An Intelligent Approach for Smart Home Energy Management System Empowered with Machine learning Techniques

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Abstract- Currently, energy is the most important necessity for humans. With new technology advancements and increased use of electric vehicles, daily energy consumption is increasing. In practically every region of the globe, the demand for electricity exceeds the amount of energy produced. The rapid development and evolution of human life, information technology, and the increase in the usage of household devices, the newest automobiles, and electric vehicles all contribute to a larger reliance on electrical energy and, as a result, an increase in carbon dioxide emissions from power plants. The existing worldwide difficulty is how to conserve electricity by reducing energy use and mitigating global warming. This project should include the construction of a Smart Home Energy Management System to optimize the operation of home appliances. It is meant to reduce energy use by monitoring resident behavior. This design suggests an energy management system for the effective use of the electricity produced by a smart home and the energy consumed by the home's electrical appliances. A comprehensive system overview, including the software setup and hardware components, is provided

Keywords: *Real-Time Sequential Deep Extreme Machine Learning, Smart Home, Energy, Smart City.*

1 INTRODUCTION:

Energy appears to be the most fundamental need of humans [1]. The use of energy is steadily growing as a direct result of recent technical developments and the expanding use of electric vehicles. The amount of actual energy that is produced is typically substantially lower than the amount of electricity that is required in almost all countries [2]. Therefore, energy needs to be addressed as one of the key infrastructures for the development of any economy [3]. Additionally, energy is a significant factor in determining whether a state or region will be successful [4]. Because of the way that electricity works, conserving energy are one of the most important things you can do to bring down the cost of energy [5].

There have been a few different residential security systems put into use [6]. These innovations can be broken down into two primary groups: power generation systems and consumption reduction solutions [7]. Both of these categories are possible to classify. The first strategy might be implemented by installing in-home micro-generation devices such as solar panels or wind turbines. However, the second proposal is more effective than the first strategy due to the fact that it requires far less money to implement. On the other hand, it is possible to accomplish this by utilizing intelligent control systems, which are able to truly organize service for household appliances by turning them off in order to save energy when they are not being used. A smart machine is a term that is used to describe emerging innovations that can be seen in many different implementations of our everyday lives [8-10]. For example, the fields of power management, medical applications, and automotive industry automation are all examples of implementations of smart machine technology [11-12]. The latest breakthroughs in bioengineering, electronic development, material science technology, and nanotechnology are some of the primary areas of focus in smart gadgets [13]. Several recently invented appliances are now available for installation in contemporary houses [14]. As a result, the efficient management of the operation of these devices could result in a significant reduction in the amount of energy that is used [15].

The management of energy is recognized as the primary prototype for the implementation of sophisticated energy systems in smart homes, according to the findings of this body of study. This piece of research presents a concise description of energy management and the challenges faced by smart cities. It then proceeds to outline a unified structure for ensuring the continued availability of energy in IoT-based smart homes. For the purpose of making smart cities more energy efficient by utilizing Internet of Things (IoT) enabled sensors with increased performance, a deep extreme learning machine (DELM) approach will be deployed [16-20]. Future smart cities are incorporating energy-efficient systems with superior control structures, control structures, and technology. Demand response strategies are also being implemented [21-26].

Researchers investigate innovative approaches to the challenges of efficient energy management. Among the several strategies that were brought forth, he decided to center his attention, in particular, on the procedures for "machine learning," which include the use of historical information to handle recurring in-patient real-life situations. It was around this time that there was a resurgence of interest in artificial neural networks, and this interest was followed with tremendous passion [27-28].

Environmental variables are taken into account as model inputs, and the amount of energy created is taken into account as model outputs, in order to deal with nonlinear relations in the capabilities of artificial neural networks. Utilizing this model, we are able to make an accurate prediction of the plant's output power depending on the characteristics of the surrounding environment [29]. Within the scope of this investigation, a GA approach for the development of MLP for CCPP power output estimations has been presented [30]. Choosing an MLP model using a genetic algorithm Perceptron with multiple hidden layers is done using a single mutation, three crossover processes, and two fitness functions.

Hall et al. [31] asserted that the infrastructures in place for things like energy, irrigation, and transportation will make smart cities clean, safe, efficient and environmentally, and efficient future metropolises. Bakıcı et al. [32] stated that place a premium on innovation and are constantly evolving by connecting people, data, and urban characteristics with cutting-edge technology to create a place that is both secure and prosperous for generations to come. Citizens play a crucial role in smart cities because of the impact their connections have on the city as a whole. Because of this, it is generally agreed that the most important factor in the success of a smart city is its inhabitants, making education, networking, and information sharing crucial tools for any smart city. Giffinger et al. [33] argued that a smart city is a community where many aspects, such as people, weather, transportation, democracy, and economics, are built into a smart framework.

Tang et al. [34] intended to include AI in fog computing to facilitate the smarter search of big data sets. in contrast to cloud-based centralized evaluation and intelligence. Specifically, they used a hierarchical fog computing model for large data analysis in the context of smart city projects.

In order to attain the maximum possible level of precision, the topic of this study is the investigation of a deep extreme learning machine for the purpose of managing the energy output of smart homes. During the training and testing phases of deep learning-based estimation of electrical energy output, a data set that contains 47840 data instances is utilized. This data set is designed in such a way that each instance incorporates a unique set of characteristics. As a consequence of this, analysis and assessment in light of the most recent and cutting-edge practices in the relevant industry are carried out. Feng et al. [35] developed a cognition architecture for smart houses based on intelligent dynamic IoT systems and detailed its components.

The remaining parts of this work are structured in the following manner. In the second section, the procedure to carry out an exhaustive analysis for the purpose of predicting the amount of electrical energy produced by power plants is presented. In Section 3, the simulation and the outcomes of using the DELM technique are discussed. The findings and interpretations of the study are presented and discussed in Section 4.

3 METHODOLOGY:

An intelligent algorithm is presented in this investigation to recognize and monitor the function of household appliances in a manner that is acceptable, taking into consideration the activity states of people living in houses.

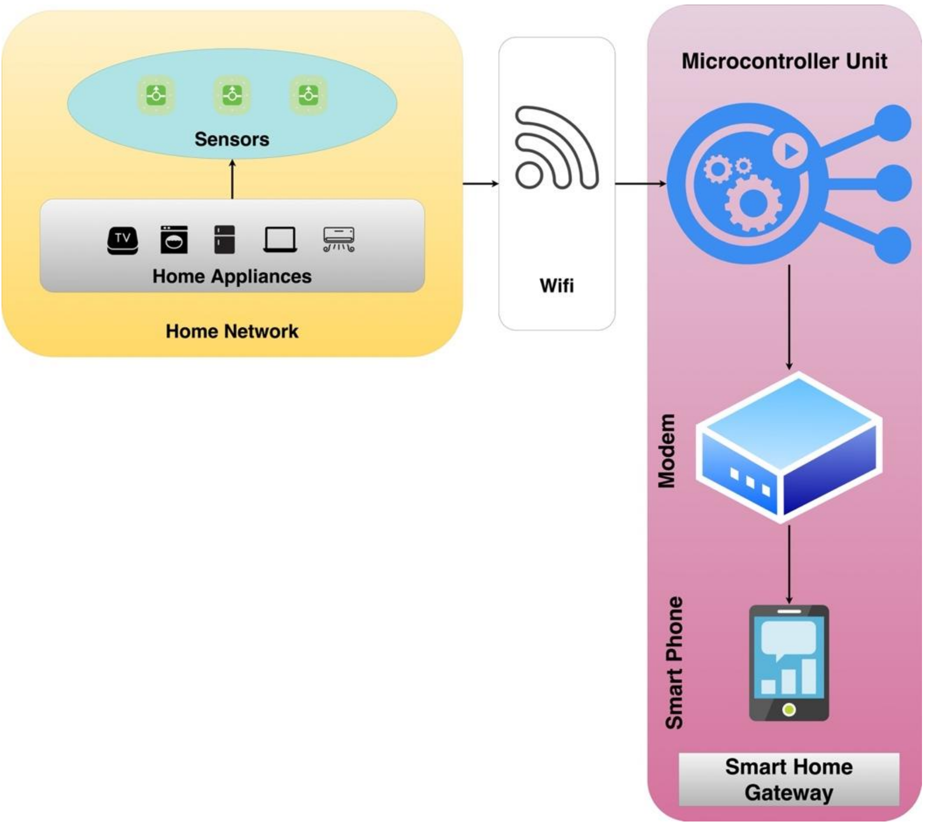

Figure 1: Proposed Model of Smart Home Energy Management System

The proposed architecture for powering home appliances depends heavily on the utilization of motion detectors and remote actuators as its primary support structures. In addition, the device is able to determine whether or not a resident is present in the home and active, whether a resident is present in the home but not active, or whether a resident is present in the home but not present. It can also determine whether or not a resident is present but not present (Away). The operation of the devices might be based on a pre-defined cycle for each state, and their operation would depend on the state that was identified for the household. The task of defining the condition of the house among the previously described states can be eliminated when the activity that takes place within the house and the logical state of the main entrance are both monitored.

The framework depicted in Fig. 1 is crucial to the functioning of the proposed system. As a result, it serves as the gateway to the system's actual cosmos in its entirety. In this system, an adaptive algorithm is built to operate continuously in order to invoke planned care for the appliances. This algorithm is triggered by the activity actions of the people living in the home. Tracking and monitoring the end-appliance systems for all of the sensing units in the home is impossible without the smart home gateway. Therefore, utilizing the Wi-Fi device, the smart home gateway is configured to track and manage all sensors and devices via the nearby Wi-Fi network. This is accomplished through the utilization of the Wi-Fi network. In addition, the router is utilized to provide a link between the occupants even when they are not inside the house for the purposes of conducting surveillance and exercising control.

Implementing the home management system improves energy efficiency without requiring the installation of expensive appliances or interfering with resident participation. In many other states, the classic national grid is already in place without the ability to monitor the home appliances of the user. This study's approach attempts to provide an efficient mechanism for incorporating an adaptive method to conserve resources. The device was constructed with the most advanced and cost-effective technology and simple architecture. The proposed method gives input on home equipment so that tenants can monitor the property from anywhere. Therefore, they feel better as a result. The recommended method might be modified to identify security issues within the home while the residents are absent. However, this function may be viewed as a potential task for the suggested system.

The DELM method was used for the occupancy data set; the findings of this analysis are presented in Table 1, where they may be viewed. After making a comparison between the predicted output and the result that was obtained after applying the suggested strategy, Table 1 demonstrates that the outcome of our proposed approach delivers an accuracy of 98.8% and a miss rate of 1.4% while being trained.

Out of the whole dataset, we use 30 percent of the data, or 14352 samples, for testing and validation. When compared to the anticipated outcome and the actual result obtained by putting the suggested strategy into practice, the findings are presented in Table 1. In addition, the suggested method achieves an accuracy of 94.8% during testing and validation, while the percentage of missed opportunities is 5.2% as shown in Table 3. The RMSE for the suggested DELM system is 2.61, which is a lower value than that of the earlier suggested technique when compared to accuracy. The results of the statistical tests point to the DELM technique having a performance that is significantly superior to that of the other methods.

3 RESULTS:

The deep extreme learning machine method has been implemented to the dataset [36] in the article that has been proposed, and the MATLAB tool has been utilized to do simulations in this respect. A python script was built in MATLAB so that it could be used to train data.

Table 1: Effectiveness of the suggested method during training and testing for predicting smart home energy output

	Training	**Testing**
Accuracy (%)	98.8%	94.8
Miss Rate (%)	1.2%	5.2%

The datasets in this study were trained and fitted using DELM. There were 47840 different sets of information. This dataset is randomly divided into 70% for training, which consists of 33488 instances, and 30% for validation and testing, which utilizes the remaining data (14352 samples). The information was processed in the past in order to eliminate data anomalies and make the data error-free. DELM has been working on locating the optimal configuration model for the purpose of predicting the energy output of smart homes. In this study, we put the suggested DELM for forecasting through its paces in order to conduct an accurate test of the efficacy of this method. We made use of a variety of statistical indicators in order to compare the efficiency of this DELM method with that of its counterpart methods.

Table 2: Comparison with literature

Method	RMSE
ANN [37]	47
GA base Multilayer Perceptron [30]	4.874
Regression ANN Model [29]	4.23
K-Means + ANN [38]	3.93
Proposed DELM	2.61

4 CONCLUSIONS:

All aspects of a smart house can be monitored by remote devices such as computers and mobile phones. To adjust the temperature or turn on the lights, there is no longer a need to rush. With the security system installed, you can turn on lights both inside and outside, close or open window coverings, and turn on or off entertainment devices. In addition, when you are on the road or at the office, you may view both the interior and exterior of your home. If you drive, your lighting gadget will behave as if everyone is home when you are away. You will automatically send notifications for motion, smoke, and water leaks. A smart home eliminates the need to consider why you closed the door or what your children are doing at home. You are able to see these details and modify settings from any location. With a smart home, you will have greater control, which increases your comfort. The controls for your heating, ventilation, power and yard watering systems are simply accessible from any location. This will save you money on your electricity costs.

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