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IoT based Home Automation System with Pattern Recognition

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Abstract*: Automation has numerous applications. This paper proposes a home automations system which can be effectively used to control and monitor home appliances using the internet. Due to its various advantages, home automation is gaining more and more popularity day by day because of its ability to ensure security and make life much easier. In the system, arduino will be interfaced with multiple sensors that can measure temperature & humidity, light, motion, and so on. The data collected by the various sensors is stored and a pattern analysis is done on the stored data which tells the user at which time the appliances are usually on or off so that they can be automatically controlled without any human intervention by observing the regular usage pattern. The user can also turn on/off any appliance remotely using the internet.

***Index Terms*: Arduino, Home Automation, Internet of Things, Pattern Analysis, Sensors, Web Server**

I. INTRODUCTION

Internet of Things (IoT) is one of the most upcoming technologies which can be used for managing and controlling any object by connecting it to the internet [11]. IoT can be used in various applications of automation where automation is the process of operating or controlling various applications or equipment with less or no human intervention [17]. Automation can be categorized depending on their application such as industrial automation, building automation, home automation, etc. The complexity of life has significantly reduced with the advancement in automation technology. Everyday, manual systems are being replaced by automatic systems [2]. With the ever increasing internet users over the past few years, it has become a part of everyone's life [2]. IoT is the latest emerging internet technology. This project is about home automation using IoT. Home Automation is the name given to the process of controlling and monitoring home appliances using various methods such as SMS, E-mail, Bluetooth, World Wide Web, etc. Electronic appliances such as light, fan, and so on, can be controlled using different control techniques via interfacing them with a relay. The system uses a web server to control a few home functions or features using the internet from anywhere around the world [2]. This will not only save human energy, but also help in conserving electricity. This makes the residents life much organized. Arduino is used as the microcontroller board for interfacing with the sensors and the appliances. The ability of the project to monitor remotely can be used for control and safety by letting us know what is going on in different parts of the house [3]. For example, we can monitor the temperature or lights, get notified of any intruder trying to break in, and so on. Another massive advantage of this project is that it will help the differently abled and the aged in performing basic tasks at home.

II. LITERATURE REVIEW

Rozita Teymourzadeh, Ceng, Salah Addin Ahmed, Kok Wai Chan, and Mok Vee Hoong have made use of the Global System for Mobile communication (GSM) technology to control various home appliances via Short Message Service (SMS). Home owners will be notified whenever any appliance is switched on/off using the mobile [12]. Ana Marie. D Celebre, Ian Benedict A. Medina, Alec Zandrae D. Dubouzet, Adrian Neil M. Surposa, and Engr. Reggie C. Gustilo have made use of Apple's Siri's capability of speech recognition as a controlling method of the home appliances. Raspberry Pi is used for interfacing with the appliances and SiriProxy is installed on the Raspberry Pi as the proxy server [1]. The drawback in this is that the system is only available to Apple users. There is no application which enables android user to use this system. Sharon Panth and Mahesh Jivani are using Bluetooth technology in their project for controlling apliances such as lights, fans, etc using a relay. It has the capability of controlling one to twenty four different appliances in the household [14]. However, this system only works with android phones and also, since it uses bluetooth technology, the range for controlling the appliances is very limited. Sarthak Jain, Anant Vaibhav, and Lovely Goyal have designed a home automation system using Raspberry Pi through reading the subject of the e-mail. The algorithm used has been developed in python environment and LEDs are used to indicate switching actions [5]. To resolve a few problems in the above systems, wifi technology should be used for a much wider range of communication. A pattern analysis can also be performed on the data collected by the sensors. This will make the system much more energy efficient as it will have the ability to automatically switch on/off appliances based on regular usage pattern

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III. FEATURES OF ARDUINO MEGA 2560

This is a microcontroller board based on ATmega2560. It has 54 digital input/output pins, 4 serial ports, 16 analog pins, a 16 MHz crystal oscillator, a power jack, a USB connection, an ICSP header, and a reset button[16]. The power supply to the board can be provided using a USB cable, or by connecting a AC-to-DC adapter or using a bettery.

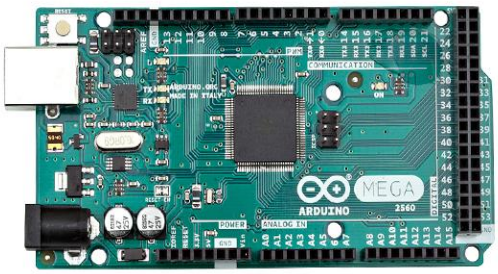

Fig. 1 Arduino Mega 2560 board

The programming on Mega 2560 can be done using the Arduino Software IDE. The board has 256 KB of flash memory for code storage, 4KB of EEPROM and 8KB of SRAM[16].

IV. PROPOSED SYSTEM ARCHITECTURE

The design for the proposed home automation system is given in Fig. 2. The system consists of different sensors like motion, temperature, and light and actuators such as buzzer, led, LCD display, etc.

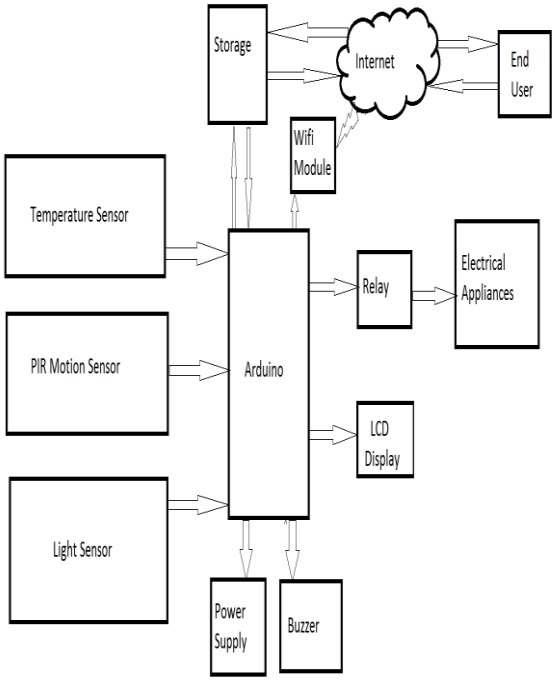

Fig. 2 System Architecture

A. *Hardware Components*

- Arduino Mega 2560 : It is a developer board based on ATmega2560 microcontroller [16]. It has memory for code storage and the coding can be done using Arduino software IDE.
- Wi-Fi module : The module used in this project is ESP8266. It has an integrated TCP/IP protocol stack that gives the Arduino mega 2560 microcontroller access to the wi-fi network. It also has storage capability.
- Temperature sensor : DHT11 is the sensor used in this project. It provides humidity and temperature details concurrently.
- PIR motion sensor : It is a digital sensor which provides a high output when motion is detected and a low output when no motion is sensed. It has a 120 degree detecting angle.
- Light sensor : The sensor used is an analog sensor which makes use of GL5528 photoresistor to observe the intensity of light.
- Relay : It is basically a digital switch that is used for switching voltages and currents [18]. The relay performs switching actions based on the input provided by the user.
- LCD RGB backlight : It is a colorful LCD display which uses I2C protocol to communicate with the microcontroller.
- Base shield V2 : A base shield helps the project look much cleaner and presentable by avoiding the use of jumper cables and bread board. It makes it much more convenient for us to connect multiple sensors with the microcontroller.
- Buzzer : It is a digital actuator which produces a sound whenever it detects a high output.

B. *Software Components*

- Arduino IDE : Arduino software IDE is used for conveniently writing the code and uploading it to the board. The software can be used with any Arduino board [19].
- Storage : All the data collected from various sensors will be stored so that they can be referenced at anytime and anywhere.
- Web server : A web server needs to be hosted to be used as a user interface for connecting to the home automation system and perform monitoring and controlling actions.

V. IMPLEMENTATION

Initially the Arduino mega 2560 is connected to all the different sensors and also the electronic appliances using relay. A threshold value is set for all the sensors such as the minimum intensity, or the minimum temperature upon exceeding which the user will be notified. The microcontroller is also connected to the ESP8266 wi-fi module which provides internet connectivity to the system by making use of its integrated TCP/IP protocol stack. A working model of the system can be seen in Fig. 3.

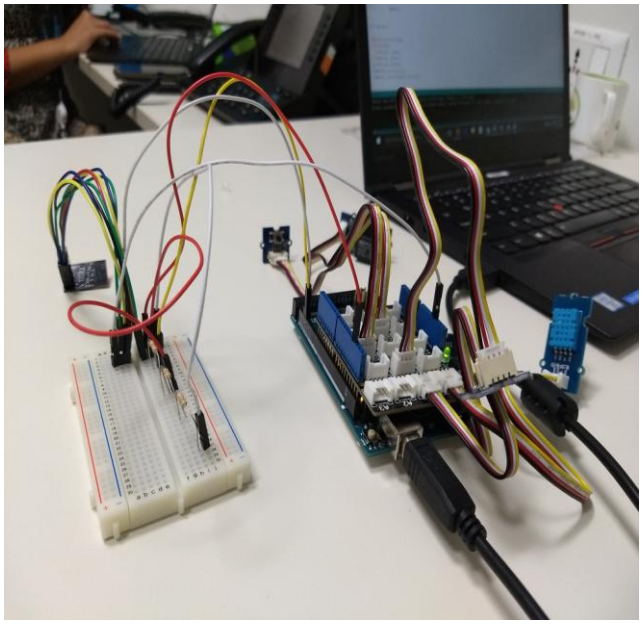

Fig. 3 Working setup of the system

A web is hosted using the ESP8266 which is used by the user for interacting with the system. The user can log on to the web server and switch on/off any home appliance that he wants from anywhere around the world. The different sensors are continuously sensing information and the data collected is stored. Whenever the threshold is breached, the user is notified of the same and the required action can be taken. The light sensor reads the intensity of light in the room. A threshold intensity is set. If the value sensed is less than the threshold, user will be notified of the same and he can then choose to switch the light on if required. Same way, the temperature sensor senses the temperature and the humidity simultaneously and displays the information through the LCD RGB backlight. Also, the user is notified if the temperature crosses the set threshold so that he can decide whether to switch on the fan or not. The PIR motion sensor is a digital sensor which when senses any motion around it, will force the buzzer to sound and also inform the user of any movement. The sensor also records the exact time at which it encountered movement and when exactly the movement stopped. This helps the user get notified of any intruder trying to break in, and hence, enhancing the security of the house. Same way, it is also recorded everyday the time at which the lights or fan were on/off and all this information is stored so that the user has easy access to the information whenever required. The home appliances such as lights, fan, and so on are connected with the Arduino mega 2560 using a relay. A relay acts as a switch. Suppose a light is on and the user decides to remotely switch it off through the web browser, Arduino then tells the relay to turn off after which the relay stops the current and voltage flow to the light switching it off. The coding to make all these features possible is done through the Arduino software IDE which makes it much easier to write the code and directly upload it to the microcontroller. Fig. 4. displays an example of the same.

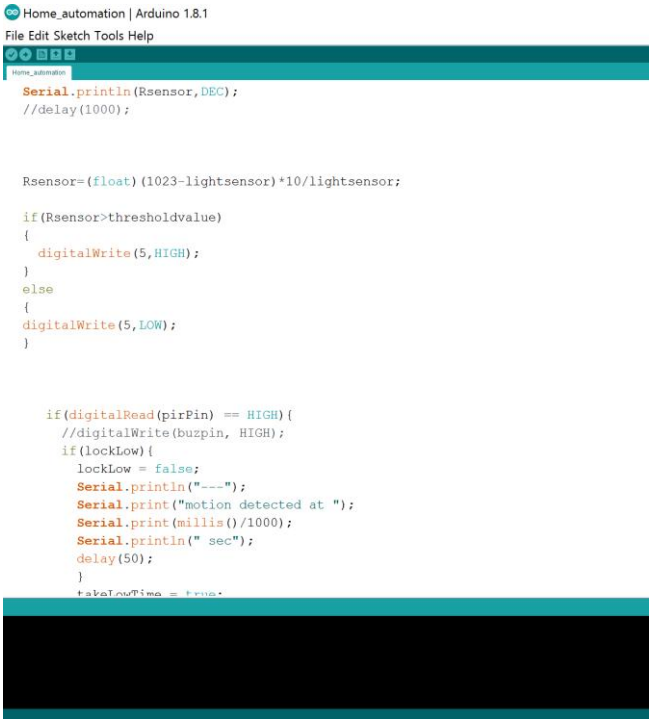

Fig. 4 Arduino software IDE

The best aspect of the project is that pattern analysis is performed on the data collected and stored by the various sensors. As mentioned before, the time of operation of all the connected appliances is also recorded. This data is analyzed to come up with an approximate regular usage pattern of appliances such as lights, fan, and so on such that these appliances are automatically switched on/off everyday according to their usual time of operation. However, the user has the ability to manually change the mode of operation of the appliances depending on his need. To demonstrate the pattern analysis feature, I have taken one min as usage cycle of the user to identify the pattern. The same can be easily extended to analyze user's pattern in a one day or one week cycle. One minute cycle has been used for demonstration purpose. Whenever the user performs any controlling action such as switching the light on/off, all these details are saved in the excel sheet such as if the action is switching on or switching off, the time at which the action was performed (in sec), etc. Then, 10 seconds interval are taken to see if the user has switched on the lights more, or off in that interval. This is learned and when the next time that interval is encountered, the same action is performed automatically. Thus, it understands the user's pattern of usage and automates it. The user can still manually change the desired action if he desires a different outcome.

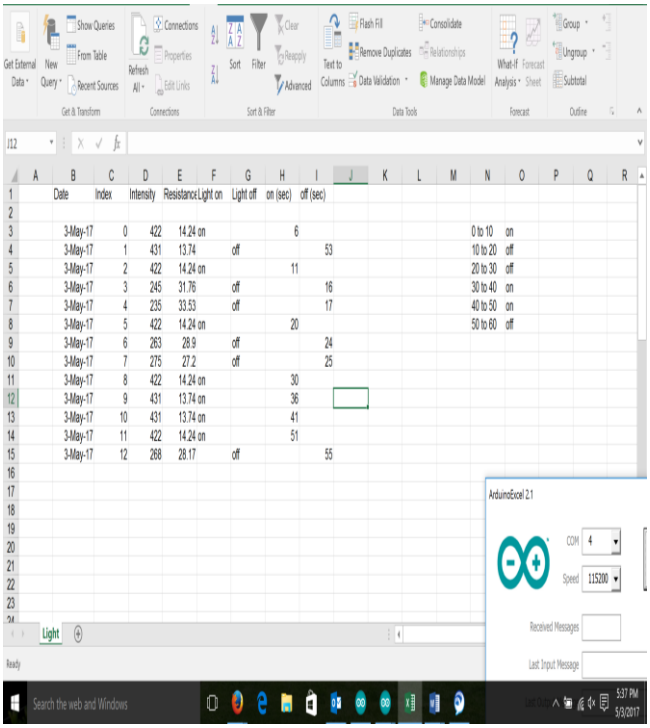

Fig. 5 Data stored in excel

The data is stored in the excel in such a manner that every time the user performs an action, either using the web interface or by using the buttons, the exact time at which the action was performed is recorded in the sheet. The code is written such that it continuously parses the excel sheet to read these recorded time of action and perform the required analysis. As it can be seen in Fig. 5 time interval is written and on/off is written next to it. The way in which the code functions is that, if the user goes to work every morning around 9-10 AM and switches off the light when going, so suppose one day he forgets to switch off the light, but the system will know that the light needs to be switched off at this time and this will be automatically achieved. The user can manually overwrite this anytime and perform a different action whenever needed.

VI. CONCLUSION

In this paper, a home automation system was designed and implemented using Arduino mega 2560 as the microcontroller and Wi-Fi as the method of monitoring and controlling the home appliances which enables the user to remotely access the system from anywhere around the world. The system is capable of automating the operation of the appliances by analyzing the regular usage patter of the appliances by the user. This not just saves a lot of human effort, but also helps in conserving energy. Also, it can help the differently abled and the elderly in performing basic tasks at home such as switching on/off the light, fan, and so on without having to depend on others.

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