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A proposal for developing and analysing an IoT based prototype to aid visually-challenged persons in Oman

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Abstract:

This paper proposes the development of a IoT based model to aid visually impaired persons in their day to day activities. The model proposed will have controllers and electronic sensors along with a power compartment and will act as a guiding apparatus to help the person to discover obstacles in his path. The said model also will act as an alarm in case of emergencies, when the differently abled person needs assistance in required situations. It will also be used to share the user's state and location with his friends and relatives when in need, employing Internet of thing (IoT) technology. One function of this will be to send message to the concerned users in case of emergency, like after sensing that the user is not holding the stick for a stipulated amount of time. In the second part of this paper, user based analysis of the visually impaired IoT will be collected from users in Oman. The feedback consists of questionnaires which are given to visually challenged users in a rehab Center in Oman will help to understand the relevance and applicability of this model. The final part of the paper will analyse the taken feedback, regarding the convenience and usability of the proposed model for users here.

Keywords **—:*IoT, SBC, visually-impaired aid apparatus, sensors, usability, feedback, Oman rehab center, controllers*.**

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I. INTRODUCTION

Visual disability is a handicap that affects people form leading a normal way of life Most of the times they are totally restricted and dependent on others for even doing their daily chores [1]. With the use of a guiding apparatus or technique, if they can achieve a means to find the obstacles in the path and also has features to relay emergency information to their near ones, visually challenged people can lead a near normal life. [2] This is the first aim of this paper. Another aim of this paper is to analyze by feedback visually challenged users in a rehab center in Oman, how a new walking aid model employing Internet of Things will help and improve the lives of differently abled people. First part of the paper will propose a model, that will employ a small single board computer(SBC) along with sensors that will be used to sense obstacles and a button for alerting others. The SBC that will be employed will be cased inside a water tight hollow portion with wires connecting the sensors and actuators. The sensors proposed are the obstacle sensor and the distance sensor, which will be located facing the path and do the needed functions to guide the visually impaired person. The SBC will also control the actuators like vibrating motor and the buzzer. The programs giving logic for sensing and actuation will be coded using Python. The model will measure the distance of the obstacle present using one ultrasonic sensor. The combined output from both sensors will be fed to a SBC and thus will have the aim of alerting the user regarding any hazard or obstacle in the way and also to share the user's state and location with his friends and relatives, when in need. This part will employ Internet of Thing(IoT) to send message to the concerned users in case of emergency, like after sensing that the user is not holding the torch for a stipulated amount of time or on the click of a button.

In this model, the SBC used will be Raspberry Pi [3]. All the sensors are located facing the path and do the needed functions as given above. The first sensing will be done by the obstacle sensor and the next one will be done by the distance sensor. The input given to the SBC will be distance and the output from that will signal the vibrating motor to be activated, and to sound the buzzer. Along with these components to be connected to each other, correct implementation of the programs needed to give logic for sensing and actuation. This paper will also analyze the user convenience to use the device that uses this model, without the help of any one to install or assist the person to set it up or wear it. Final part of the paper will be thus to analyze the feedback from the users regarding the convenience of the model.

II. CONFIGURATION

The following table shows the devices that will be used for the model

TABLE 1
DEVICES USED IN THE CONFIGURATION

Serial number	Sensors used	Actuators used	Communication devices	Controller used
1	IR Obstacle Sensor-RKI-3141	Passive buzzer-5V	GSM module SIM900	Raspberry Pi 3
2	Ultrasonic measurement sensor-HC-SR04	Vibrating motor-5V	-	-
3	-	Push button-3.3V	-	-

a. IR Obstacle Sensor

Infrared sensor module obstacle is used for sensing road-blocks has built-in I.R.-transmitter and IR-receiver. Specifications of IR sensor are given as below-

- Operating Voltage is 3.0V – 5.0V
- Detection range is minimum range of 2cm and maximum of 30cm

It works by sending out infrared rays and then looking for any IR radiations getting reflected. This will help the model to detect presence of any blockage in front of the sensor setup. The module is also equipped with a potentiometer that has a screw which can be adjusted to fine-tune the exact range needed and thuschange the detection range. One good feature of this sensor is that it does not need any visible light and gives response in ambient light and also in pitch darkness. When obstacle is detected, the sensor gives an output of Low logic, which can be detected in the signal pin that will be transmitted to the SBC [4].

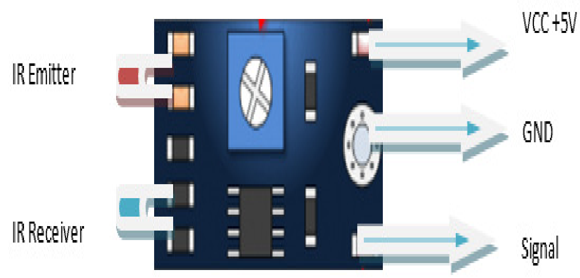

Fig. 1- IR sensor pins

The following setup shows the IR sensor connection to a SBC. Here IR is connected to the GPIO4 of Raspberry Pi. IR Light Emitting Diode emits the IR rays which are caught by one Infrared photodiode and thisopto-coupler setup can easily detect any reflected or deflected infrared radiation. As the model's sensor emits IR radiation periodically, if it hits any obstacle it will be bounced backed which is caught by the receiver. [4] This will be shown

in the sensor as Active low in signal pin GPIO4 which can be passed on the Raspberry Pi.

Fig.1 - IR sensor pins

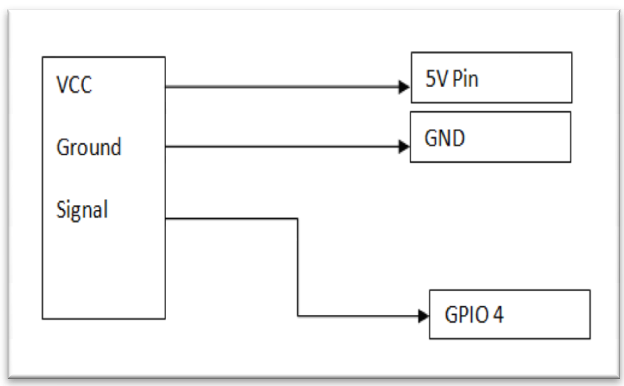

Fig.2- IR connection with SBC

b. Ultrasonic measurement sensor

The above sensor will be used to measure the distance to the obstacle encountered in the setup mechanism. The module consists of four pins usually, one for VCC with a voltage tolerance of 5 V. Another pin will be grounded and the rest two pins are for actuating the ultrasonic signal and the last one for collecting information on the distance by scanning the reflected wave from the object fromwhich the sound got reflected. The pins for activate and echo can be connected to the GPIO header of a Raspberry Pi.

The module that is used is a model called HC-SR04 module with small size having dimension 10.5cm x 5 cm. There are two transducers which are used to give out and sense the ultrasonic sound, giving it a distinctive appearance. The working of this module with a single output and input pin is as follows. It sends out an ultrasonic sound pulse for a stipulated time interval and the program will run measuring the time taken for the sound to reflect back. This time value is fed to the program in the SBC that will calculate the distance the pulse has travelled from the sending transducer to the receiving one [5] .

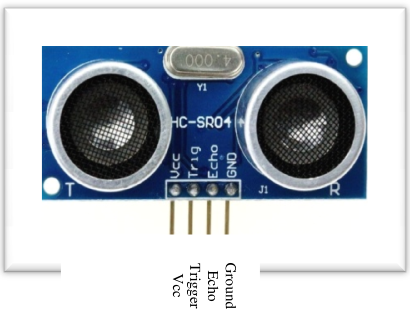

Fig.3- Ultrasound distance sensor

c. Ultrasonic sensor pin layout

The sensor VCC pin is connected to pin 2 or 1 of Raspberry Pi. Alternatively, VCC can be supplied by a dedicated battery or rechargeable power-bank also. Then the needed in and out pins are connected to the pins GPIO 23(trigger pin) and GPIO 24(echo pin). The input pin is marked as trig and will trigger the start of sending an ultrasonic wave using the 5V signal which runs its electronics. The module can work in 3.3V positive current also which can be given from the Raspberry Pi GPIO dedicated 3.3V pin. The sensor gives its output, and the input is taken using echo-pin. Here the program will measure the time taken when the module receives a reflected ultrasonic signal which is read in the echo pin giving it a logical high (+5V). The program will measure the time for which the pin stays high. As 5 Volt will be high for the chips that control the module, two resistors (330 and 470 ohms) are used as illustrated below to act as a basic voltage divider to ensure the SBC gets its input as 3.3V to measure. This will measure the time taken, from which distance to the obstacle can be measured.

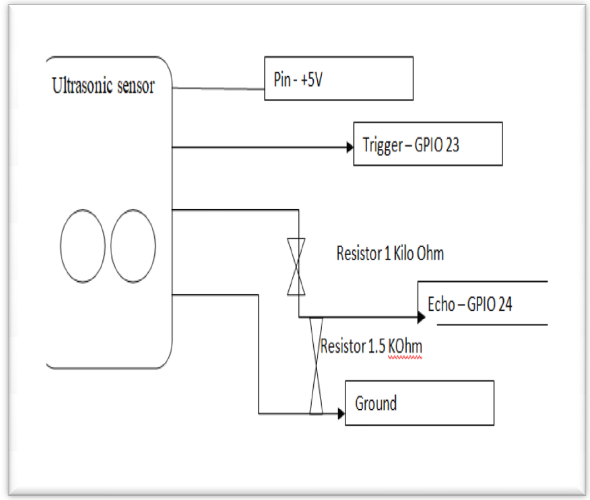

Fig.4- Distance sensor setup with SBC

d. Push button and GSM module SIM900

The button will be another sensor device that can be used for activating the sending process of a message over internet, if the user is in some emergency. The signal pin out of the button can be connected to GPIO 26. GSM module will be connected using pins 8 and 10 of SBC to the Rx and Tx pin of SIM900. The module will be powered by a 5V battery as shown.

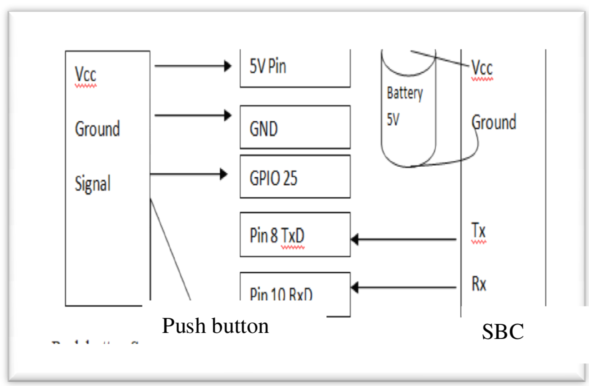

Fig.5- Push button and SIM900 connection with SBC

e. Actuators-Buzzer and vibrator motor

The buzzer and vibrator motor will be the actuators that can be connected to the GPIO6 pin GPIO5, and grounded accordingly.

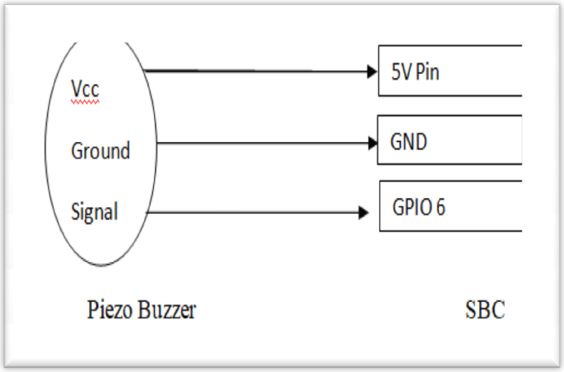

Fig.6- Buzzer connection with SBC

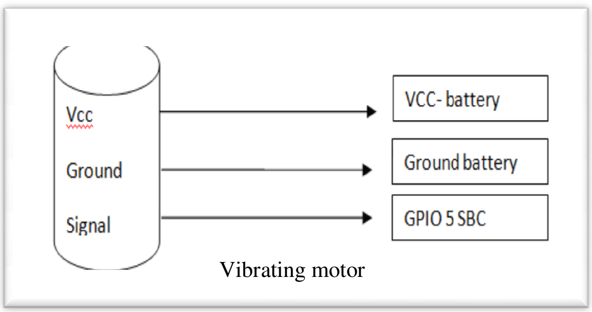

Fig.7- Vibrating motor connection with SBC

III. DESIGN

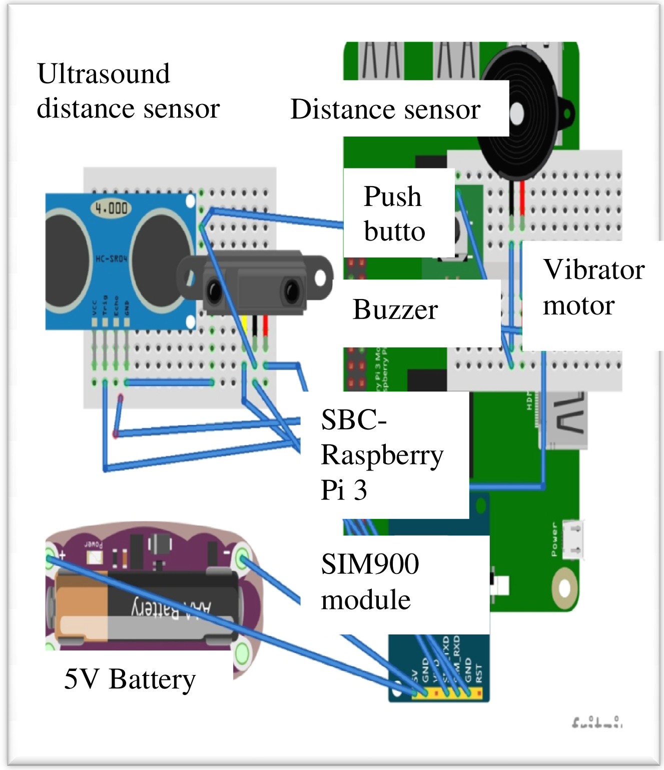

Fig.8- Fritizing Circuit diagram

The above circuit diagram for the proposed model was created using the application Fritzing which is open-source hardware modelling software for creating illustrations, which includes the needed electronic parts, sensors and needed SBCs or microprocessors. [6]

IV. IMPLEMENTATION

In this model, the prototyped sensors, actuators and needed electronics are connected using jumper wires to the SBC separately. This way the testing of distance, ultrasonic sensors can be checked individually by connecting them separately with the SBC. After the test results shows correct results it can be connected all together. After testing all the sensors, connection to the sensors and actuators are given to the Raspberry-Pi. As per the initial model, it can be designed as a torch that contains sensors which will face the ground. Ultrasonic sensor which will be measuring thedistance aids the mechanism and has the following pin layout. It is connected to the 5 V pin of SBC which is pin 1 or 2, the trigger pin to pin number 7, and the echo pin to pin number 35. The negative or Ground can be connected to the Ground of Raspberry Pi which can be pin number 9. Measuring the distance can have some issues due to the fact that the obstacle sensor can measure obstacle only when it's placed vertically. It can also measure obstacles with a minimum distance of 15cm or more. The obstacle avoidance sensor will be connected to the SBC pin as mentioned in the above setup and the sensor can be used to detect obstacles which can come within a range of about 6cm from the mechanism.

The buzzer and vibrator motor will be the actuator that can be connected to the GPIO6 pin GPIO5, and grounded accordingly. The button will be another sensor device that can be used for activating some alarm or send a message over internet, if the user is in some emergency. The signal pin out of the button can be connected to GPIO 26. This button can be placed on the side of the walking stick so that the user can use it with ease when needed. All the other sensors will be included in the model in the bottom part of the model. This setup can be made more useful by means of a vibrator-motor that will be fitted in the handle, preferably attached below the rubber grip wound around it. The buzzer will make the alarm sound whenever an obstacle is present so that that the user can avoid the obstacle from a distance. Buzzer will be used to alert the user of any hindrances in the path which gives a shrilling sound, hearing which the user can pause and take a new path. But in case the user somehow missed the sound, the next sensor which is the distance sensor which will be measuring the distance for nearby obstacles in the order of less than 10cm. After that is realized, the sensors output is read by the SBC that will activate the vibrator motor which will give a strong vibration to the user handle. This will give an immediate sensation to the user regarding the imminent danger in the form of obstacle for which the user can take a remedial action. Lastly but not the least, in case the user is in some sort of help or emergency, the last help for him can come in the form of the push-button attached. This mechanism will need a GSM module also to be attached to the setup for sending immediate short message or can activate a call to any number that is pre-fed to the system. The module can still be functional using the inbuilt Wi-Fi of the Raspberry Pi and the below said IoT portal gives an option to send SMS. A battery will provide the 5V Voltage required for the GSM module without interruption.

For the Internet of Everything (IoT) connectivity, the web-portal Cayenne was tested which gives us connection to the internet using GSM module or inbuilt Wi-Fi. The SBC can be controlled once we set it up so as to manage the sensors and get the real time information on the signal states. The following steps will be needed for the working ofIoT-First step will be to add the needed sensor which gives digital output to the site and then give the correct button interface for the SBC. Trigger will be created next that will act based on the configuration that will be given as follows. The below triggers will ensure that the buzzer will be activated even if the SBC –code is not running because of some reason.

- As obstacle sensor is actively-on by default and the first trigger will make the actuator passive-buzzer sensor to be off.
- On getting activated the passive buzzer should be made on whenever the sensor above gives a signal off or zero as it means that it has detected one obstacle.
- On pressing the button in case of some emergency, a SMS will be send via email and also the provided phone number. This will be the next trigger that will be given in Cayenne API.

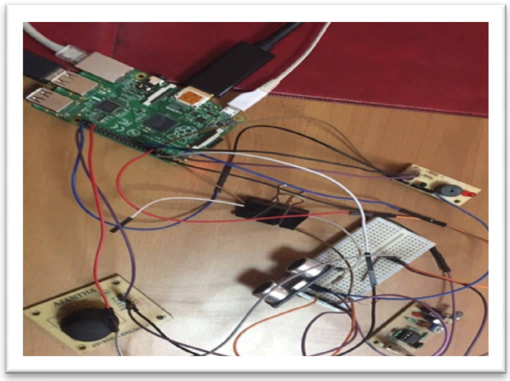

Fig.9- Physical setup of devices and controller

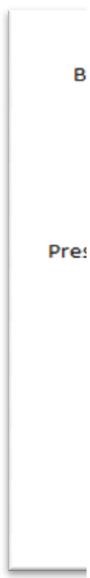

Fig.10- -Model setup of the various devices

V. RESULTS

The above model was tested using a miniature model in a test bed and the results were obtained as shown in the below screenshots and images given. As the obstacle was introduced before the test-bed, at a distance of 15cm, buzzer got activated. The buzzer was programmed to ring for 15 seconds. On ignoring the sound, as the mechanism was moved forward toward the obstacle, at a distance of 10 cm, the ultrasound sensor picked it up. It activated the vibrating motor which ran for 8 seconds intermittingly for 3 times, as coded. Along with that text-message, email messages were also received on button click, as programmed in trigger code.

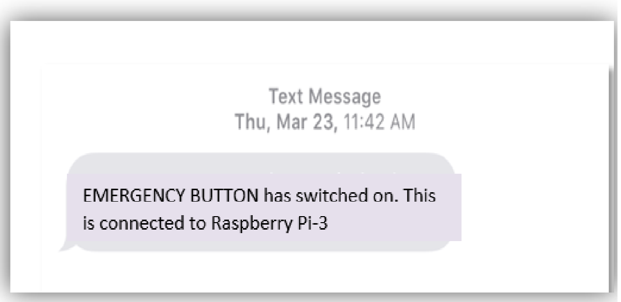

Fig.11-Emergency button press- SMS received

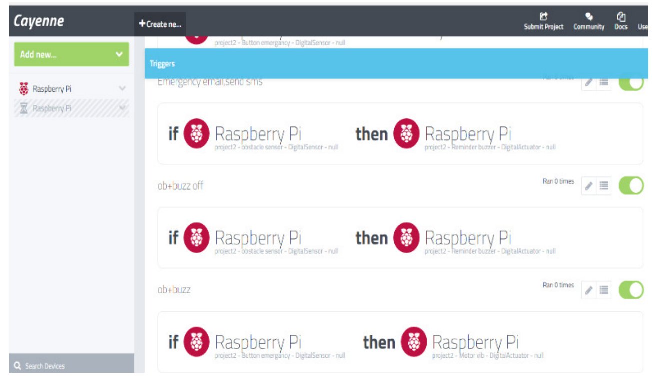

Fig.15- Triggers coded in IoE portal Cayenne

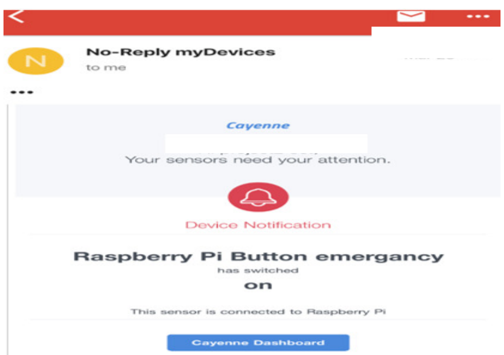

Fig. 12-Email received on Emergency button press

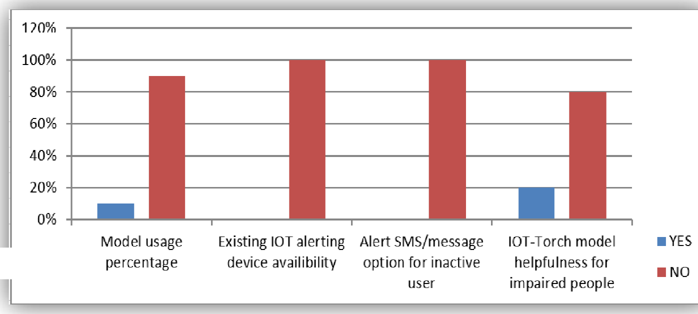

Fig. 16- Bar-chart showing usage and availability of IOT model

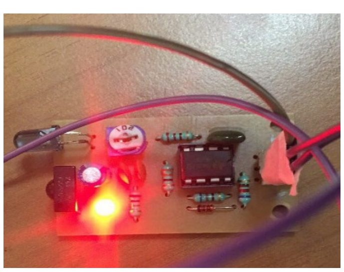

Fig.13-Inbuilt LED of IR-sensor activated

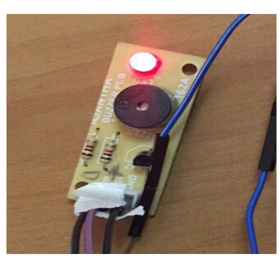

Fig.14- Buzzer LED activated as omes High

TABLE 2
TESTING OF MODEL

Distance to obstacle	Sensing device	Actuator activated	IoT activation
15.1cm	IR obstacle	Buzzer	No
9.7 cm	Ultrasonic distance	Vibrator motor	No
N.A.	Button press	Cayenne IoT-trigger	SMS and Email received

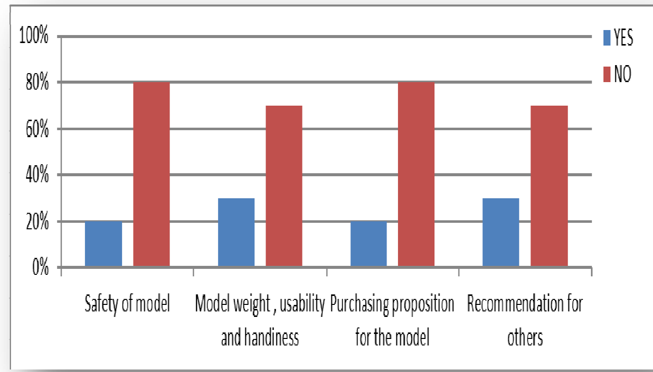

Fig.17-: Bar chart showing usability and satisfaction level

After testing, a model was given to a user group of 20 persons who are fully or partially impaired. The feedback was taken as a questionnaire which were closed ended. The

feedback intended to find the answers to the current availability of these kind of visually impaired models in the market first. Then the next part of the feedback analyzed the usability, convenience and impact of this IOT based model for the visually impaired people. The data collected were recorded and analyzed with representation using bar charts. It is given below in Figure 16 which gives the results of usability, existence of these models, alerting facility if it's there, and helpfulness if its available for use. The next feedback given in Figure 17 show the usability and satisfaction level of the model, which includes safety, weight of the model as well as purchasing inclinations if available in the market.

VI. SUMMARY OF FINDINGS

a. Testing the model

The testing was done using the above set of sensors, SBC and associated actuators. In this sample test-bed, the following observations were obtained. The first line of action was initiated by the IR-based obstacle sensor that picked up the obstacle lying at distances from 15 to 20 cm. this was sensed a few number of times which made the alarm sound by the buzzer. Second activation was done for the vibrating motor by taking the input received by ultra-sonic distance sensor which measured obstacles at distances 10 cm or less. The next checking was done using the emergency button that will verify the working of IoT connectivity using the Cayenne portal. On clicking the button, the portal sensed the input and sent SMS and email to the registered phone number and email-id respectively. The tests were conducted in a lab setup and the average results are tabulated as below.

b. User analysis of the feedback conducted for the model

The study as shown in Figure 16,17 reveals the analysis of the feedback with respect to the current status and impact of IOT based system for physically challenged and visually impaired people. In the research study, information was gathered using dichotomous questions methods and these data were analyzed accordingly. Feedback was collected from a total sample size of 20 participants from a rehab center in Oman. Analysis from the collected feedback given in the following figures reveal that this type of IoT based warning system is not used by 90% of the people surveyed. Based on the data analysis provided by the users shown in figure 16 and 17, it can be inferred that the model can be preferred for use, based on the features and benefits that this IOT based torch model provides. In average 75 percentage of the consumers agreed that this model can be very useful for the visually impaired people, whereas an average of 22% percentage surveyed users feel that this system can be improved with more features.

VII. FUTURE SCOPE

Features like geo-location using Google maps or MapQuest can be employed, that can pin point the exact location of the disabled person if he is stranded outside. This will help the user's relatives or friends to a great extent and can get the help of aid-agencies to reach the person. Instead of using buzzer sound or vibrator to alert the user, playing pre-recorded voices to give direction to the user will be more helpful. It can be done using AWS services that using AI to listen to voice commands and give necessary audio directions too. Another way is to incorporate voice libraries that uses MP3 recorded files that can be played using a speaker attached. Microphones will be needed if voice enable support is needed using AWS.

The setup of this mechanism is designed to be inside a torch like model, but can become bulky when all sensors, actuators along with the SBC and battery are attached to it. Instead of that, the setup can be designed to be a wearing device and can be in the form of a watch or can be installed at the tip of a light weight walking stick which can make the mechanism lighter, usable and effective.

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