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Smart Home Automation Using Intelligent Electricity Dispatch

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ABSTRACT The evolution of technology has increased the consumption of electric power locally and globally which lead to a dramatic increase in demand for electric power. Electricity consumption rate in different forms at home and commercially increased. Sometimes, it affects household appliances due to the raised demands based on conditions of load shedding, electricity shortfall, and emergencies. It includes sudden electricity breakdown due to heavy rainfall or storm. This study investigates the adaptation of an optimal solution for the usage of energy to meet a revolutionary change. A technique is proposed that will address the issues regarding electric power shortfall and emergencies caused by the sudden breakthrough of electricity. The proposed technique automates the appliances in three main ways, a) locally automation, b) web-based, c) app-based automation. Using a microcontroller, appliances are locally controlled. By using a web page or application, the appliances are controlled remotely. This work helps in saving energy by automatic or manual switching of appliances on and off according to need through the web or apps. Experimental results show that the average accuracy of the system for local scenarios is 88.71, for web-based scenarios is 88.55 and for app-based is 88.56 respectively. It also handles emergency situations by calculating the load and perform smart switching, so that devices may remain safe even in abnormal situations like low or high voltages.

INDEX TERMS App-based automation, automation, electricity dispatcher, electricity shortfall, local-automation, web-based automation.

I. INTRODUCTION

The technology is evolving with the passage of time and making humans lives more dependent on it. The basic needs like water, food, and shelter with other resources like power, oil, gas etc, are also indirectly becoming our necessities. Without these resources, it seems impossible to carry out our daily tasks. The severity level of this can be seen in the case of their shortfall. Like, if a country is facing a shortfall of electricity the activities of life will stick as form the small led light to heavy machines are working due to electricity. If it isn't provided properly then many issues may arise, and the country will fall in heavy crises. So, as we may have the idea that, how dependent we are on these resources, we need to save these resources by proposing and implementing such solutions that may save them.

In this paper, we have focused on the problem of electricity shortfall and proposed a model which will help to reduce energy consumption for home, office or any desired place. The electricity grid becomes unbalanced when there is insufficient power plant capacity to supply the demand (load) from all the customers, which can cause it to go out country-wide (a blackout), and which may take days to recover, its called the electricity shortfall [1]. Studies show that in the last few

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years, consumption of energy has increased to double therefore, the world is having heft challenges in the power sector. Globally gross final consumption of electricity reached 22,315 Terawatt Hours (TWh), in 2018, which is 4.0 percent higher than in 2017. Total final electricity consumption in the organization for Economic Cooperation and Development (OECD) was 9,728 TWh in 2018 and it is 1.8 percent higher than in 2017, While the final energy consumption was 12,587 TWh in non-OECD countries, which is 5.7 percent from 2017 [2].

Now a days, it's being generally accepted that the dramatic rise in demand and supply of energy would eventually lead to a global energy crisis, resulting in a catastrophic effect not just on the global economic development and environment, but also on social & political consequences. The huge surge of energy has encouraged many researchers to put the combined effort in order to closely investigate and create technology-based solutions for optimal electric power consumption. Due to inadequate electricity issues, there is a need to develop a system that uses various appliances effectively and efficiently while keeping the cost of electricity minimum. This research is compromised of the automated smart and cost-efficient in terms of electricity consumption, a model which will provide better energy management and conservation. In our technique, we have designed a system which consists of hardware and software part. Hardware is comprised of microcontroller which is connected to sensors switches and relays and appliances can be controlled under given conditions. Software based part is comprised of webpages which control switching of appliances through cloud server. Also, our proposed system is intelligent enough to make smart decisions in emergency situations i.e., when the voltages are high and low, it will calculate the voltages and perform the action. This will save the appliances from damage often in stormy & thunder conditions and sometimes when voltages go down due to some technical issues. It's a whole package that will overcome the issues of the existing solutions.

The paper is structured as follows. Section II provides literature review of relevant papers in the domain electricity dispatch. Section III presents the architecture of proposed system and illustration of each part of the system. Section IV gives the experimental details of the proposed system. Results and discussion is provided in Section V. The last section provides conclusion of the proposed work and future directions.

II. LITERATURE REVIEW

The dispatch model was associated with various power structures, like cooling, heating, electrical energy, response on any desired request. This model [3] was composed of an orderly manner prototype. Similarly, the structure had many substructures, like calculation of risk factors, the response, which was demanded, power plants that existed virtually, knowing the situation conditions and optimization. In this dispatch model, every sub-structure interacted with one another to get the desired results. With the help of this case study clearly, we could get the improved and integrated renewable power from response which was demanded. This paper [4] is about the smart home problem, regarding the power dispatched the system. The technique used here was to convert domestic loads into 3 major groups on the basis of controllability. These three groups were the divided generation model, a small-scale wind rotatory engine, and the photovoltaic structure in the aimed model. Minimal time, which is allotted to every load, can be extracted from the prescribed load power control strategy. From the proposed algorithm performance of the battery is also improved. Apart from the above-mentioned advantage, another advantage of demanded power is that the loss and expense of transmission are decreased. Results from the proposed model meet the requirements of demanded requirements, and the overall performance of the model increases.

In [5], the aim of the technique was to quantitate the performance of household demanded forecast by the impact of integrated electric power measurement. State of the art is used for the measurement purpose, as a tool of the forecast. The tool used the integrated data, got from sensors in an automated home or smart home, to valuate home level demanded forecasting. Results are based on three main categories. Category one contains performance relation of prediction based on machine learning with a continuous prediction. The next category was the advancement of prediction around (4 to 33 %). This percentage is got by a relation of prediction depending on integrated data acquired from smart, automated home sensors along with persistence and smart-meter benchmarks. Last category was analyzing sensitivity according to time resolution information. This research [6] was about the problem of a smart home regarding energy management. Here the three types of load characteristics were investigated. The first was interruptible, the next was uninterruptible and the last one was time-varying. These types were the utility grid of a dynamical electricity cost, photovoltaic modules, and house holding appliances. Model results show that overall electricity cost was minimized. Also, the HEMS model delivers optimum scheduling performance in financial and lead to the effective user's comfort level aspect.

In a smart home, integrated solar energy and the stored energy resources were implemented as an embedded system [7]. The control algorithm was proposed that efficiently managed both desegregated energy resources and energy get from the power structure. This was done for the reason of minimizing the grid power price at the initial level like individual homes. So, the aimed model is required to minimize the user's electricity price specifically. The load dispatch curve is generated from a method by load dispatch. This curve [8] is the response of dispatched resources and the forecasted rebound effect information. Based on the load dispatched curve, the method recognized the main time period, from which we can supply the curve information and produced resultant load dispatched scheduling. This resultant load dispatched scheduling is transferred to the smart house-holds meters to bring out the best economic advantage. Paper deals with grid interconnected household energy systems. The research [9] includes fuel cells that unite the heat & power. Also, it has a battery as an ESS (i.e., energy storage system). The scheduling algorithm model is developed for the management of different origins. For determining optimal process scheduling, effective look-up tables were generated to minimize the whole operation process cost (for the smart house). To optimize the operation process scheduling, electricity bills and an effective energy storage system were considered.

In [10], a system based on Arduino (UNO R3) and with front end framework of j. Net named jubito were used. The main work of this research was to build a low-cost household automation structure. The whole scenario of this work was automatically switching the light to turn on and off according to the condition. Doors of the smart home turn to open and close according to the situation by using the servo motors. This automatic household model was accessed locally or internet-based; the name of this system was HOMION. For testing purposes, the model was carried out on a household prototype. The authors proposed a context to the smart household, compromising, and low budgeted answers to the battery power management [11]. Basic focus of the trained model was to make smart conclusions, also advanced the training cognition. In this research, two perspectives of the trained model were used. The first was to specify user actions. At the same time, the second was for achieving the load equalizer according to each user's need to use different categorized appliances. Here the main control unit depended upon the SEEHEIM structure. For the user front end, a web-based application, in terms of client-server, was developed. To show the notification smartphone application was trained, based on android. The app gave control, continuous check, configurations, and notification about the sensors connected to each appliance. With the help of AI algorithms, adaptive behavior evaluation in percentage of this research was possible i.e., FL (79% accuracy) & SVM (71% accuracy).

The work in [12] contained material of remotely access to the appliances for a smart household. System worked in two ways for controlling the home widgets. The first way was to ensure that appliances worked fine by using voice to text SMS. And the second way was using the smart phone, for accessing as remote-control access. This research was useful for old people or handicapped ones. Also, it could be used for people who cannot write an SMS. In smart households, this paper gave an idea regarding smart agents' structure [13]. These agents used their small power and produced a solution that has a larger impact on optimizing the appliances and their scheduling. For the scheduling purpose, the architecture of smart agents needs to know the space to give decisive results and schedule widgets across their individual restrain. Few restrictions could be done by owner, like automatic washer timeline could be set by owner or charging/discharging of electric appliances could be set by the owner as well. These types of constraints do not need smart agent to do these types of tasks.

Nevertheless, many of the widgets are subjected to physical restraints, like the washer is a non-interruptible appliance; similarly, the prototype of decision space is non-trivial. This work aimed to get this model using raspberry pi for smart automated households, the web address was accessed, and appliances were controlled. The algorithm used in this work [14] contains a python environment for programming, in raspberry pi by default, for graphical user interface algorithm used PHP or HTML platform. Implemented results prove the efficiency of the proposed model. Research contains user-friendly effective energy control of household widgets and connectivity of web by the internet of things. Interconnected appliances and the interface get from hard & soft of whole model is reached by the help of raspberry pi. By Ethernet port platform of raspberry pi gave knowledge of three main technologies i.e., Python, Linux, HTML. Automated household is the smart house where we want to get control over the house appliances from anyplace. On a commercial level many smart products were available, by which we could get the access control to these products over the internet very easily. Major problem with these products had security shortfall.

According to this paper [15], smart phones were the solution to efficient and secure remote control access. As smart phones had become a vital element in the life of a civilian. For making the home act as a smart one, the research introduced a new structure. Your mobile phone is connected with the house appliances to give the advantage of communication and remote access control of household widgets. In this research paper [16], the model was for smart homes. This work was composed of two factors; one is household automatic model, and the other is different methods. Both of these factors reveal the configuration of a device state. But in terms of input from client devices at the server side, both factors did not limit receiving inputs. In the database configuration of device state at server side along with input and configuration of device state from the server to the client device is send and received as input [17]. In [18], smart household energy maintenance by machine learning as well as HEMS-IOT system was used. For smart home safety and reliability energy optimization, the Rule-ML and Apache driver was used. For validation, purpose experimentation was performed to ensure the reliability and safety of the smart household.

From every corner of the world, household appliances can be controlled in the proposed smart efficient energy house automation [19]. For instance, the main supply control unit was connected to the internet connectivity module for getting the internet connection. The use of static IP addresses was made through wireless connectivity. A multimodal app operates for making home automation more intelligent and secure. It was done from Google Assistant by using the command of voice recognition.

Using the Arduino microcontroller, an affordable and user-friendly home automation structure was built [20]. With that board, the Ultrasonic module, moisture module, Bluetooth sensor, and smartphone were connected. In this structure, smartphone applications have been made so that the use of Bluetooth devices has controlled up to eighteen devices.

More features have been found in the proposed system as compared to the convolutional home automation models. In this structure use of moisture, the module was for plant irrigation automation system, and the use of Ultrasonic module is for detecting the water level.

For smart home automation, another complete design of internet of things based on supervising model was proposed in [21]. This proposed structure comprised of three parts. First was collecting the data, which was done by the EmonCMS platform. The second was monitoring the supervised data. The last one was controlling the households through remote. NodeMCU microcontroller was connected inside the house, allowing real-time data reading, data monitoring, and download/upload to/from EmonCMS cloud server.

Many devices have been controlled by the integration of rule base event processing, cloud computing, and the internet of things [22]. In this work, different households have been considered for the review. These house gadgets were cameras used for surveillance, Smart televisions, prevention models, ACs, fans, doors, Light structures, gas systems, and humidity structures. For smart home automation, the above-mentioned gadgets perform abruptly in the absence of the internet of things. According to the case study, IOT usage gives an effective and efficient system in terms of the home automation system.

In [23], the GJK algorithm was proposed in order to avoid obstacles for redundant manipulators. The procedure was done by calculating the distance between the manipulator and the obstacle. Two referenced trajectories solve the trajectory tracking problem in a redundant manipulator. The first was a hypotrochoid and the second was an arbitrarily shaped hurdle, i.e., character M. Results showed that the proposed ZNNBAS was able to track down the reference route and pass the obstacle successfully.

The comprehensive review of literature shows that there is a need to propose a system that solve required problems with improved system performance.

III. PROPOSED SYSTEM

This section includes the structure of proposed technique for constructing a household automatic system. This system is the combination of software and hardware based technologies. In our proposed model, we have focused on power consumption problems. Electricity Dispatcher for home automation is the proposed solution for most of the electric power consumption problems. This proposed system consists of three automated techniques web-based, app-based, and locally. The implementation of this model has included the Arduino Uno along with sensor, switches, and relay modules. For research we have focused on four appliances Bulb, Fan, Ac & electric heater, which are being observed under defined conditions and by three ways i.e., locally, web and app-based they are being controlled. In the local case, Arduino Uno is programmed in such a way that it will take the results from the sensor then after processing the response is being generated so relay module and switches will perform their actions accordingly to break or restore the circuit. In web and app-based cases the circuit consists of Arduino, relay, and NodeMCU connected to appliances.

One can connect to the app or web page make the request to on or off the device according to need this request is sent to the server where it will be processed, and defined action will be performed. In the following cases local, web or app the priority is given to the app and web-based modules, i.e., lets say a person is present in the room light will be switched on due to the presence of that person as sensor will detect the presence and in response light will be switched on which is based on the condition of the local system but if he/she does not want that light to be switched on, he/she will do it by using app or web page. Light will be remain turned off as priority will be given to the web & app case. Details of these techniques have been presented in the following sections A, B and C given below. Our model works according to the two main situations normal, and emergency, mentioned in Figure 1.

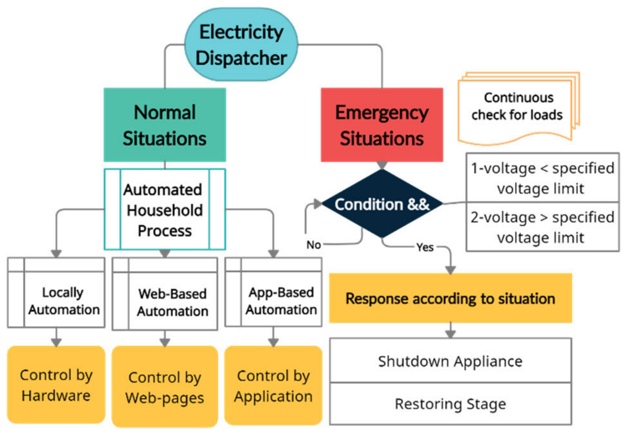

FIGURE 1. Working model of electricity dispatcher.

In electricity dispatcher model under normal situation the appliances of smart household are controlled in three ways.

A. LOCAL AUTOMATION

The first method is named local automation. In local automation, the proposed system will act smartly and make decisions on its own under the given conditions based on the sensor's response. Sensors will be attached with a microcontroller, and specific conditions will be applied to switch appliances automatically. In this technique, we have established the hardware part consist of D6T mems thermal sensor, relay module, switches, Arduino. D6T sensor is used to detect the human presence and also used for temperature calculations. These calculations are useful for switching the appliances according to given conditions, like if the person is present in the room devices, i.e., lights will be switched on automatically, and Also, the temperature indication feature is useful for the switching of air conditioner and electric heater according to the given condition. As if the person is present and temperature is high then the normal temperature of room mentioned in the code, appliances like fan/Ac will be turned on and in contrast if the temperature of the room is lower than the normal temperature, heater will be turned on automatically. But if there is nobody present in the room, the devices will automatically be switched off.

B. WEB-BASED AUTOMATION

The second method for controlling the gadgets smartly is web-based automation. Web-based module will operate on user commands if user want to switch on or off appliances from anywhere, he/she can do it by accessing web pages. Web-pages will be deployed on server and integrated with the hardware part i.e., microcontroller. The hardware contains the Arduino Shields, Relays, Switches, Electric Appliances, Server and Mobile phone. Webpages are deployed on server and user will send command to the server through webpages then server will send the request to microcontroller which will process it and perform the action in form of turning load on or off. Figure 2 shows the working model of web-based automation.

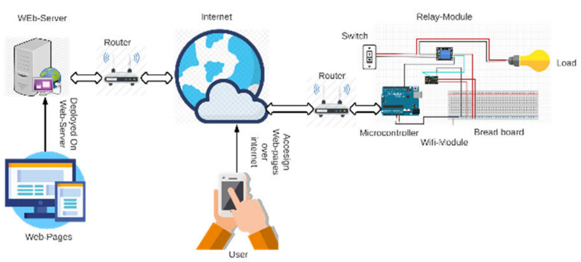

FIGURE 2. Working model of web-based automation.

C. APP-BASED AUTOMATION

The third one is app-based automation. In this module, app is connected with a Blynk server via the internet. App server will communicate to the local router, which will act as a bridge between hardware setup consist of NodeMCU esp8266 and the app. App interface consists of buttons and pins connected to NodeMCU, giving users options to turn off or on the widget according to his/her desires. When NodeMCU is connected with the internet and power supply, the app will automatically connect with NodeMCU. When we click on the button of the app to turn on the device, NodeMCU will get a command from the server and turn on/off the device. App-based automation is presented for the convenience of the user, whether a user wants to use web or app-based automation. Working module by app is elaborated in Figure 3.

Our proposed model also performs another task. In an emergency state, our proposed system will behave intelligently and perform switching on its own. In this situation continuous check is being carried out to detect the work load of appliances. According to the emergency situation like mentioned in Figure 1, the response is built, and appliances will be shut down. In order to save appliances during critical situations i.e., very low or high voltages in homes, our

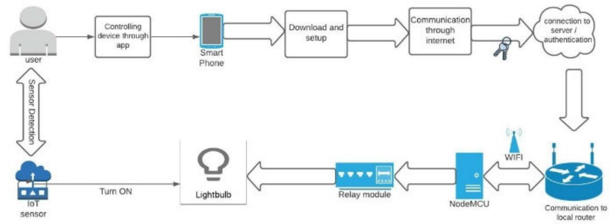

FIGURE 3. Working model of app-based automation.

proposed technique helps the appliances to be switched off and emergency light to switch on. This is done with the help of a voltage sensor module. As the voltage sensor calculates the voltages and if the voltage exceeds or decreases from the mentioned limit, it will send the circuit breaker to trip the appliances. When the voltage goes up or down the short circuit occurs, as current is normally very high or very low during these types of situations. By the help of voltage sensor, the Arduino receive the value and then it will compare it with our threshold value, comparison will be done on run time for making a proper decision, in order to save the appliances. After that if voltages are back to normal, then restoring/reclosing stage command is executed so that the circuit breaker could return back to normal work mode [24]. This mentioned technique will be effective in situations like sudden electric breakdown, storm, and other disasters that cause electricity to fluctuate and bring severe damage to appliances for which the user faces loss. Our system has addressed it and comes up with the solution to solve it effectively and efficiently.

Our proposed model required a server. We have made our machine a webserver by installing the Ubuntu server in a virtual box, and after that Apache is installed on that Ubuntu server. Figure 4 depicts the successful running of Ubuntu server 20.04.

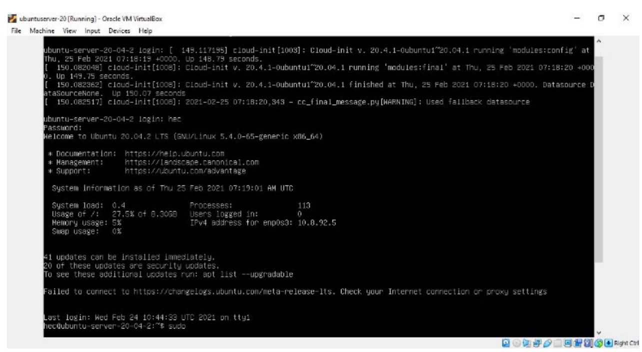

FIGURE 4. Login interface of Ubuntu server-20.04.

In electricity dispatcher module, the workflow of server side is explained in Figure 5. The server loads pages from web page of our model and turn on microcontroller i.e., Arduino shield connected to it. The embedded controller turns on the sensors and check the switching condition. Sensors like D6T sensor or infrared detects the light intensity and the

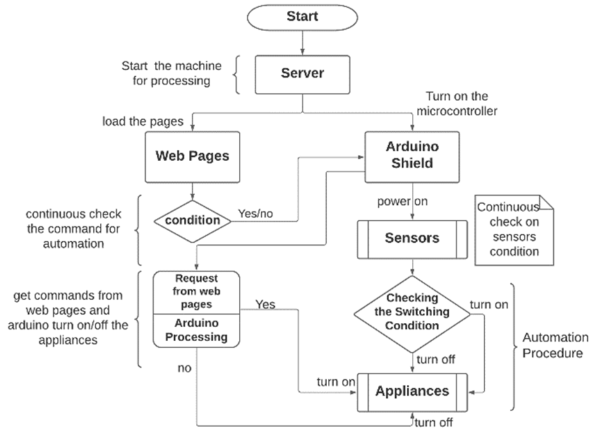

FIGURE 5. Workflow at server side in electricity dispatcher model.

switching condition is made according to those results get from sensor i.e., choose the appliances to turn on or off. On the other side if user command for appliances to turn on or off web pages, the request from web pages is send to the microcontroller. After the request made by web pages the Arduino shield process it and make response according to the request made. Like if request of turning off/on the lights are made, the controller command to turn on that type of appliance. Similarly, if the request of fan or specific switch is made, the controller also gives command to turn on switch or that type of appliance specifically.

IV. EXPERIMENTAL SETUPS

The hardware part of our research includes three major sensors and one microcontroller. These are D6T MEMS Thermal sensor, Voltage sensor module, Relay module, and Arduino Uno as microcontroller. Following TABLE 1, TABLE 2, TABLE 3 and TABLE 4 show the specifications of each sensor.

TABLE 1. Arduino Uno microcontroller specifications.

Parameters	Specification Details
Microcontroller	8-bit AVR family microcontroller
Operating Voltage	5V
Recommended Input Voltage	7-12V
Input Voltage Limits	6-20V
Analog Input Pins	6 (A0 – A5)
Digital I/O Pins	14 (Out of which 6 provide PWM output)
DC Current on I/O Pins	40 mA
DC Current on 3.3V Pin	50 mA
Flash Memory	32 KB (0.5 KB is used for Bootloader)
SRAM	2 KB
EEPROM	1 KB

V. RESULT AND DISCUSSION

We have expected flexible, cost-efficient, user-friendly and competent results from the proposed structure. The testing of the model has been done via the help of different procedures across the functioning of appliances. Its relation and conditions are shown in Table 5. Here in local automation

TABLE 2. D6T MEMS Thermal sensor specifications.

Parameters	Specification Details
Power supply voltage	4.5 to 5.5 VDC
Storage temp range	−20 to 80°C
Operating temp range	0 to 60°C
Storage humidity range	95% max.

TABLE 3. Voltage sensor specifications.

Specification Details
Input Voltage range 0 to 25V
Voltage Detection Range 0.02445 to 25
Analog Voltage Resolution: 0.00489V
Needs no external components
Easy to use with Microcontrollers
Small, cheap and easily available

TABLE 4. Relay module specifications.

Specification Details
5V 4-Channel Relay interface board
Requires 15-20mA signal drive Current
TTL logic compatible
High current AC250V/10A, DC30V/10A relay
Status LED
Equipped with 3.1mm screw holes for easy installation
Weight: 61g
Dimensions: 75 x 55 x 19.3mm (2.95 x 2.16 x 0.76″)

for bulb light turning on/off main condition is to find the intensity of light by the help of D6T mems thermal sensor. Then according to the presence of a human in a room, the bulb and fan is turned on or off. Similarly, for the switch which is connected to AC & heater, thermal sensor along with the presence of person also detects the temperature fluctuation from normal temperature. D6T mems thermal sensor sense temperature and presence of person, directs Arduino shield. Then microcontroller turns on/off the relay to either complete the circuit or break the circuit. In web-based automation all the commands are conducted through Arduino Shield. When microcontroller receives its web pages request, it performs automation just like local automation does. The request is made as similar to the web pages in app-based automation, Arduino shield receive and process request then perform action like done in local automation.

In Table 5, responses of different appliances are shown. In Local, web base or app-based automation, bulb, fan or circuit switch is controlled with the help of D6T mems thermal senor. A sensor is called a thermal sensor because it can detect the change in temperature of environment. The main work of this sensor is to detect the slightest change in temperature. It gives output in different pixel valued temperatures. Here we use an 8-pixel temperature valued thermal sensor for giving us accurate results about human presence. By sensing the

TABLE 5. D6T MEMS Thermal sensor specifications.

Exp. #	Automation ways	Response of Appliances								Pass / Fail
		Bulb		Fan		Circuit Switch				
						Air conditioner On/Off		Electric Heater On/Off		
		On	Off	On	Off					
01	Locally automation	Turn on bulb if human detected	Turn off bulb if no human detected	Turn on fan if human detected	Turn off fan if no human detected	AC is on If temperature is above limit	AC is off If temperature is below limit	Heater is on If temperature is below limit	Heater is off If temperature is above limit	✓
02	Web based automation	Turn on bulb If web page request	Turn off bulb If web page request	Turn on fan If web page request	Turn off fan If web page request	Turn on AC If web page request	Turn off AC If web page request	Turn on heater If web page request	Turn off heater If web page request	✓
03	App based automation	Turn on bulb If app request	Turn off bulb If app request	Turn on fan If app request	Turn off fan If app request	Turn on AC If app request	Turn off AC If app request	Turn on heater If app request	Turn off heater If app request	✓

TABLE 6. Test of bulb automation across different scenarios.

For bulb Case Experiments #	Locally			Web based			App based		
	Time span 0.1-0.4 sec	Time span 0.5-1.4 sec	Time span 1.5-2.5 sec	Time span 0.1-0.4 sec	Time span 0.5-1.4 sec	Time span 1.5-2.5 sec	Time span 0.1-0.4 sec	Time span 0.5-1.4 sec	Time span 1.5-2.5 sec
1	93.33	86.35	85.87	92.78	87.44	84.35	90.44	88.30	83.35
2	96.98	86.87	84.81	93.98	88.74	85.09	92.67	85.98	80.89
3	94.67	89.67	82.23	96.87	87.60	83.40	91.09	85.42	85.35
4	91.67	87.39	81.40	95.22	89.11	82.30	93.21	86.56	84.39
5	93.67	88.79	80.91	91.92	89.90	81.50	94.55	87.49	84.49
6	92.67	86.99	85.55	90.99	88.83	81.38	93.57	89.30	82.43
7	91.33	88.29	84.38	94.32	90.01	80.10	90.87	86.24	81.49
8	96.35	86.79	82.84	96.33	89.79	80.93	94.81	90.05	83.99
9	97.31	89.33	83.54	97.33	86.68	80.87	93.98	87.89	84.87
10	95.67	90.10	83.51	95.67	87.79	80.57	95.01	88.79	85.76

change in human body temperature, the thermal sensor can easily detect human presence. This thermal sensor is able to detect both stationary and moving human bodies on the bases of thermal change. It helps in switching on or off of appliances like bulbs, fans, or circuit switches. For the bulb and fan type appliance, the thermal sensor gives results to the microcontroller like Arduino. If these appliances need to turn on the Arduino, turn on the relay module which completes the circuit to turn on the bulb or fan Similarly if the appliances need to turn off the Arduino, turn the relay module off so that the circuit remains incomplete and the appliance will be off For circuit switch type appliance, either the Air conditioner or the electric heater is connected at the same time to the circuit switch. The same procedure is followed by the thermal sensor in the switch circuit, for detecting the minor change in temperature. For AC, if the temperature detected is above the limit it will be turned on. Similarly, if the temperature is below the limit, then AC will be off. For the heater if the temperature detected is below the limit, it will be turned on. Similarly, if the temperature is above the limit, it will be off [25].

Below is Equation (1), and by using this equation Table 6, Table 7, and Table 8 are being generated. Table 6 shows the number of experiments performed to turn off or on the blub in three used case scenarios. In each scenario, we get the response of D6T mems thermal senor in three-time spans as mentioned in Table 7 for the time span of 0.1-0.4 seconds, the accuracies are in a range of 90-98 %. For the time span of 0.5-1.4 seconds, the accuracies are in a range of 85-91 %. For the time span of 1.5-2.5 seconds, the accuracies are in a range of 80-85 %.

$$\text{Accuracy Detection (AD)} = \left(\frac{\text{Appliance accurately controlled}}{\text{Total performed experiments}}\right) * 100 \quad (1)$$

Similarly, Table 8 represents experimentation performed for turning off or turning on the fan by three methods. One is called local, the second is called web based, and the third is called app-based. Accuracies of fan case is similar to bulb.

Table 8 presents different experimentation for controlling switch cases in local automation, web-based automation, and app-based automation. As compared to bulb or fan case accuracy value achieved for switch circuit case is less.

The accuracy value of switch case drops because in this case both the conditions i.e., presence of person and temperature has to be checked. The action of the relay module is dependent on response given by thermal sensor in the all

TABLE 7. Test of fan automation across different scenarios.

For Fan Case Experiments #	Locally			Web based			App based		
	Time span 0.1-0.4 sec	Time span 0.5-1.4 sec	Time span 1.5-2.5 sec	Time span 0.1-0.4 sec	Time span 0.5-1.4 sec	Time span 1.5-2.5 sec	Time span 0.1-0.4 sec	Time span 0.5-1.4 sec	Time span 1.5-2.5 sec
1	92.99	86.4	82.58	97.28	86.76	80.87	94.55	90.34	85.33
2	95.68	86.87	83.48	91.98	87.78	81.12	96.7	88.59	84.77
3	95.76	89.51	81.22	96.67	89.67	84.4	96.19	84.52	83.55
4	92.17	90.12	80.14	92.52	90.76	83.3	92.13	86.16	83.94
5	92.11	87.09	81.91	91.29	89.95	82.59	90.45	89.34	84.23
6	93.01	89.91	85.05	91.09	87.33	83.81	95.73	87.45	84.32
7	94.91	86.29	85.43	92.42	86.32	81.87	97.12	86.01	84.91
8	96.79	86.73	80.84	93.6	87.19	84.91	94.14	89.05	83.75
9	97.76	88.35	85.54	95.73	88.68	85.09	93.98	87.8	85.8
10	95.98	87.01	81.35	96.75	90.11	84.57	91.56	87.98	86.45

TABLE 8. Test of switch case automation across different scenarios.

For switch Case Experiments #	Locally			Web based			App based		
	Time span 0.1-0.4 sec	Time span 0.5-1.4 sec	Time span 1.5-2.5 sec	Time span 0.1-0.4 sec	Time span 0.5-1.4 sec	Time span 1.5-2.5 sec	Time span 0.1-0.4 sec	Time span 0.5-1.4 sec	Time span 1.5-2.5 sec
1	92.33	85.35	84.87	91.78	86.44	83.35	89.44	87.30	82.35
2	95.98	85.87	83.81	92.98	87.74	84.09	91.67	84.98	79.89
3	93.67	88.67	81.23	95.87	86.60	82.40	90.09	84.42	84.35
4	92.67	86.39	80.40	94.22	88.11	81.30	92.21	85.56	83.39
5	92.67	87.79	79.91	90.92	88.90	80.50	93.55	86.49	83.49
6	91.67	85.99	84.55	89.99	87.83	80.38	92.57	88.30	81.43
7	90.33	87.29	83.38	93.32	89.01	79.10	89.87	85.24	79.49
8	95.35	85.79	81.84	95.33	88.79	79.93	93.81	89.05	82.99
9	96.31	88.33	82.54	96.33	85.68	79.87	92.98	86.89	83.87
10	94.67	89.10	82.51	94.67	86.79	79.57	94.01	87.79	84.76

of the cases. As bulb or fan case uses only a single module while switch case uses the two modules therefor in Table 8, the accuracy value is less as compared to Table 6 and Table 7.

The bar chart of the controlling bulb is shown in Figure 6 vertically. The accuracy of controlling the bulb appliance in three ways is shown by this bar graph. Here the first one is local automation. The next one is Web-based automation and the last one is app-based automation. Each way is additionally distributed over the elapsed time. Each time domain is represented with a specified color. Percentage Accuracy of controlling a bulb is shown vertically in ten different cases across the numeric value as given below. Accuracy of controlling Fan appliance along with different experiment is shown in Figure 7 horizontally. Ten cases are shown in the diagram across the different spans of time. In each case controlling the fan, accuracy is shown below. Case 1, 2, and 3 are for controlling fans by local automation. Here case 1 shows the time span of 0.1-0.4 sec. Case 2 shows the time span of 0.5-1.4 sec. Case 3 shows the time span of 1.5-2.5 sec. Cases 4, 5, and 6 are for controlling fans by Web based Automation. Here case 4 shows the time span of 0.1-0.4 sec. Case 5 shows the time span of 0.5-1.4 sec. Case 6 shows the time span of 1.5-2.5 sec. Similarly, the case 7, 8 and 9 are for controlling fan by app based automation. Here case 7 shows the time span of 0.1-0.4 sec. Case 8 shows the time span of 0.5-1.4 sec. Case 9 shows

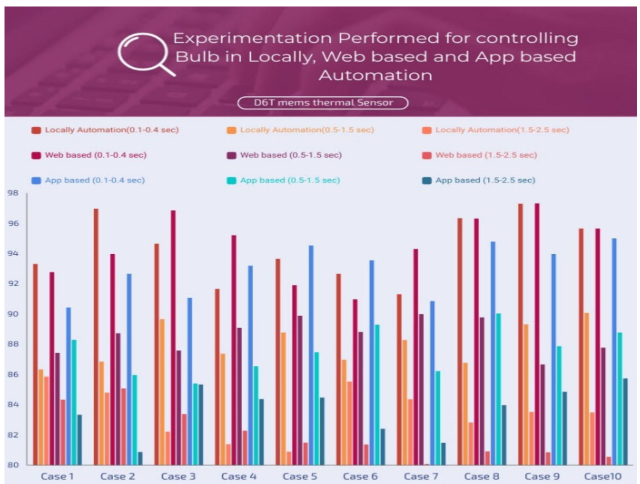

FIGURE 6. Result of achieved accuracy for the bulb scenario.

the time span of 1.5-2.5 sec. The accuracy of the fan controlled by local automation has 90 plus values, web based has 85 plus values, and the app-based has 80 plus values. In Figure 8 on vertical axis the accuracy of controlling switch circuit is shown. Here accuracy of three ways of automation is shown across different time spans. In fig 8 bar chart the localautomation is shown by orange color for every timespani.e. (0.1-0.4 sec, 0.5-1.4 sec, 1.5-2.5 sec). Web based

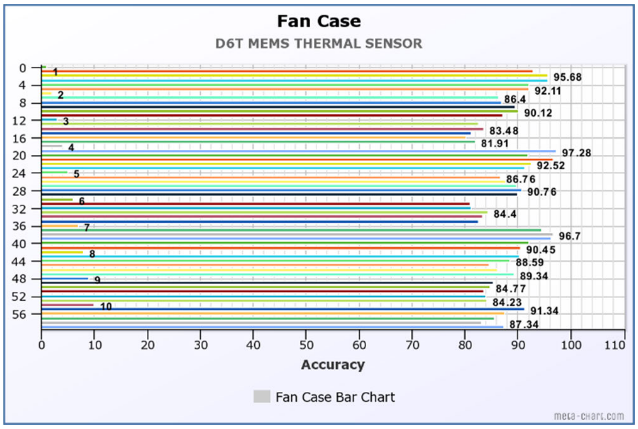

FIGURE 7. Result of achieved accuracy for the fan scenario.

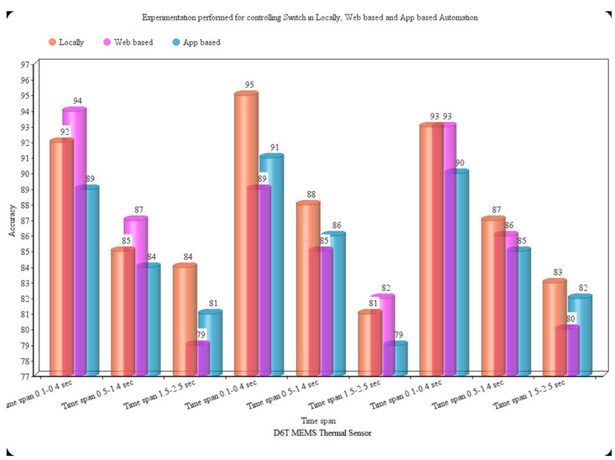

FIGURE 8. Result of achieved accuracy for the switch scenario.

automation is represented by violet color for every timespan i.e. (0.1-0.4 sec, 0.5-1.4 sec, 1.5-2.5 sec).

App-based automation is presented by blue color for every timespan (0.1-0.4 sec, 0.5-1.4 sec, 1.5-2.5 sec). The highest accuracy is achieved in the time span of 0.1-0.4 sec. And the lowest accuracy is achieved in the time span of 1.5-2.5 sec. For three different timespan, experiments have been performed repeatedly. And shown in the bar chart as below.

The total achieved accuracy of the electricity dispatcher model during each type of automation depends on the bulb, fan, and switch case scenario. On the basis of data gathered during implementation in different cases the efficiency of model is determined.

We have completed the circuit and perform the accuracy check against the various time spans, like already mentioned in Table 6, Table 7, Table 8. Now we have calculated the average of these accuracies. Assuming all the three cases of fan, bulb, and switch and in each case scenario average is taken by the number of experiments performed during the test. Like in the bulb case, three different timespans i.e., Timespan 0.1-0.4 sec, Timespan 0.5-1.4 sec, and Timespan 1.5-2.5 sec are merged to give the average accuracy output. Similar is

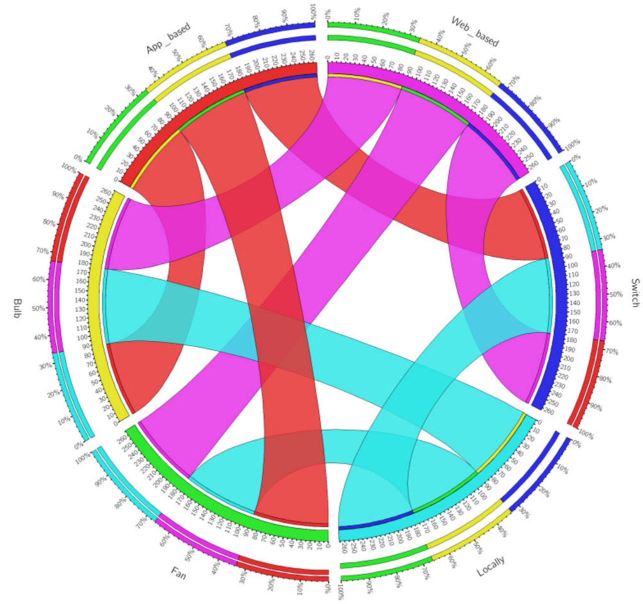

FIGURE 9. Accuracy of electricity dispatcher.

TABLE 9. Overall accuracy of electric dispatcher model.

Scanerio	Bulb (%)	Fan (%)	Switch (%)
Locally	88.64	88.43	88.71
Web based	88.39	88.55	87.39
App based	88.11	88.89	87.07

the case for fan and switch scenarios. According to Table 9, we have average accuracy for case bulb, fan, and switch against local scenario is 88.64, 88.43, and 88.71 respectively, for web-based scenario is 88.39, 88.55 and 87.39 and for app based is 88.11, 88.89, and 87.07. Table 9 shows the accuracy of each case scenario according to local, web-based, and app-based automation. Figure 9 depicts the circus graph. In which each scenario web-based, app-based, and local maps each of these three cases fan, bulb, and switch. This mapping represents their bond how much each case is performing under these scenarios. Here purple color represents a web-based scenario, red for app-based, and cyan for local.

VI. CONCLUSION

This research investigates the smart home automation using an intelligent electricity dispatch model. This study focuses intelligent automation in three different ways and making the automated household act smartly at the time of voltage distortion. The proposed methodology is beneficial for electricity saving as it overcomes electricity consumption, which is the main target to achieve as unwanted appliances will be automatically switched off according to given conditions. In addition, proposed technique provides convenient solutions to the user to switch devices from remotely. Users according to their requirements just one click to switch turn it on/off and not need to worry about the appliances at home or office.

Therefore, our proposed model provides ease and comfort to the user. It is cost-efficient in terms of electricity usage of hardware/software. The solution is effective and reliable as giving the real-time response. Furthermore, planning to address issues related to home automation and present its solution that temperature if exceeded the threshold will generate the alarm and put the heater off. Using voltage or other sensors for controlling loads in the drastic conditions. Based on this solution, more work can be done in the domain of emergency situations for future work and further extended for impact on the Internet of Things(IoT).

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