete picture has been scanned, the kernel will adjust its horizontal and vertical positions dependent on an image having three (i.e., RGB) channels, the kernel's height, and width will be minimal, but its depth will extend over all three. The primary goal of the pooling layer is to reduce the number of dimensions. It aids in reducing the number of computational resources required for data processing. Maximum pooling and average pooling are two types of pooling that may be distinguished from one another. Maximum (Max) pooling gives you the highest value in the image kernel. When using a kernel across a region of an image, "average pooling" yields an average of all the values in that region. Since the fully linked layer uses a flattened input, every input is associated with every neuron. The normal mathematical functional operations are performed on the flattened vector as it is passed via many additional fully linked layers. At this point, we start the sorting procedure. In CNN designs, completely linked layers, if present at all, tend to be saved for very late stages. For learning-based face detection, a fully-connected neural network is used. There are 1024 neurons in each of the two hidden layers of this neural network, and 2 neurons make up the single output layer. To identify human faces in a photograph, we employ ReLu and Softmax activation functions in the hidden and output layers, respectively. Here, we optimize the procedure during backpropagation by setting the learning rate to 0.28. Equations (1) and (2) describe the convolution procedure and the ReLu activation function, respectively.

$$S_{ij} = (I * K)_{i,j} = \sum_{a=0}^{m-1} \sum_{b=0}^{n-1} I_{i+a,j+b} K_{a,b} \quad (1)$$

S_{ij} represents the Output of convolution, I represents the Input image matrix, K = Kernel matrix, i and j represents the Filter number and Input grid number concerning neuron, a value indicates the range of 0 to $m-1$, and b value is 0 to $n-1$.

$$y = max\ (0, x) \quad (2)$$

Where, x = Value of the convolution matrix in pixels, and

y = Normalized output.

3.1 Dataset

The data that was gathered by the IoT-enabled ceiling fan was transferred to the MySQL database that was set up for storage on the Digital Ocean server. The information was taken from the database and placed in 3 different "comma-separated values (CSV)" files before the dataset was made accessible to the general public [14]. The dataset includes information on the utilization of three fans in the following rooms: the living room, the lounge, and the bedroom. Each of these rooms is tagged in the CSV file. Every file comprises the columns of data that were obtained from the network and entered into the proper fields. These fields include "date time, temperature, humidity, fan speed, operating time, energy used, and energy saved". A broad overview of the dataset is shown in Table 1. These are the original datas that were recorded by the fan along with the timestamps, and each row in the dataset comprises a change in the condition of the interior. The timestamp column consists of the time, as well as the month and year that the data was taken, even though the data is not particularly designated with details on the season. By including a weather report that offers details on conditions within the period that the information was obtained, readers may receive extra context.

Table 1: Description of Data

Column	Meaning	Unit	Example
temperature	The sensor's reading of the outside temperature.	°C	27
datetime	The timestamp of any modification to any variable	MM/DD/YYYY	02/07/2022 10:38

		HH:MM :SS	
Speed	Fan speed, with a scale of 0 (not running) to 5 (fastest speed). A certain RPM value is represented by each level.	level number	2
humidity	The sensor's measurement of the ambient humidity	%RH	35
eSpent	The amount of energy used by the fan.	Ws	902
eSaved	The energy that the fan conserved.	Ws	1262
opTime	Operational time is the length of time that the fan ran at a specific speed.	seconds	90

In addition, temperature measurements may not be related and humidity sensors found within and the forecasts of the weather outside, depending on the specific conditions under which the data was collected. In this scenario, the humidity and temperature sensor readings may be affected by the building's protection, dimensions, development, and tasks, such as having dinner, employing equipment, and preparation. As a consequence of this, the results derived from the temperature and humidity sensors found within a building are likely to be substantially different from those obtained from outside sensors.

In a similar vein, readers may anticipate varying degrees of humidity if the weather condition notes that there was significant precipitation while the period in question. Table 2 displays the results of a calculation using Bedroom_Fan_1.csv. The mean is determined by adding together all of the values in the appropriate columns. Table 2 shows the average monthly interior temperature and relative humidity, allowing the user to make an informed decision about the optimal fan speed throughout the year. The other rooms may be compared in the same way, and a general pattern can be deduced.

Table 2: Calculating a monthly mean of climate variables

Month	Mean of Humidity (%RH)	Mean of Speed	Mean of Temperature (°C)
January	61	2	21.15
March	63.04	2	31.42
April	56.19	2	33.14
June	73.89	5	34.01
July	74.78	4	32.18
August	79.68	3	31.63
September	72.87	6	35.50
October	78.22	3	32.64
December	68.26	2	23.82

3.2 Inter of Things

The IoT links together physical objects that are outfitted with sensors, software, and connections to make it possible for these devices to share data and interact with one another. Thermostats, door locks, lighting systems, and other home appliances may all be IoT connected in a smart house. These gadgets can gather data about their surroundings as well as the preferences of the user, which creates a plethora of knowledge that may be used for automated purposes. As an example, a smart thermostat that is outfitted with IoT capabilities may study user behavior, modify temperature settings by that behavior, and maximize energy use by occupancy patterns.

The IoT is the driving force behind the notion of remote device monitoring and control. Home automation systems allow users to control many aspects of their house from any location with an internet connection, including the ability to change the temperature, switch the lights on and off, lock and unlock doors, and see live footage from security cameras.

3.3 Artificial Intelligence

AI is an essential component of home automation since it processes the data obtained from IoT devices and enables intelligent decision-making. Automated home systems can recognize and comprehend human habits, preferences, and patterns of behavior thanks to the use of AI algorithms. This enables personalized automation, in which the system adjusts to the specific requirements and habits of each individual. AI may also allow predictive skills, such as anticipating user needs and automatically modifying settings to optimize comfort, energy efficiency, and security. These are just a few examples of how these capabilities might be used. Based on user input and environmental changes, it may continually learn and adapt. They can reduce energy usage, recommend customized settings, and gradually become used to the habits and preferences of users.

4. Result and Discussion

The outcomes of the execution of the suggested smart automation model and the actions to be benchmarked are presented in this part together with the appropriate reasons and conclusions. The process of putting together the home automation system begins with disassembling the complete system. The deep learning-enabled smart mats (DLES-mats) [15] and home energy management systems (HEMS-IoT)

[16] that are currently in use are contrasted with our suggested technique, which is depends on the Internet of Things and artificial intelligence [17]. The metric includes recall, accuracy, and precision.

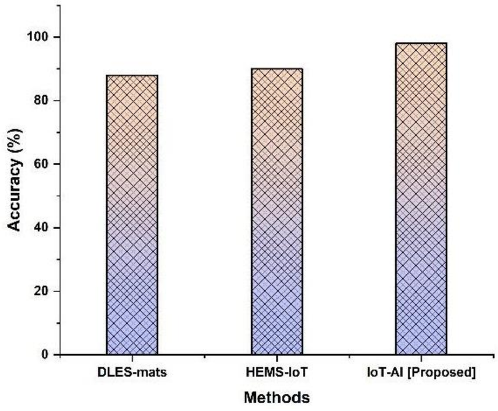

Fig. 2. Comparison of Accuracy

Accuracy in home automation systems relies on several parameters that work together to allow the system to carry out duties accurately and by user instructions. For dependable environmental data collection, high-quality sensors that deliver precise readings are required. Figure 2 shows the accuracy comparison. Our suggested solution had a 98 percent accuracy rate compared to the current methods' 88 and 90 percent, respectively, of DLES-mats and HEMS-IoT. When compared to other ways, our suggested methods have higher accuracy. The accuracy using suggested and current approaches are contrasted in Table 3.

Table 3. Accuracy

Methods	Accuracy (%)
DLES-mats	88
HEMS-IoT	90
IoT-AI [Proposed]	98

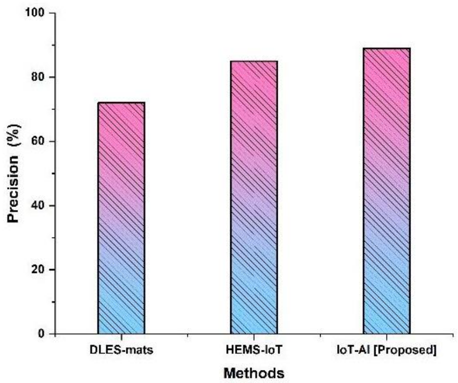

Fig. 3. Comparison of precision

It is important to ensure that the automation system runs with precise tolerances and provides reliable outcomes. This is accomplished through several important factors. The system can make educated judgments and take appropriate action thanks to accurate sensor data. The accuracy comparison is shown in figure 3. The accuracy of the current approach, DLES-mats, was 72%; that of HEMS-IoT, 85%; and that of our suggested method, 89%. When compared to other ways, our suggested methods have higher precision. The precision of the suggested and current approaches is compared in Table 4 for comparison.

Table 4. Precision

Methods	Precision (%)
DLES-mats	72
HEMS-IoT	85
IoT-AI [Proposed]	89

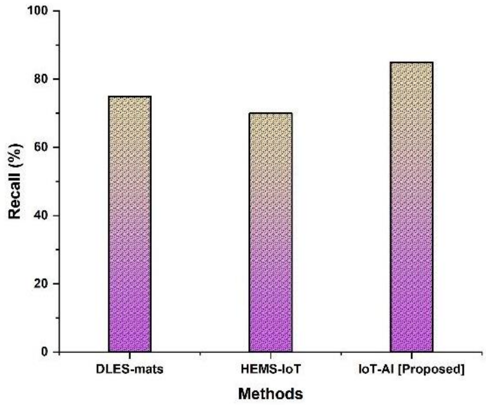

Fig. 4. Comparison of Recall

Home automation provides convenience, energy efficiency, and increased security by scheduling and personalizing settings based on preferences. It makes everyday life simpler and produces a comfortable and effective living environment by having the capacity to automate ordinary chores like turning on and off lights or regulating the temperature. The recall comparison is shown in figure 4. The recall of the current approach, DLES-mats, was 72%; that of HEMS-IoT, 85%; and that of our suggested method, 89%. When compared to other ways, our suggested methods have a higher recall. The recall of suggested and current approaches is compared in Table 5.

Table 5. Recall

Methods	Recall (%)
DLES-mats	75
HEMS-IoT	70
IoT-AI [Proposed]	85

5. Conclusion

In conclusion, enhanced recommendation systems that automate houses have been made possible by the fusion of the IoT and AI. AI algorithms provide sophisticated analysis and decision-making while the IoT enables seamless communication between numerous smart devices and sensors. However, in the context of IoT and AI-based home automation, it's crucial to take security and privacy considerations into account. The recent advancements in the IoT allowed us to begin formulating ideas for a societally beneficial and financially feasible home automation system. A home ecosystem may benefit from the current iteration of the generic home automation system. Maintaining user privacy and defending against possible cybersecurity risks require the protection of personal data, guaranteeing secure communication, and putting in place strong authentication methods. Risks to security and privacy are raised by smart gadgets' growing connection. System flaws might perhaps result in unauthorized access to personal information or even jeopardize the home's physical security. To safeguard home automation systems from cyber-attacks, future research may concentrate on creating strong security mechanisms, authentication protocols, and encryption approaches.

Reference

[1] Sardianos, C., Varlamis, I., Chronis, C., Dimitrakopoulos, G., Alsalemi, A., Himeur, Y., Bensaali, F. and Amira, A., 2021. The emergence of explainability of intelligent systems: Delivering explainable and personalized recommendations for energy efficiency. International Journal of Intelligent Systems, 36(2), pp.656-680.

[2] Lops, P., Jannach, D., Musto, C., Bogers, T. and Koolen, M., 2019. Trends in content-based recommendation: Preface to the special issue on Recommender systems based on rich item descriptions. User Modeling and User-Adapted Interaction, 29, pp.239-249.

[3] Jabbar, W.A., Kian, T.K., Ramli, R.M., Zubir, S.N., Zamrizaman, N.S., Balfaqih, M., Shepelev, V. and Alharbi, S., 2019. Design and fabrication of smart home with Internet of things enabled automation system. IEEE access, 7, pp.144059-144074.

[4] Iyer, R. and Sharma, A., 2019. IoT based home automation system with pattern recognition. International Journal of Recent Technology and Engineering, 8(2), pp.3925-3929.

[5] Jantapoon, W., Tipsuwanporn, V. and Numsomran, A., 2021, October. The design of PI with delayed-time integral mode controller for wireless networked control system. In 2021 21st International Conference on Control, Automation and Systems (ICCAS) (pp. 1031-1036). IEEE.

[6] Feng, Q., He, D., Zeadally, S. and Liang, K., 2019. BPAS: Blockchain-assisted privacy-preserving authentication system for vehicular ad hoc networks. IEEE Transactions on Industrial Informatics, 16(6), pp.4146-4155.

[7] Jain, A., Tanwar, P. and Mehra, S., 2019, February. Home Automation system using internet of things (IOT). In 2019 International Conference on Machine Learning, Big Data, Cloud and Parallel Computing (COMITCon) (pp. 300-305). IEEE.

[8] Rani, R.B., Bavithran, N. and Prasannakumar, S., 2022. Design and development of home automation system. In Recent Advances in Manufacturing, Automation, Design and Energy Technologies: Proceedings from ICoFT 2020 (pp. 387-395). Springer Singapore.

[9] Bicakci, S. and Gunes, H., 2020. Hybrid simulation system for testing artificial intelligence algorithms used in smart homes. Simulation Modelling Practice and Theory, 102, p.101993.

[10] Venkatesh, K., Rajkumar, P., Hemaswathi, S. and Rajalingam, B., 2018. IoT based home automation using raspberry Pi. J. Adv. Res. Dyn. Control Syst, 10(7), pp.1721-1728.

[11] Goni, I. and Hassan, R., 2019. Intelligent arduino home-based security system using a global system for mobile communication (GSM) and passive infrared (PIR) sensor. Communications, 7(2), pp.45-49.

[12] Badar, A.Q. and Anvari-Moghaddam, A., 2022. Smart home energy management system–a review. Advances in Building Energy Research, 16(1), pp.118-143.

[13] Lytvyn, V., Vysotska, V., Shatskykh, V., Kohut, I., Petruchenko, O., Dzyubyk, L., Bobrivetc, V., Panasyuk, V., Sachenko, S. and Komar, M., 2019. Design of a recommendation system based on Collaborative Filtering and machine learning considering the personal needs of the user. Восточно-Европейский журнал передовых технологий, (4 (2)), pp.6-28.

[14] Khan, H.R., bin Khalid, M.H., Alam, U., Atiq, M., Qidwai, U. and Qazi, S.A., 2023. Dataset of usage pattern and energy analysis of an Internet of Things-enabled ceiling fan. Data in Brief, p.108900.

[15] Shi, Q., Zhang, Z., He, T., Sun, Z., Wang, B., Feng, Y., Shan, X., Salam, B. and Lee, C., 2020. Deep learning enabled smart mats as a scalable floor monitoring system. Nature communications, 11(1), p.4609.

[16] Machorro-Cano, I., Alor-Hernández, G., Paredes-Valverde, M.A., Rodríguez-Mazahua, L., Sánchez-Cervantes, J.L. and Olmedo-Aguirre, J.O., 2020. HEMS-IoT: A big data and machine learning-based smart home system for energy saving. Energies, 13(5), p.1097.

[17] Dr. Vishnu Rajan, & De La Cruz, A. (2022). Utilisation of Service Robots to Assist Human Workers in Completing Tasks Such in Retail, Hospitality, Healthcare, and Logistics Businesses. Technoarete Transactions on Industrial Robotics and Automation Systems (TTIRAS), 2(1), 8-13.