IoT-Based Wardrobe and Steel Closet Theft Detector

S. Shrinidhi, S. Vinuja, and E. Prabhu

Abstract In recent years, the increasing burglary has been creating a great sense of anxiety, in assuring the safety and security of the essentials placed in the wardrobe. This paper focuses on providing a user-friendly and cost-effective mechanism, to ensure the safety and security, by intimating the user in case of any burglary. The above purpose is achieved by (1) periodically monitoring the inner walls of the wardrobe, (2) monitoring the continuous darkness that prevails in the wardrobe when the doors are closed. The monitoring process involves the presence of an ultrasonic sensor (HC-SR04) on one side of the opening door of the wardrobe, which sends ultrasonic waves to detect the precise distance of the wall of the wardrobe facing the sensor when it is closed. The photoresistor sensor (LDR) senses even the slightest presence of light in the wardrobe, in case of it being opened. The monitored distances and light-sensing data are stored in an authenticated IoT platform of ThingSpeak using ESP-8266. Any inaccuracy in this uploaded data from the previously set data causes the IFTTT application to intimate the user of the wardrobe being opened, through notification and e-mail services.

Keywords IoT · ThingSpeak · Smart wardrobes · Sensors · Theft detector

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1 Introduction

Recently, the alarming rates of burglary have emphasized the need for a more secure smart lock system like biometric devices. The presence of smart wardrobes relieves the users from the stress of having the essentials safe in case of their absence. Regardless of using these special devices, the rates of burglary crimes continue. In the absence of an authenticated user, these devices can be accessed with an identical copy of biometric data, obtained using the tools of forensic sciences. The electronic locks, digital locks and the complex mechanical locks can be accessed using their respective counter technologies.

An ultrasonic sensor (HC-SR04) and a photoresistor sensor (LDR) can continuously monitor the current conditions of the wardrobe. The monitored data is then channeled into an IoT platform of ThingSpeak, wherein the obtained data is compared with the predefined data module. Any inaccuracy or discrepancy in this data, caused due to the opening of the wardrobe, triggers the ThingSpeak *platform.* The details of the user are stored in the cloud and provide a *quick* insinuation to the user of the same, through notification from the IFTTT app and e-mail services.

2 Background

2.1 Sensors and Modules

The wardrobe and steel closet theft detector employs the usage of the ultrasonic sensor (HC-SRO4), a photoresistor and the Wi-Fi module (ESP-8266). The machine is modeled in such a way that it is supposed to be attached to one of the opening doors of the wardrobe. The distance is periodically checked using HC-SR04, which measures the distance of the opposite surface of the door from the sensor. The sensor contains a transducer that sends and receives ultrasonic pulses of high-frequency sound waves. By sensing the echo pattern of the received waves, the object's distance is found. The distance is given by Eq. (1).

$$\text{Range} = \text{Time off light}/\text{Speed of sound} \tag{1}$$

The maximum and the minimum distance which can be detected using HC-SR04 are 400 cm and 3 cm, respectively. If there is no object to be detected then, a high-level signal of 38 ms occurs in the output pin. HC-SR04 gives the precise value since it has high a penetrating power and can sense any material in any adverse condition. The darkness inside the wardrobe is observed using a photoresistor sensor. This sensor is a resistor that has values in megaohms in the absence of light and a very few ohms in the presence of light. There are two types of photoresistors which are intrinsic and extrinsic. Regardless of what type of photoresistor used, both reveal a drop in resistance or rise in conductivity with an increase in the intensity of incident

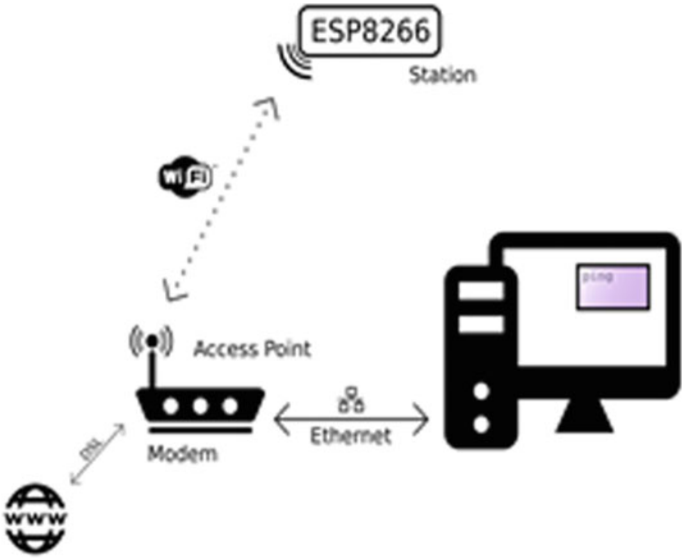

Fig. 1 Working of ESP-8266

light. Normally, the photoresistors take a few tens of milliseconds to acknowledge the light when it is made to strike after total darkness, but when light is removed off, it takes one second or more to reach its final level of resistance. The purpose of using the photoresistor is that it is bi-directional, it offers quick response, and it is highly accurate.

The recorded data from the Arduino to the cloud is updated using an intermediate chip called ESP-8266. ESP-8266 is the first Wi-Fi module at a very low cost. This module is manually connected to the Arduino UNO and is programmed in Arduino IDE using the AT commands to provide a connection with the local Wi-Fi network. The communication of ESP-8266 with the local Wi-Fi network is depicted in the Fig. 1. Figure 2 gives the overall flow of the proposed prototype.

2.2 Arduıno UNO

To program the sensors and to make them interactive, Arduino UNO is used. All the sensors and modules required for the prototype are connected manually to the Arduino board. It is then programmed in the Arduino integrated development environment (IDE) using the C++ language. The board is first connected to the laptop/computer through a portable USB cable to store the code in the Arduino UNO. Once the code is loaded, the board can be powered using a power bank or any other battery of use.

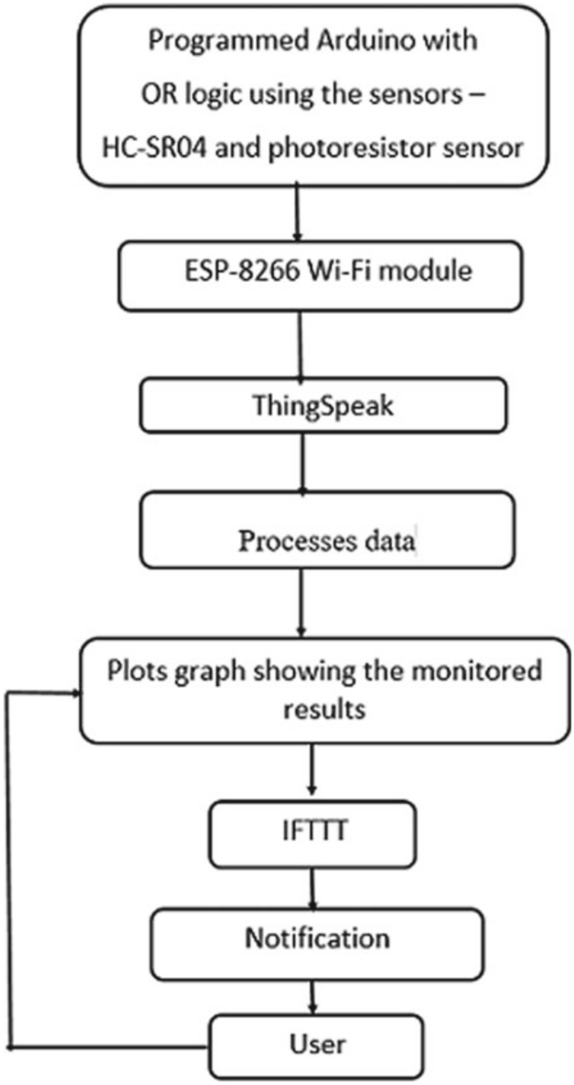

Fig. 2 Architectural framework of the proposed system

2.3 IOT Analytics Platform and Services

ThingSpeak interface: The collected data from the sensors is transmitted to ThingSpeak. The ThingSpeak allows an open visualization of all the details collected as a plot in a graph, for the user to monitor whenever required. The link from Arduino to ThingSpeak is depicted in Fig. 3.

Fig. 3 Communication of Arduino with ThingSpeak

IFTTT: IFTTT is a free Web-based applet, where triggers can be given from other platforms to perform any action. Here, the triggers are configured to send e-mail and notification in the IFTTT app.

3 Related Works

In this generation, all the information which is physically available in this world is transformed to us in the form of figures or data. This is achieved predominantly by the sensors. The sensors used in this project are mainly used for detecting the distance of an object and the presence of light [1, 2]. The data collected from these sensors is made to interface with the Arduino UNO for the working in [3, 4]. Arduino UNO is preferred in this prototype as it is inexpensive and can be supported on Windows, Linux, Mac OSX, iOS and Android [5].

The data thus generated is stored in the cloud through Arduino for further analysis. This is facilitated by using ESP-8266. Since the cloud used here is ThingSpeak, its further connections to the Arduino IDE have been referred from [6–8].

The data stored in this cloud is further integrated with the IFTTT application to send a notification through its app and an e-mail [9]. This is where the IoT comes into picture wherein the two applications are made to interact without any human touch thus making this prototype cost-effective, efficient and accurate [10, 11]. To track stocks available in the kitchen, an inventory system using IoT was developed [12]. The reconfigurable hardware approach for the implementation of the digital logic was discussed in [13].

4 Proposed Methodology

Several case studies reveal that the wardrobe thefts happen, either by breaking the lock of the wardrobe, shattering the doors of the wardrobe, or by drilling holes on the surface of the wardrobe. In many such cases, the thefts happen only in the absence of people in their respective homes. Wardrobe and the steel closet theft detector is a prototype designed to facilitate such people to get information whenever someone is trying to access their wardrobe without their knowledge. Further, they can also monitor their wardrobe periodically using their mobile phones and can check whether their wardrobes have been approached by someone. If any of the initially discussed scenarios take place, the wardrobe is definite to undergo damages and changes. To monitor and record such changes from breakage or opening, sensors such as HC-SR04, photoresistor sensor are used and ESP8266 connected manually to the Arduino UNO. The designed system is to be placed on the inner side of one of the opening doors of the wardrobe. The circuit diagram of the entire working model is given in Fig. 4.

Step 1: Monitoring changes in wardrobe

Whenever a thief breaks open the lock or the doors of the wardrobe, there occurs a change in the distance between the doors and the facing wall of the wardrobe. This distance is monitored and recorded by using an ultrasonic sensor. The monitored distance is then compared with the initially programmed distance obtained when the

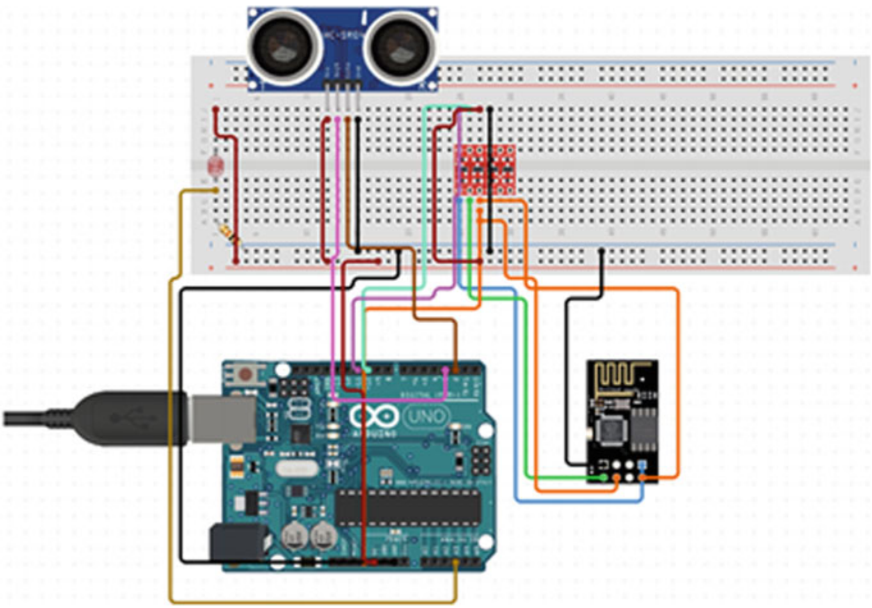

Fig. 4 Circuit diagram of the proposed working model

wardrobe is closed. Any change in the newly measured distance from the initially set distance programs the Arduino IDE to take the value as 1, else the value will be recorded as 0.

When a thief drills holes on the surface of the wardrobe, there can be two cases:

Case 1: DAY Ideally, the inner space of the wardrobe appears dark when it is closed. During the day, whenever the thief tries to access the valuables by drilling a hole on the surface of the wardrobe, a reasonable amount of light penetrates the wardrobe.

Case 2: NIGHT At night, if a thief chooses the path of drilling to access the valuables, he would ideally choose to carry a torch or any other sources of light alongside.

In either of the above two cases, one observes that the light penetrates into the wardrobe. Hence, light is sensed inside the wardrobe. To sense this presence of light due to the opening of the wardrobe, a photoresistor is used. Its values are periodically recorded. Similar to the previously discussed sensor, the value is recorded as 1 in the presence of light and 0 in its absence to denote a safe condition.

Step 2: Assigning solution using OR gate ideology

The Arduino IDE is programmed in such a way to obtain a value of 1 in the cloud when any one of the sensors gives the value 1 or when both the sensors give the value 1. Only when both the sensors observe the value 0, the value 0 is stored in the cloud. It works on the principle of an OR gate, as given in Table 1.

Step 3: Linking the solution with ThingSpeak using ESP8266

ESP8266 Wi-Fi module is manually connected to Arduino UNO, and the Arduino IDE uses the SoftwareSerial library for doing serial communication with ESP8266. This Wi-Fi module requires the respective Wi-Fi address and password to be mentioned. It is further programmed using AT commands for wireless communication such as to pass the values recorded by Arduino UNO to the cloud simultaneously. The cloud that is used here is ThingSpeak where all the data are collected and visualized as a plot graph. For plotting the collected data, a new channel is created in ThingSpeak, and the API key mentioned here must be given in the Arduino IDE program.

The wardrobe owner can periodically check this plot for ensuring whether the wardrobe is secured or not. This graph plot will be updated every 15 s. As already mentioned, the solution from Arduino UNO, which is finally in the form of binary

Table 1 OR gate truth table

A	B	$F = A$ OR B
0	0	0
0	1	1
1	0	1
1	1	1

digits, is recorded in this cloud as a plot. For the prototype, the ideal distance is fixed as 10 cm. The change in the plots according to the four OR gate conditions is given in Figs. 5, 6, 7 and 8.

These plots can be examined only by the user unless he has changed the channel settings to public view. As all the information from the sensors is finally transfigured to binary digits, there is no factual data that can be accessed by any hackers. Further, ThingSpeak is a secured cloud, and the API key generated is unique for different channels. Hence, it cannot be easily accessed by anyone. Even if the third party tries to hack, there is no such appreciable data in this cloud which can help them to retrieve the actual information.

Step 4: Integrating ThingSpeak with IFTTT

Now that the values are recorded in ThingSpeak, it is further integrated with IFTTT which is especially used for alerting the wardrobe owner whenever the thief tries to access the wardrobe without their knowledge. For this purpose, a new ThingHTTP is created in ThingSpeak. In IFTTT, a URL is given which in turn must be specified in the newly created ThingHTTP. Now, a new React is created in ThingSpeak, wherein the channel name, ThingHTTP name and the condition as to when the solution is 1 (when the thief is trying to access and there are changes in wardrobe), a trigger must be created in IFTTT application, are to be mentioned. Thus, whenever the condition is met, the trigger is activated in the IFTTT application and is made to send a notification and an e-mail to the respective wardrobe owner. The IFTTT is also an app, and the user gets notifications from this app when the trigger condition is met. Figure 9 shows how IFTTT alerts through mail and notifications on mobile phones.

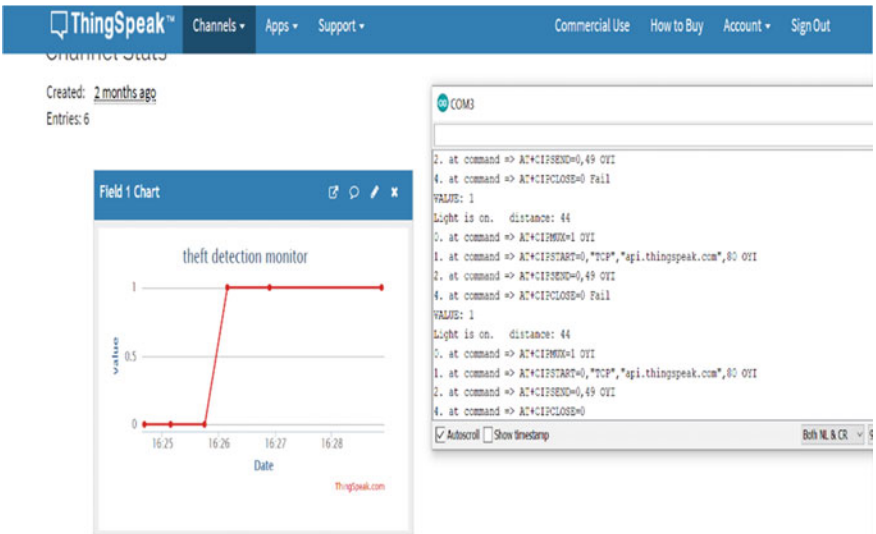

Fig. 5 When light is ON and distance is not 10 cm

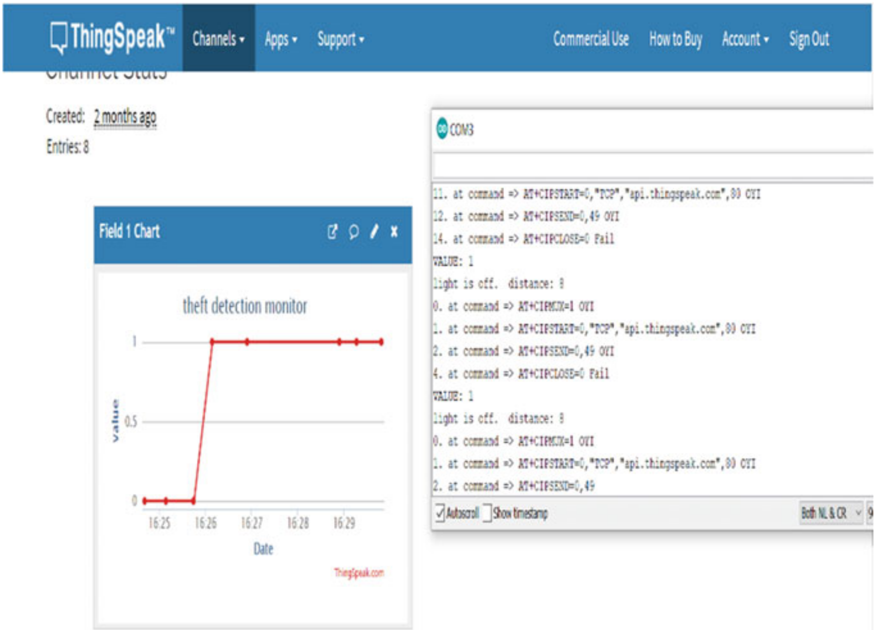

Fig. 6 When light is OFF and distance is not 10 cm

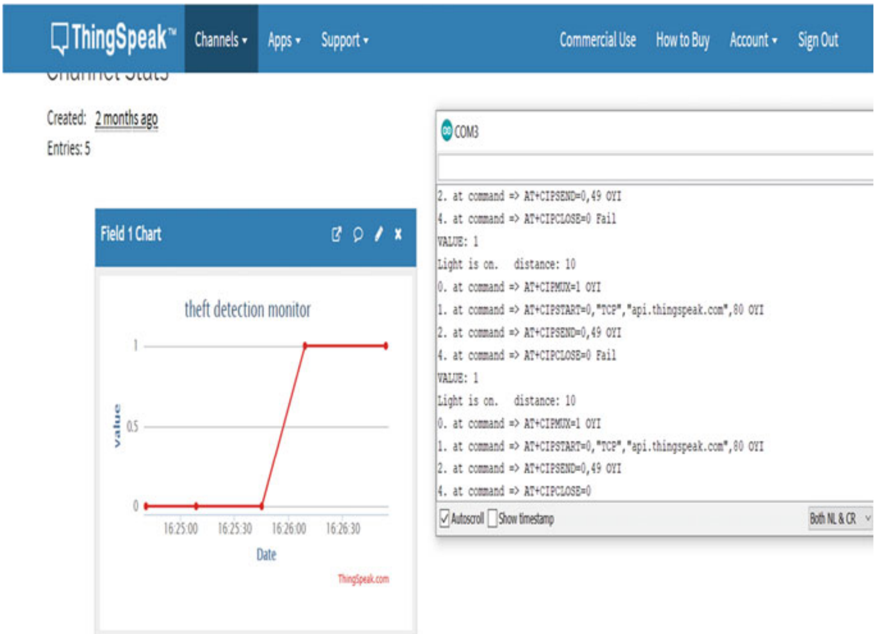

Fig. 7 When light is ON and distance is 10 cm

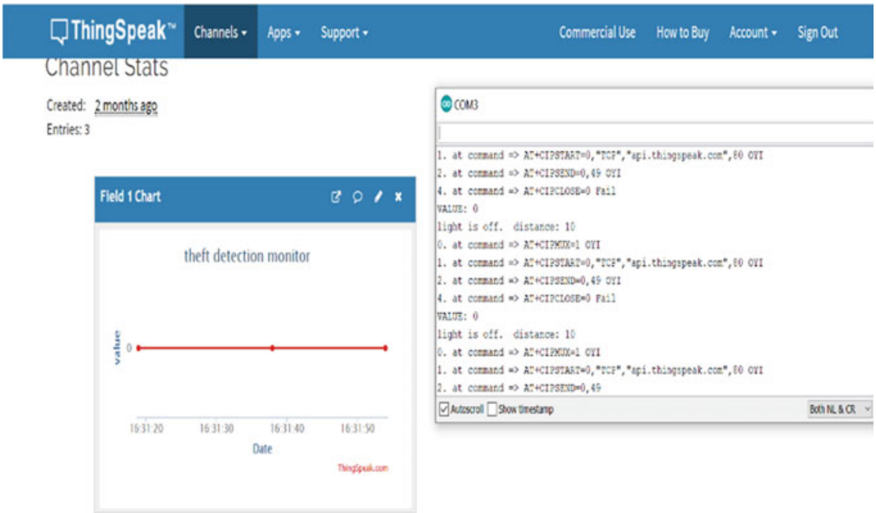

Fig. 8 When light is OFF and distance is 10 cm

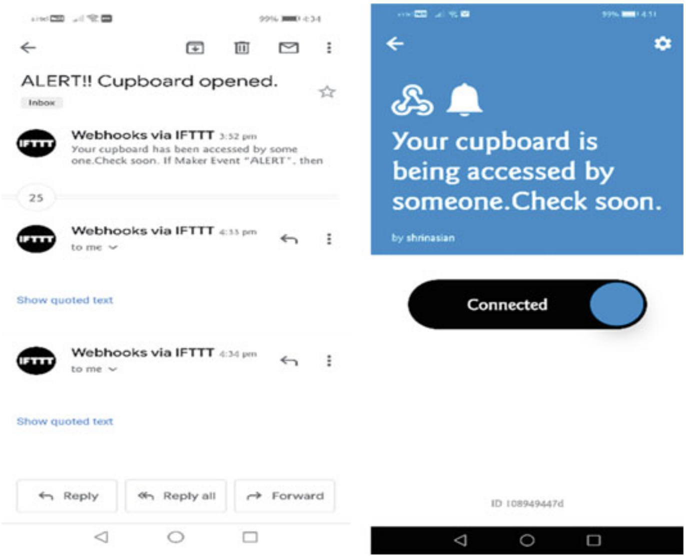

Fig. 9 Notification in user's mobile through mail and app stating wardrobe is being accessed by someone

5 Result and Discussions

The developed prototype uses the IFTTT application instead of the GSM modem for sending notifications, and so, the user may now wonder whether this prototype is accurate enough to alert. To prove the proposed model to be accurate, the system was tested under various conditions to make sure of the efficiency and the accuracy at which the wardrobe owner gets an alert. It is plotted as a graph given in Fig. 10, where the straight line indicates that the user has received the alert within a few seconds of the incident.

If the user has further insecurity about the wardrobe's safety, apart from tracking the ThingSpeak cloud, they can also keep an eye on the IFTTT app, notifications menu which is provided with two options namely view activity and heck now which is shown in Fig. 11. In view activity, the user gets all the records of notifications of when the cupboard has been accessed along with the time specified in it as shown in Fig. 12. The check now option can be opted by the user to check currently whether the wardrobe is safe or not. If there occurs any notification or e-mail from IFTTT, then the wardrobe has possibly been accessed. The check now option is just a backup for the user, in case if the user is very much uncertain about the wardrobe. Otherwise, there occurs alerts regarding the threat.

The practical application of the proposed model has specific pros and cons:

Pros:

1. The model is user-friendly, cost-effective and demands no specific skills from the user for its initial installation.
2. It occupies minimum space and is placed out of sight.
3. It provides precise values under all conditions of the day and night.

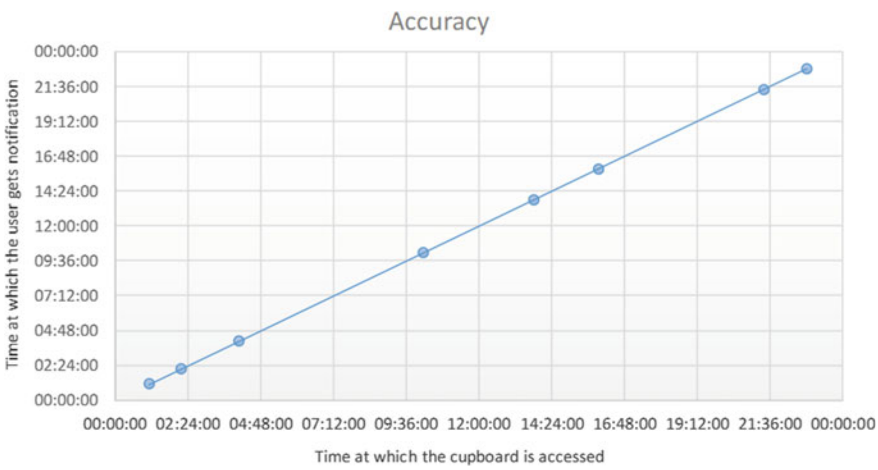

Fig. 10 Time at which wardrobe was accessed versus time at which users received the notification using IFTTT

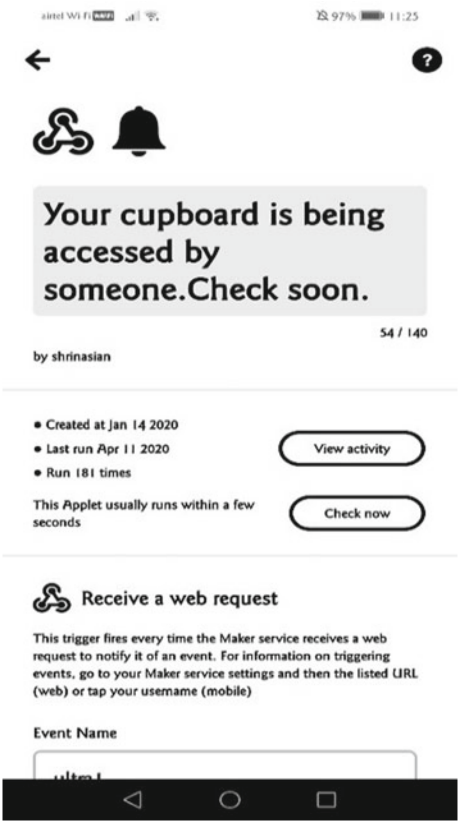

Fig. 11 Menu options

4. The sensors provide accurate results irrespective of the material under observation.

Cons:

1. ThingSpeak records information every 15 s.
2. The model does not prevent the burglary from happening but rather the intimates the user of the misdeed.

6 Conclusion and Future Scope

There is an increase in the theft cases in the villages, where a row of houses in the same street are being targeted at once. By hiring the proposed system, people can be alerted to safeguard their properties. This system is cost-effective, and hence, it can be acquired by anyone. If one has more than one wardrobe in their house, they can buy as many as required. This product can further be operated using a switch to

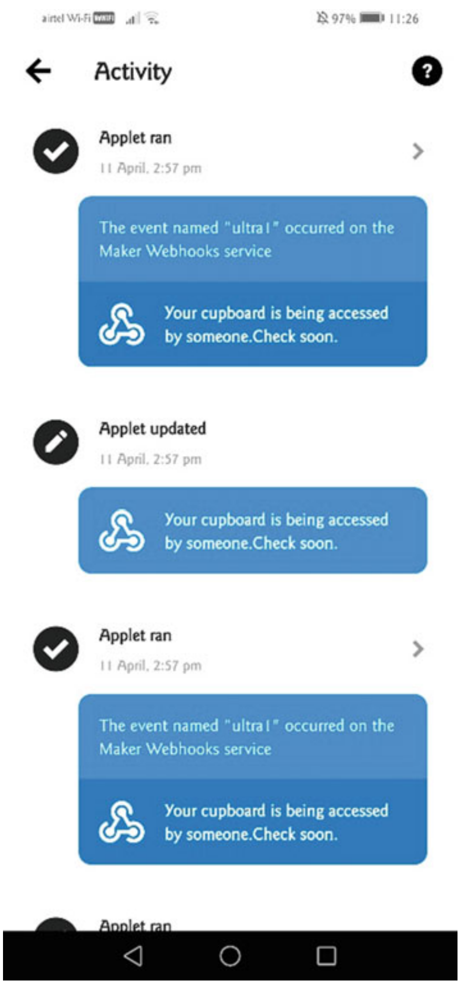

Fig. 12 Record of notifications

have control over power consumption. In many of the case studies, it is seen that the burglars even go to the extent of killing people. Hence, it is recommended to operate this model even when people are alone to get alerts about the theft.

The future work of this proposed system is to convert this prototype model into a full-fledged working product and to make it available in the market for better usage. Further, a suitable vibration sensor can also be added to make the system more sensitive to touch, and the prototype can be linked with image processing using the surveillance camera to capture the image of the thief for easier investigations. The IFTTT application can also be integrated to send notifications to neighbors and the nearby police station to alert them of the theft for the right timely action to be taken. The usage of the ESP8266 Wi-Fi module connected to the Arduino UNO for wireless communication, using AT commands to retrieve the results obtained in the

Arduino and the passage of this information to the cloud platform of ThingSpeak for further analysis is indeed a time-consuming process with a delay of 15 s to provide an alert. In order to reduce the response time of the model, the IoT cloud platform of ThingSpeak can be replaced with an efficient GSM module which can directly be connected to the Arduino UNO, thus enabling a quicker action in sending SMS to the user.

This product can also be hired for alerting and securing motors, vehicles and many other commodities. The proposed model can also be employed to use in the main door of the house. While considering the fact of a full-fledged product, a set of advancements available at that time of market expectations will also be incorporated within the proposed system to make it an effective product to work along.

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