Design of Sensor Technology based Smart Home System

Kevin Chittilapilly, Rahul Dusaje, Mohan Jagannath

Abstract*: Smart home is the general term commonly used to represent a resident that embodies a home controller to integrate the resident's home automation systems. The domain of home automation came up with new innovations and today it is commonly known as an area where the "Internet of Things (IoT)" has become a reality. Mostly, home automation system aims at reducing human labor in producing goods and services. The important thing that we learn is how each and every device constitutes a subsection of Internet, using which the device is able to link and communicate, and incorporate additional features in the system. This paper proposes an actualization of home automation using Arduino Uno, completely customizable and user programmable embedded board (ATmega 32 processor) mounted with numeral peripherals and network transmission and reception.

***Index Terms*: Home Automation, Internet of Things (IoT), Arduino Uno, Safety, Comfort.**

I. INTRODUCTION

Any ideal home automation design needs to be easy to understand for a common man and should always have room for further improvements [1, 2]. Additionally, smart home automation brings a comprehensive answer to the rising crisis of depletion of non-sustainable energy forms [3]. The core of any home automation system is sensor networks and Controller to power up the Arduino all the time. Home automation is a technique to remove as much human interpose as possible and replacing them with easily programmable systems. So that being lazy won't be an issue. Ultimately, we aim to design a system that modernizes quality of life with the smart appliances that can be controlled over the Internet or through smart phones. Previously, this system regulated Heating, Ventilation and Air Conditioning (HVAC) operated by a central computer [4, 5].

With the advancement in technologies smart home automation comprises additional features for security, access control, surveillance, energy management. Home automation aims at providing an easy to implement approach to reduce the consumption of energy and cost expenditure and should also be convenient to the user. The motivation for this project was the film Iron Man. We were particularly mesmerized by the artificial intelligence 'Jarvis' and so we decided to work on a home automation using voice commands. In recent days, Amazon ECHO works on advanced AI (Alexa) playing the role of Virtual Assistant. A centrally regulated system enables communication between a central computer (root) and appliance controllers. The flamboyant advantage of this system is that it can control almost all types of electric gizmos but if the controller crashes, the entire grid breaks down [6, 7].

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II. SYSTEM ARCHITECTURE

Figure 1 shows the smart home system model which includes essentially two modules, the hardware interface module and the software module.

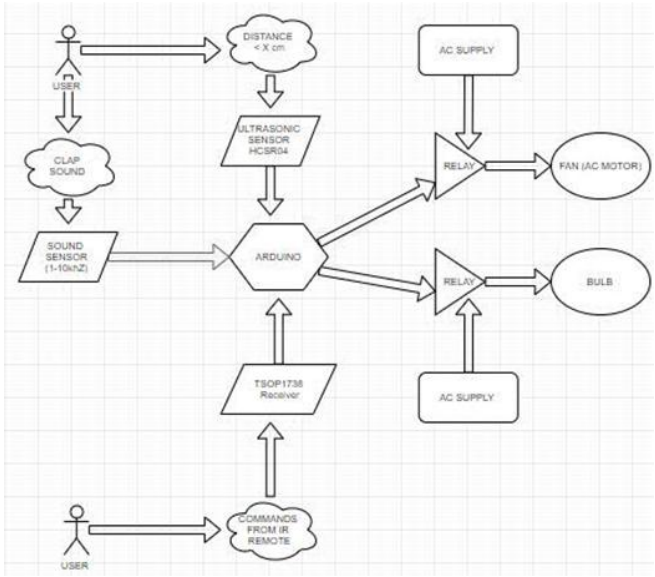

Figure 1. Smart home automation model.

A. Hardware Interface Module

Arduino both in software and hardware interface is a microcontroller used for performing multiple actions like actuating the sensors, configuring computer systems, which are further implemented in making Bots, automation industry. It has digital and analogue (pulse width modulation) pins used as per the external device connected to it. Furthermore, it includes transmitter (Tx) and receiver (Rx) pins respectively. In this study, the analogue pins are mainly used for interfacing sensors that sense values from environment and translate them into dubious values, calculations are made to get the actual values.

The proposed smart home system has been implemented in two different ways, using clap circuit and infra-red (IR) remote controller.

Clap Circuit: In this implementation we aim to control the home appliances such as tube lights and fan using clap. We use a sound sensor to detect the clap. We connect the sound sensor to the 'analogue in' A0, A1, A2. We cannot use digital pins because the sound sensor provides an analogue value as the output. First we connect a LED to check the circuit; the

LED can be connected at pin 13. The sensor gives the output as the difference between the analogue values at its two pins. The following is the code for acquiring values from sensors.

```
void loop() {
Sensor1 = analogRead(SoundPin);
Serial.printIn(Sensor1);
Sensor2 = analogRead(SoundPin);
Serial.printIn(Sensor2);
If (Sensor1 – Sensor2 > 4 || Sensor2 – Sensor1 > 4) {
lightOn =!lightOn;
delay(100);
digitalWrite(LED1, lightOn)
}
}
```

An ideal value for this difference should be 4 as it will eliminate the turning on of the circuit accidently due to some random noise. Next step in this is to connect bulb to this circuit instead of led. We accomplish this using a relay of either 7A/250V or 12A/120V. We need to use a relay in order to connect his power components to Arduino. Using multiple relays we can connect multiple components simultaneously using a single Arduino. Finally we connect our fully running Arduino to the main board of the room and get the desired clap automation. Alternating Current in India (220V) powers the home appliances. Arduino cannot control such high voltage, but a relay can be used to switch control between the high power devices [8].

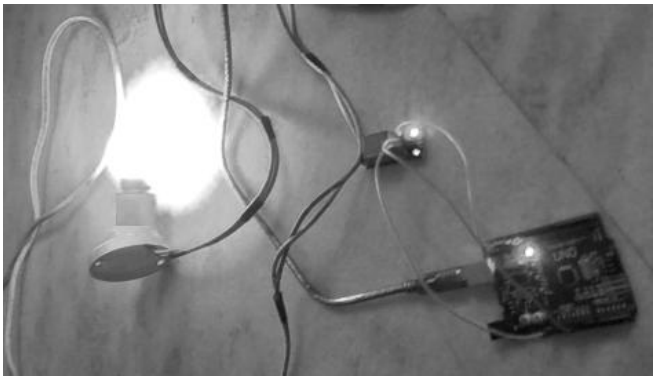

Figure 2. Hardware interface module.

Relay-Appliance Connection: Our home appliances (AC controlled) are usually connected with 2 wires attached to a plug. One wire is connected directly to plug and the other wire is connected to relay first and then from relay to the plug. We use relay in NO (Normally Open) mode, it acts like a switch, since it is open. When a trigger is applied it connects to COM (Common Connection) and the circuit gets closed. So the toggling between the appliances works using NO and COM of relay. To check if the connection is properly made, run the following code:

```
void setup() {
pinMode (13, OUTPUT);
}

// the bulb glows for 2000ms
void loop() {
digitalWrite(13, LOW);
delay(2000);
// the bulb turns off for 2000ms
digitalWrite(13, HIGH);
delay(2000);
```

Infra-red (IR) Remote Controller: In this implementation, the control of appliance is made using the remote. The devices/appliances get activated by pressing a remote button, this implementation can also be carried out using the IR sensor remote generally present in smartphones [9, 10]. The TSOP1738 IR receiver is used with the carrier frequency of 38 kHz. The receiver output will directly be linked to a microcontroller for further analysis. Once the above connection is established, configuration of the remote buttons for each device is done. For example, when key 1 is pressed, the output (dubious value) is displayed on serial monitor and has to be noted. Similarly, repetition for the other keys is performed and noted the values. For key 1 the value was 2340092731, and using 'if statement' we can check is key 1 is pressed or not. If the value matches the above one, it indicates that key 1 is pressed and the further functionality can be carried out. If the sensed value is 2340092731, implying key 1 is pressed so switch ON the bulb and if the value is 2086679999, key 2 is pressed to turn OFF the bulb. Replace the bulb with a motor (using appropriate motor drivers) and we can switch on/off fan also.

Ultrasonic Sensor: In this implementation, the proximity is considered as the main criterion to decide the switching of the device. The values of voltages (mV) are taken against the distance values (cm), taken from the sensor 2, implies the increasing distance between sensor and object increments voltage by dubious amount. For example, when you open the door of dressing table, cupboard lamp the bulb glows on and remain in the ON state as long as the door is open, and switches OFF after the door gets closed. For this implementation, the ultrasonic sensor HCSR04 is used. There are mainly three pins in HCSR04 sensor (Trigger, Echo and Load). The trigger pin sends the waveform after being deflected by any object (except a glass, as Ultrasonic waves pass through it) by 180 degrees and gets received by echo pin. The distance 'D' between the object and the sensor is given in Equation (1):

$$D = \frac{S*T}{2} \quad (1)$$

Where, S is the speed of the ultrasonic waves in air (340m/s) and T is the time difference that is calculated by echo pin. The threshold value is set to 25 (means if the bulb lies within 25cms to the sensor, it should glow).

```
duration = pulseIn(echoPin, HIGH);
distance = (duration/2) / 29.1;
Serial.println(distance);
if(distance<=25)
{
 digitalWrite(12,LOW);
 delay(100);
}
else
{
 digitalWrite(12,HIGH);
 delay(100);
}
```

Table 1 depicts the distance versus the voltage obtained from the ultrasound sensor. The basic approach is to configure the sensor first, for this; an object is kept exactly at 10cm from the sensor and noted the value from serial monitor. Let the value be x for 10 cm, for distance 'D', the value should be (10/x)*D. The procedure is repeated for several distances for better accuracy. So this factor which in our case was 29. The sensed value from the sensor has to be manipulated to get desired distance with accuracy of 0.5cm.

Table1. Distance versus analogue output voltage from the ultrasound sensor.

Distance (cm)	Analogue Output Voltage (mV)
5	270
10	300
15	330
20	360
25	400
30	430
35	510
40	605

III. RESULTS AND DISCUSSION

Once the circuit is working fine, the bulb gets replaced with any home appliances. Figure 3 represents a plot of the sensor values obtained from the Arduino.

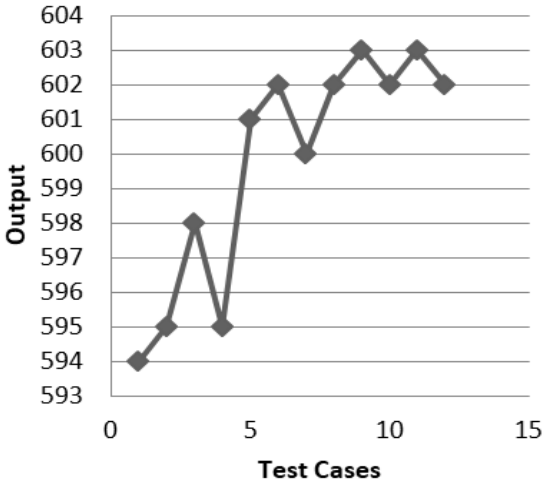

Figure 3. Sensor values obtained from Arduino.

People often find it difficult to adjust to a new piece of technology. We have introduced a combination of a smartly automated home and its architecture design features to support dwellers environmental awareness. We observe that for many customers, electricity being first entity not actively consumed or "an indomitable and abstract force entering the household often via wires hidden", and second because it is difficult for people to connect their specific behavior to electricity consumption [11]. Use of the presented approach with Arduino as its core makes its applications endless.

We have now stepped into the modern/advanced era where people favor everything to be operated in the blinking of the eye. The IoT is the most dynamic and demanded field in the present era with new inventions, possibilities and breakthroughs occurring every day, raising the demands for fully skilled engineers. IoT plays a pivotal component in any home automation system. In other words, use of affordable hardware, like proposed, Arduino Uno and other hardware such as PIC, Raspberry Pi or other AVR boards [12], and open source software, makes it programmatically possible to control all sorts of devices.

The hardware cost to implement the above all implementations are very less making it a very cost-effective innovation for home automation. By introducing IoT and Android development this method can be taken to the next stage by controlling the appliances using phones over internet anywhere. Several implementations excluding the ones included in this research paper have been done using Bluetooth module incorporating with Bluetooth controlled devices but can only work on smartphones. But the only problem faced is the time taken for proper devices and smartphone bluetooth connection. Contemplating from the example of XBee–ZigBee network topology [13], the developers have demonstrated how to design and customize a sensor network with ease. Additionally, the advantages of using a Raspberry Pi development board as a ZigBee home automation server has been demonstrated [14].

IV. CONCLUSION

Thus, the smart home system has been successfully implemented using sensor technology. The proposed implementation can be adapted in real life appliances. Unlike many available commercial solutions such as Apple, this proposed system implementation is an open solution, which gives scope for building smart cities. One such solution would be introducing Raspberry Pi as a sensor web node for smart home system.

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Kevin Varghese is studying third year Bachelor of Technology (Electronics and Communication Engineering) at Vellore Institute of Technology (VIT), Chennai, India. He is very much interested towards Arduino related projects. He is passionate about learning and mastering new skills to achieve greater heights in the field of automation technology.

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