Arduino Based Smart Home Automation System

Abdul Mueez[1], Tahrat Tazrin[2], Shaily Roy[3], Waqqas Iqbal[4] and Nadib Hossain[5]

Students of BRAC University, Department of Computer Science and Engineering
{[1]mueezdhaka@gmail.com, [2]ttazrin12@gmail.com, [3]shailyroy37@gmail.com, [4] waqqas.ess@gmail.com, [5]nadib2015@gmail.com}

Abstract – Forgetting to turn off lights, fans and other appliances when they are not needed contributes to wasted energy. Our setup aims to eliminate unnecessary energy consumption by detecting an individual's entry and exit from a room, and thereby turn the lights on and off respectively. Our entrance will be fitted with a laser pointing an LDR followed by a SONAR. Changes in the former followed by the latter will register an entry and the reverse as an exit. Based on the ambient temperature the system will also toggle the fans accordingly. A heat sensor will enable this to happen. Additionally, users will be able to control the devices independently via a push button. Overall, an eco-friendly home such as ours will not only add convenience and benefit the environment, but also increase our savings.

Keywords: Smart Home, Home Automation, Efficiency, Energy Savings, Green, Eco-Friendly, Arduino

1 Introduction

Technology has drastically changed our lives. In this day and age, people want to do anything and everything to be more energy efficient as polls suggest [1]. Conserving energy is not only beneficial for the environment, but it also helps consumers save money in the long. Reports indicate that the average home in the U.S. now uses roughly 40% less energy overall than it did in 1970 [2]. This is not surprising given that energy efficient homes lead to reduced unnecessary energy consumption, demand for non-renewable resources and thereby greenhouse gas emissions. They also provide notable savings over conventional homes.

Now, the good news is that there a number of ways one can make their home energy efficient with energy efficient plans and products. The bad news is that they cost an arm and a leg for the average consumer. Hence they are usually out of most people's reach. That's not all; smart home technology is supposed to make life easier, but all too often, it ends up making things only more difficult. Take an analog light switch for instance. Turning a light bulb on is as simple as flipping a switch on.[3] On the other hand, a smart bulb needs an app for it to be turned on, requiring one to first look for their phone, then navigate to that specific app and perform the required action – a process that can take a minute or so. Moreover, many hardware manufactures fail miserably when it comes to building user friendly apps. Sometimes after investing a lot of money users find out that the apps that control the hardware keep crashing on a constant basis, lack basic features and usually have horrible interfaces that take forever to figure out. Also, with every component having its own app comes the problem of app clutter. Lastly, security can become an issue too. In 2013, a weakness in an internet connected video baby monitor allowed a hacker to penetrate the device and frighten a Texas family [4]. These norms that are usually associated with smart homes are what our projects aims to break.

Firstly, our model project is made up of components that cost approximately 1200 BDT, making it affordable for most people. Secondly, we are removing the use of apps to control appliances all together from the equation, making the process a whole lot simpler for the consumer. Everything will be automated, but it won't be a one size fits all model. While we will be using sensors to control the operation of both the lights and the fans, users will have the option to adjust them according to their own will via a push switch, removing the unnecessary hassle involved with using an app. Thirdly, none of our components will be connected to the cloud, thereby completely eliminating the risk of an attack from a hacker. A detailed explanation of how the setup works will be explored in the fourth section titled experimental setup.

2 Background Information

The idea of home automation has been around for a long time, but the technology to make it viable was not. It all started with the unveiling of the wireless remote control in 1898 by Nikola Tesla. He demonstrated how a small boat could be controlled using radio waves. Then came domestic appliances beginning with the first engine powered vacuum cleaner in 1901. 6 years later it was electrically powered. Throughout the next 20 years, home appliances such as refrigerators, clothes dryers, washing machines, irons, toasters, etc were being revolutionized. However, these were had very high price tags and could only be afforded by the extremely wealthy. The idea of home automation was explored widely in the 1930's, but it was not until 1966 when Jim Sutherland developed the first home automation system called the ECHO (Electronic Computing Home Operator) IV.[5] It could make a grocery list, maintain temperature, toggle appliances and so on. It had dozens of publications covering it, but was never commercially sold. Next came the Honeywell Kitchen Computer in 1969 which could create recipes. This too unfortunately never took off because of the high price. Later, in 1971 the microcontroller entered the picture and this meant a swift fall in electronics' prices, making technology more accessible. Finally, in 1984 the term 'Smart Home' was first coined by the American Association of House builder [6]. By the end of the century, domotics was a common term that described the combination of domestic appliances with computers and robots. Consequently, in 1998 there was a demo that displayed how automation could be integrated into a home with heating systems, automatic garden controlling soil, security systems, lights, doors. As the tech revolution began, this became widespread courtesy of lower prices and increased efficiencies [7]. Today we're seeing a myriad of independent smart appliances, but eventually these products will be programmed to work in tandem. But until that day we will stick with our setup.

3 Proposed Model

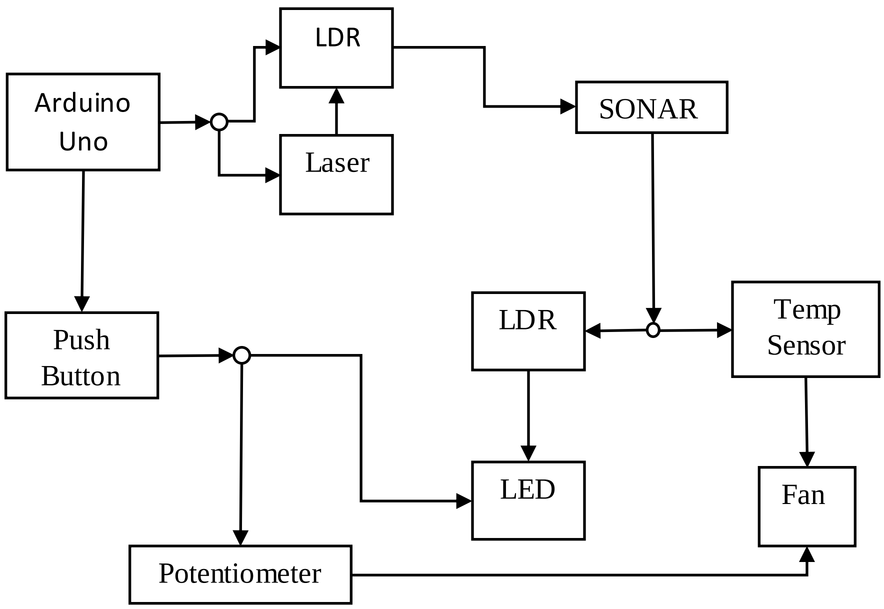

Figure 1: Working process of home automation system

The basic block diagram of the home automation system is shown in Figure 1. A micro-controller is used to obtain values of physical conditions through sensors connected to it [8]. These integrated sensors such as the temperature sensor read temperature values, the sonar and laser diode reads appearance of a person. The automatic switching on and off of the light is controlled by the Light Dependent Resistor (LDR) which determines the day light intensity. A relay switch push button is used to send control signals from the micro-controller to the electronic device used to achieve the switching on and off action. A potentiometer is used to control the speed of a fan manually.

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button [9]. It can be used to support the microcontroller by connecting it to a computer with an USB cable or power it with an AC to DC or battery. For this project, we used an 8V battery as the power source. (a) of Figure 2 has illustrated this component.

HC-SR04 Sonar Sensor an Ultrasonic ranging module which consists of a transmitter, receiver and control circuit. It has four pins for VCC, GND, Trigger and Echo which are connected to the Arduino [10]. When it receives instructions from Arduino, it transmits a signal towards the object in front through the transmitter and detects the echoed signal through the receiver. The received data is then sent back to the Arduino which is used to calculate the distance of the object from the sonar. It is shown in (b) of Figure 2.

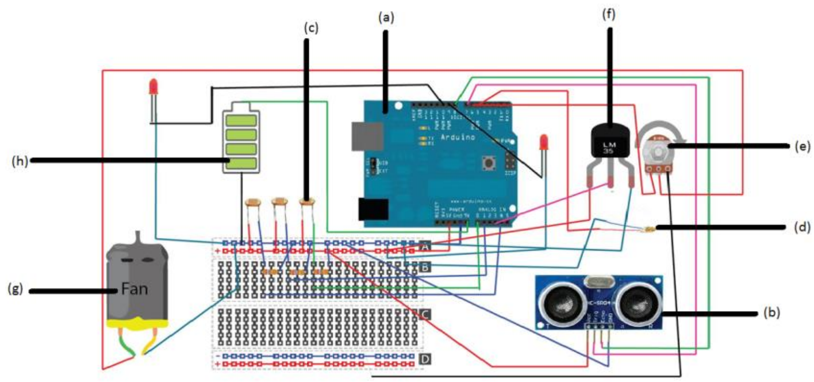

Figure 2: Pin diagram of proposed model

Light Dependent Resistor (LDR) is a variable resistor whose value decreases with increasing incident light intensity and vice versa. In this project, the LDR is accompanied by a laser diode which is pointed towards it. Hence, whenever the laser beam is interrupted, the LDR’s resistance changes and the Arduino takes action accordingly [11] which is visualized in (c) of Figure 2.

Laser Diode is the most common type of laser whose configuration is similar to a light emitting diode. It is continuously directed towards the LDR in order to detect any obstacle. (d) of Figure 2 is a laser diode.

Potentiometer is a variable resistor which is generally used as a voltage dividing element. It consists of a knob which is rotated to alter resistance and thus voltage supplied to an electrical component. It also contains three pins, GND, Vcc and Signal. The signal pin is connected to an analog pin of the Arduino to get different resistance values [12]. It is shown in (e) of Figure 2.

LM-35 temperature sensor is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the Celsius temperature [13]. It has Vcc, Output and GND pin where the output pin is connected to a digital pin in Arduino. The LM35 does not require any external calibration or trimming and maintains an accuracy of +/-0.4 at room temperature and +/- 0.8 over a range of 0 to +100. The picture of (f) of Figure 2 visualizes this component.

To help with the rotation of the electric fan, a dc motor is used. It has two leads, a positive and a negative one, which can be connected directly to the battery or to the Arduino. The function of the motor is to convert the electrical energy into mechanical energy which causes the motor to rotate [14]. We can see this component in (g) of Figure 2.

Push button is used as an alternative switch in case someone wants to control the lights manually. The battery supplies external power to the Arduino. An 8V battery is used for the whole setup. Push button and battery are shown in (h) and (i) of Figure 2 respectively.

Algorithm for the hardware project

1. Arduino and the automation starts on power.
2. Initialize the I/O ports
3. The laser beam from the first diode is obstructed by an object. This triggers the LDR to signal microprocessor. Check whether the object crossed sonar or not.
4. If it crossed the sonar last, people are entering the room and if it crossed the sonar first people are leaving.
5. If person is entering, the system turns the light and fan on
6. Then it checks whether the temperature is less than 18 degree
7. If yes it turns off the fan
8. If person is leaving the room and calculated person is 0,it turns the light and fan off
9. Another LDR checks whether it is day or night
10. If it is night it will turn on the light of outside of the door.
11. Push Button can turn the lights on or off manually.
12. Potentiometer controls the speed of fan manually.
13. The system waits for another passing object

4 Experimental setup

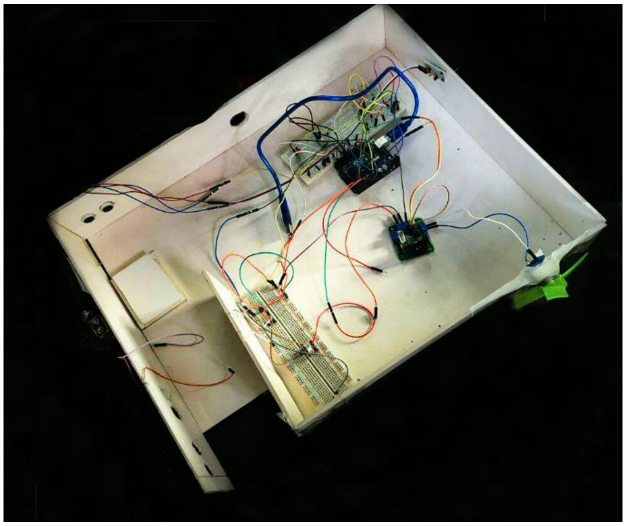

Figure 3: Prototype of Home automation System

Figure 3 shows the sample of our experimental setup. We attached the Arduino UNO with the sonar sensor, LDRs, the push button, the laser diode, the temperature sensor and a Bluetooth module using several tiny breadboards of dimension 5.5 cm by 8.5 cm. The coding is done in Arduino IDE to run the system. Our design choice was influenced by the fact that the Arduino UNO is a cheap, low-resource micro-controller, and the board is already occupied with receiving and processing signals from the sensors. Most importantly, Arduino programming is relatively easy to learn and apply to beginners [15]. The purpose of using several small breadboards is that the sensors and devices used are attached at different locations of the house, use of a single breadboard would make the circuit clumsy. Moreover, the use of long wires from room to room is also prevented this way.

The setup goes as follows:

A laser beam is attached outside the front door of the house pointing directly towards the LDR. The laser acts as a constant light source to the LDR. When the laser is interrupted, the LDR reading changes drastically.

However, to know if a person is entering or leaving the house a sonar sensor is attached inside of the house facing towards the front door. If a person walks in the door and comes in the range of 12-15 cm (according to our model), the sonar sends a pulse to the Arduino. The change in LDR reading followed by a sonar sensing an object in its specified range is marked as an entrance into the house. The counter is incremented and recorded for the number of people entering the house. Likewise, the sonar sensing an object in the range of 12-15 cm followed by an interruption of the laser is considered as exiting the house. The counter is decremented when leaving the house and all the lights and fans turn off when everybody has left the house. This procedure is visualized in Figure 4.

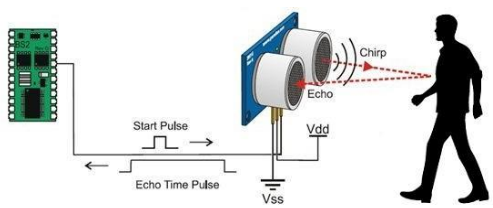

Figure 4: A sonar detecting a human approaching it

There is LDR inside the house to detect whether there is sufficient light in the house and a temperature sensor which measures the temperature inside the house to be less than 20 [16]. If not, an entrance of a person causes the lights and fans to turn on. However, for the control of the speed of the fan, there is a potentiometer for the user to manually regulate it. It is also perfectly plausible that the user needs to switch on or switch off some light due to some other reason that doesn’t quite meet the conditions set by the LDR. In this case, the push button can be used to easily instruct the light to be switched on and off as he pleases without the intervention of the sensors.

Moreover a LDR is attached to the outside of the door to detect if its day or night. This third LDR is used to turn on the light outside the front door during night [17]. The above mentioned description is illustrated in the flowchart of Figure 5.

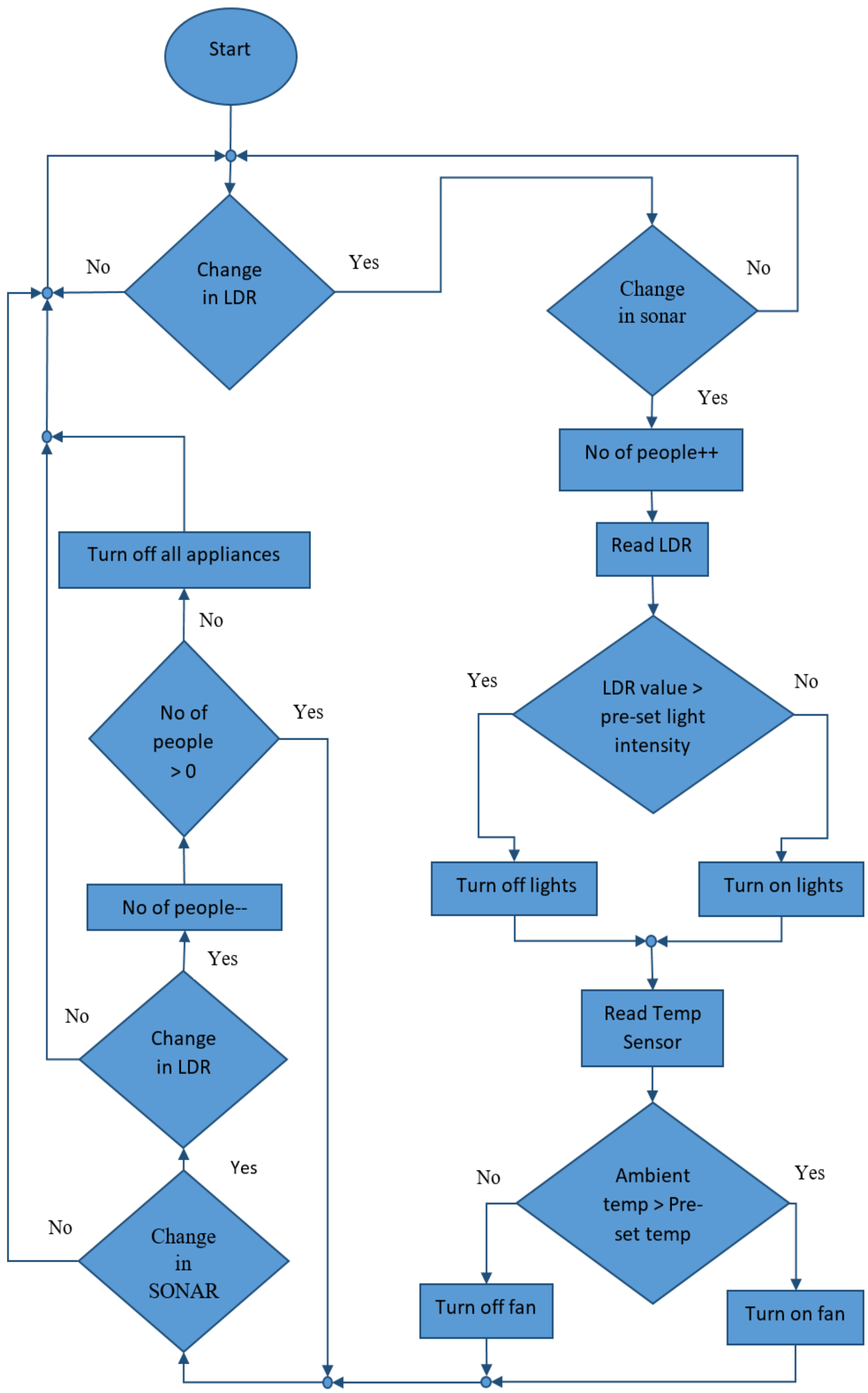

Figure 5: Flowchart of the setup

5 Results and Evaluation

The pros and cons of each devices that we were working with became more vivid as we started experimenting our system. Initially, we setup the circuit with no laser diode and one less LDR. We intended to use a sonar outside the front door of the house to detect any person passing by just as we used one inside the house. Four out of ten times the sonar was unable to differentiate between the wall on the other side of the sonar and the person. We found out that the sonar wasn't so accurate in doing the task we wanted it to do outside of the door and it had its limitations. Only then we decided to add a laser diode outside of the front door pointing a LDR. Then on, we experimented quite a few times and observed favourable results for an adult sized human figure passing by the front door. We realized we had to take into account that it was highly likely if a child passed the door our laser might not get interrupted so we set the laser only 4 cm (equivalent to 2 ft. in real environment) above the ground in our model. This way we took care of this problem and tried to simulate our model using a smaller human figure and observed that in 45 times that we performed the test, our system was able to detect the entrance and leaving of a child-like human 40 times giving an overall success rate of 88.9%.

Secondly, we faced difficulty in testing the light inside of the house. Our system should not turn on lights during daytime when there is sufficient light inside the house as it is completely redundant and simply a waste of energy to turn on light when not required. But how much light was sufficient still remained a question. We carried out the testing in a full lit room to simulate daytime and then in a dark room to replicate night. Our model house responded quite perfectly in both the situations. However, it was during dusk that our system gave anomalous results. For that we had to retry for different intensities of light to fix this problem. The code was also updated accordingly. After doing so, we experimented for different intensities of light, and obtained more accurate results than before.

6 Conclusion

In this paper, a home automation system, with the use of Arduino, is proposed and implemented successfully using different components embedded in an Arduino UNO board. We designed and implemented this model considering low cost, reliability and user friendliness. Our setup aims to reduce human labour to the point it adds value to the user and save time of those who are chronically busy. Not only will it make life easier for the users but will save great amount of energy and a lot of money in turn. It is certain that systems such as ours will be in demand in the near future.

Acknowledgement

We would like to express our gratitude to Dr. Jia Uddin, Assistant Professor who gave us the opportunity to do this project which required a lot of research and thereby taught us some invaluable lessons.

References

[1] Matzner, F. “Poll: Americans Want Energy Efficiency, but Will Congress Listen?”, March 03,2014.

[2] C. Cornel, “CONSUMERS WANT ENERGY EFFICIENCY, BUT WHAT WILL THEY DO ABOUT IT?”, September 13,2015.

[3] Ming Yan and Hao Shi “SMART LIVING USING ARDUINO BASED SENSORS”, Vol. 5, No. 1, February 2013.

[4] Ngak, C. “Baby monitor hacked, spies on Texas child”, August 13, 2013.

[5] Buckingham, A. (2015). “The history of home automation from the beginning”, July 3, 2015.

[6] David, N, “Design of an Internet Based Security System”, NIJOTECH, 29(2) 118-129, 2010

[7] E. Ahmed, A.H. Karim, “Design and Implementation of a Home Automation System”, International Journal of Computer, Electrical, Automation, Control and Information Engineering, vol.6, no.8, July.2012.

[8] Stewart. L, “Domestic automation system”, October 21,2011

[9] Mohamed Abd El-LatifMowad, Ahmed Fathy, Ahmed Hafez “Smart Home Automated Control System Using Microcontroller” International Journal of Scientific & Engineering Research, Volume 5, Issue 5, May-2014 ISSN 2229-5518

[10] N. D. Hileskas “Ultrasonic Sensor HC-SR04 and Arduino Tutorial”, March 10, 2013

[11] M. KARTOGI, “Laser Setup and Detection”, August 09,2008.

[12] K.M David, “Controlling Speed of fan using Potentiometer”, January 13,2012.

[13] A.M Khan, “ANALOG SENSOR: TEMPERATURE USING LM35”, August 09,2011.

[14] Daware, K. (n.d). “How A DC Motor Works”, June 19, 2010.

[15] A. Ahmed. “Home Automation System Using Arduino”, UNIVERSITI TEKNOLOGI MALAYSIA. pp. 4. 2014

[16] D, K. CHOWDHURY. “Learn Arduino Coding and Algorithm”, April 12, 2011.

[17] Chakradhar, B., KrishnaveniI, S., and Naresh , D. 2013. “Home Automation and Security System”, International Journal of Engineering Trends and Technology (IJETT) , Vol. 4 Issue 9, Pg 4053-4058.