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Design and Implementation of a Smart Assistive System for Visually Impaired People Using Arduino

Saidur Rahman
Lecturer, Department. Of the Computer Science and Engineering
Daffodil Institute of IT, Dhaka, Bangladesh
Email: saidur@diit.edu.bd

Chandan Debnath
Student Department. Of the Computer Science and Engineering
Daffodil Institute of IT, Dhaka, Bangladesh
Email: chandan1410@diit.info

Tahmina Aktar Trisha
Lecturer, Department. Of the Computer Science and Engineering
Daffodil Institute of IT, Dhaka, Bangladesh
Email: tahmina@diit.edu.bd

Abstract: *Now a day's many visually impaired people face many problems when they walk on the streets or roads. These visually impaired people need a device which is used in avoiding an obstacle and also aware people by using voice guidance. In order to detection, the obstacles visually impaired people use a stick when they are walking but this instrument just can help them find objects on the ground. Our proposed system is a cost-effective automated device, which detects the objects by the ultrasonic sensor for blind people that makes easy the walking environment and help the visually impaired people to hear the distance of the obstacle by using Bluetooth module with android application, which generates human voice through a mobile headphone.*

Keyword: *Android; Arduino; Bluetooth Module; Human Voice; Microcontroller; Ultrasonic.*

1. INTRODUCTION

Viewing the surroundings picture of this beautiful world through vision is such ability gifted by Almighty Creator that due to lack of vision, the existence of human life seems incomplete and meaningless. But it is a matter of thinking that there are lots of people in the world are carrying their lives without having the ability to visualize the beautiful things of the world. To them, the universe is nothing but a black hole. According to statistical data globally, every 5 seconds one person goes blind and every minute one child goes blind. According to WHO statistics, approximately 1.3 billion people in the world have vision impairment, of which 36 million are totally blind. 217 million have moderate to severe vision impairment due to uncorrected refractive errors [1].

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According to the WHO, 87% of the visually disabled live in underdeveloped countries. Eye specialist say 80% of blindness can be cured. Moreover, 75% of the population of Bangladesh lives in remote villages with few basic facilities. Bangladesh has almost 700,000 blind people, of whom 40,000 are children under the age of 15 [2][6]. The condition is very difficult for a visually challenged person in every aspect of the life especially outside of the home and in working place. It is quite impossible for a visually impaired person to move into a busy road or crowded place or even plain but unfamiliar areas without helping others or any equipment.

Advanced technologies have become hope for visually impaired people in recent times; the concept of the assistive technology for the blind is not so ancient. Among all these technologies; Smart Walking Stick that performs a fresh dimension of useful assistance and provides a little bit of artificial vision [4][5]. The Guide Cane a fancy device is designed to reduce hazards faced by a blind pedestrian. The NavBelt is a wearable device that gives acoustic feedback in two distinct modes of operation: the guidance mode and

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the image mode. However, these devices have some specific limitation such as they can do only a specific task [3][7].

This paper proposes an embedded device and a user self-customized android app “Easy way” to assist the visually impaired people by telling the distance of obstacles in the form of human voice. It is compact, lightweight and has an ultrasonic sensor to measure the distance of the obstacle in front of the user. The device uses Arduino microcontroller and provides output in the android phone.

2. THEORATICAL EXPLANATION

In the proposed system, we have used a re-programmable open-source microcontroller device “Arduino Uno R3”.It use“ATMEGA328P” microcontroller so it is easy to customize the system program. For measuring the distance, there is an Ultrasonic sonar sensor “HC-SR04”. Bluetooth module “HC-05” is used to send the data from the device to the Android phone. This module can be used in both slave and master mode. At last, the android application “Easy way” is used for receiving the data by Bluetooth module and converts it as a human voice.

2.1 OBJECT DETECTION AND DISTANCE MEASUREMENT

For detecting object our system has used ultrasonic sensor HC-SR04. The module consists of 4 pins, Ground, VCC, Trig and Echo.

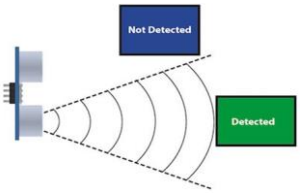

Fig.1: Ultrasonic sensor obstacle detection [9]

Figure 2: Ultrasonic sensor [9]

The Ground pin needs to be connected to the Ground and the VCC pins of the module need to be connected with 5 volts pins on the Arduino Board respectively [9]. The trig and echo pins can connect with any Digital I/O pin on the Arduino Board. It emits an ultrasound wave at 40 000 Hz which travels through the air Whenever there was an object or obstacles is in front of this sensor then the sensor works according to the following system.

From the aforementioned figure we can see that the green object is detected by the ultrasonic sensor and the blue object is not detected because the blue object is not in the ultrasonic frequency. So the sensor cannot measure the blue object and it can measure the green object distance correctly.

Sending Ultrasound: Ultrasonic sound vibrates at a frequency above the range, so human cannot hear. It has two drums, one is emitter and another is receiver. Emitter emits the ultrasound and it emits ultrasound for 10 microseconds high pulse. At this time the echo pins remain high.

So the equation:

$$\text{Distance}=\text{Speed} \times \text{Total Time} \quad (1)$$

Receiving Ultrasound: When any object reflects an ultrasoundit pursues the Ultrasound and receives it by the receiver as well as echo pin is made low. For measuring distance, the total time is stored in the Arduino. Therefore, to calculate the distance between the sources to object is half the time take to travel source-object-source. Then the final equation will be:

$$\text{Distance}=(\text{Time}/2) \times \text{Speed} \quad (2)$$

2.2 CONNECT WITH BLUETOOTH MODULE

Bluetooth module “HC-05” is used to send the data from the device to the Android phone. There is another Bluetooth module which also can be used, for example, HC-06.

Fig.3: Bluetooth module [10]

But the HC-06” module works only in slave mode This Bluetooth module “HC-05” can be used in both slave and master mode and it has a secure protocol. It is perfect for the short-range communication [11]. It consists of six pins Key, VCC, GND, TXD, RXD, and State. The Ground pin needs to be connected to the Ground and the VCC pins of the module need to be connected with 3.3 volts pins on the Arduino Board. The TXD and RXD pins can connect with any Digital I/O pin on the Arduino Board [8]. The remaining two pins Key and State will not be useful.

3. PROPOSED SYSTEM

In this proposed methodology there are three sonar sensors are used for object or obstacle detection in

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front of impair people. We propose to develop a system which implemented as, these their sonar sensors are attached in a following manner, one sensor is attached is on a pocket of a shirt, the second one attached on a position of a knee and the last one is attached on bottom of a leg.

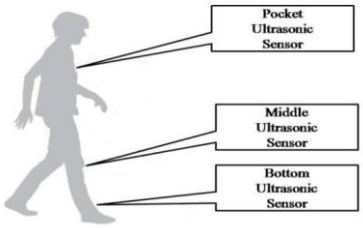

Figure.4: Position of Ultrasonic sensor

Our proposed system's block diagram as shown in Figure 5.

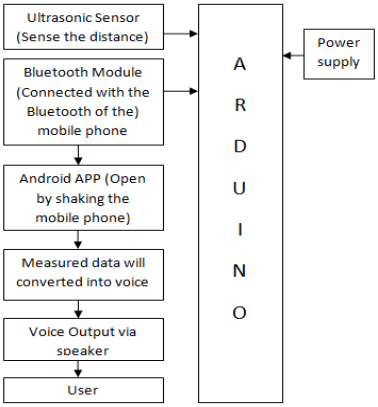

Figure 5: Block diagram of proposed system

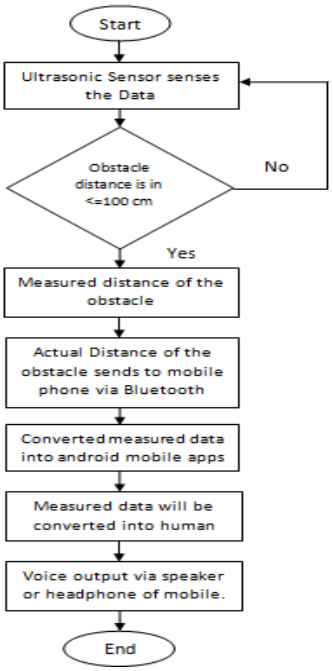

Figure 6: Flow chart of proposed system

we show a flowchart of our proposed system that will be clarifying the system very well. The flow chart (Fig. 6) of obstacle detector using ultrasonic sensor, which is having two parts, first part, deals with the obstacle detection while second part deals with distance measurement and alerting the user depending on distance of the obstacle to avoid collision. Finally, we got voice command from the device.

4. EXPERIMENTAL SIMULATION

The three mounted ultrasonic sensors operate at a same frequency. The alarm is generated when any obstacle is encountered in the threshold distance. A voice-controlled module is enabled instead of using a buzzer or an LED for the alarm signals.

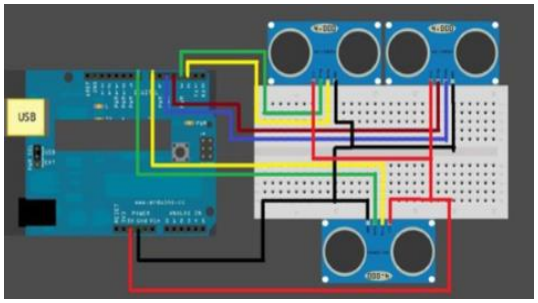

Fig. 7: UltraSonic Sensors Interface with Arduino Board

We were simulated our full project in Fritzing software which create a virtual environment for smart assistive system for visually impaired people using arduino.

5. EXPERIMENTAL RESULTS ANALYSIS

We used three sensors in our proposed prototype. Whenever there was an object or obstacles in front of this sensor, the buzzer began making sounds. If the users came less than 50cm near to the object and android application started voice command.
Result of Distance Measurement by Ultrasonic Sensors and Accuracy Rate shown below.

TABLE I DIFFERENT OBSERVATION FROM POCKET SENSOR

Actual Value (cm)	Measured Value From pocket Sensor				Avg. Measure value	Accuracy Rate
	Obs. 1	Obs. 2	Obs 3	Obs 4		
5	4.83	4.8	4.9	4.97	4.875	97.5
7	6.7	6.75	6.73	6.79	6.74	96.32
10	9.54	9.21	9.63	9.68	9.51	95.15
15	14.1	13.75	13.6	14.9	14.08	93.91
20	18	17.5	19.3	20	18.70	93.50
25	23.5	24	24.5	19	22.75	91

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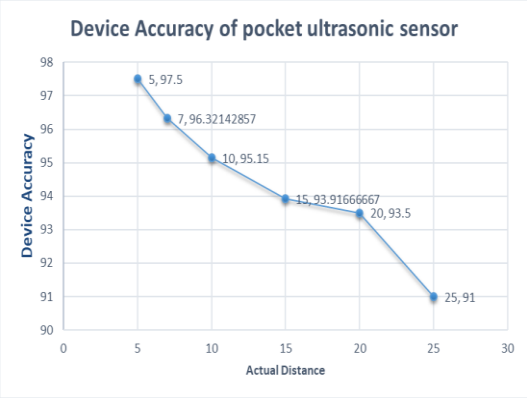

Figure 8: Accuracy Rate of Pocket Sensor.

TABLE II DIFFERENT OBSERVATION FROM KNEE SENSOR

Actual Value (cm)	Measured Value From Knee Sensor				Average Measure value	Accuracy Rate
	Obs. 1	Obs. 2	Obs. 3	Obs. 4		
30	28	28.5	29.5	29	28.75	95.83
40	38	37.5	37	39	37.87	94.68
50	46	46.5	47	47.5	46.75	93.5
60	55	54	55.5	56.5	55.25	92.08
80	73.5	75	72	71	72.8	91.09
90	82	82.5	81	80	81.37	90.41

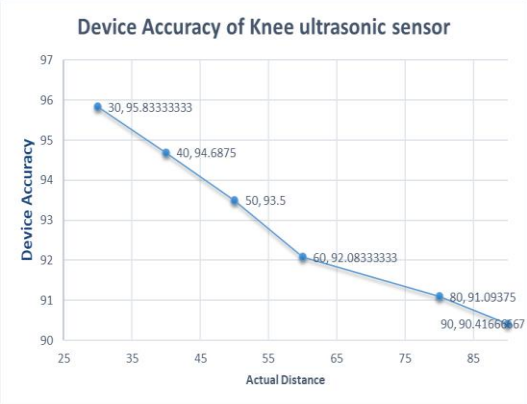

Figure 9: Accuracy Rate of Knee Sensor.

TABLE III DIFFERENT OBSERVATION FROM BOTTOM SENSOR

Actual Value (cm)	Measured Value From Bottom Sensor				Average Measure value	Accuracy Rate
	Obs. 1	Obs. 2	Obs. 3	Obs. 4		
95	94	94.5	94	93.5	94	98.94
100	98.5	98	99	99.5	98.7	98.75
110	108	108.5	107	106	107.3	97.61
115	112	112.5	110	113	111.8	97.28
120	116	115	116.5	117	116.1	96.77
130	124	125.5	124	125	124.6	95.86

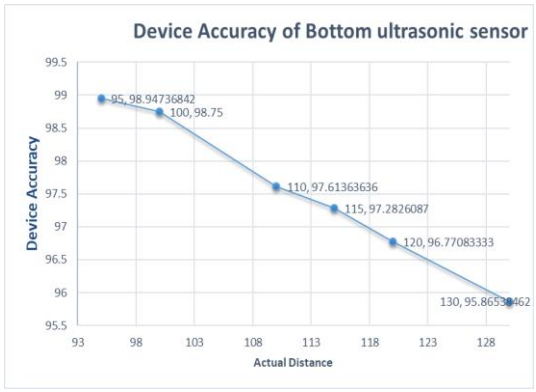

Figure 10: Accuracy Rate of Bottom Sensor.

Since the device is continuously moved while walking, the bottom sensor has to be fixed in its initial place to detect high heels or surface. The gyroscope and accelerometer module sent quite correct three axis values to Arduino and only one particular axis value is used here to maintain the fixed position of bottom sensor.

6. SOFTWARE IMPLEMENTATION

The most popular open source Web application tool for any learner is MIT app inventor, initially make available by Google, but now sustain by the Massachusetts Institute of Technology (MIT). MIT permits to assemble android apps for android oriented devices also Novices are able to expand their apps with less time than the traditional text-oriented programming Language practice. Our android apps is accumulate with MIT app inventor showcases the best features for the blind human is, by shaking his android mobile phone than the apps is turn on automatically without touching the mobile display whereas the data signal is passed via Bluetooth module and display the measured distance on mobile screen and send voice data through speakers or earphone as well as. So, he can get the exact direction for his movement whether the obstacle is detected.

When the obstacle is present on the top of the visually impaired person the audio output become, “You have obstacle on the top position”.

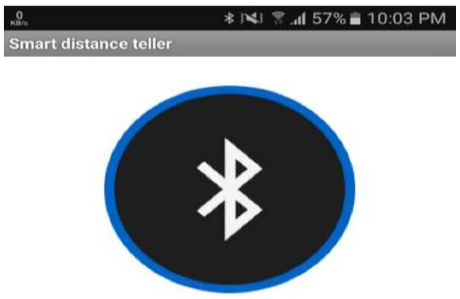

Figure 11: Android Application.

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When the obstacle is present on the middle position of the visually impaired person the audio output become, “You have obstacle on the middle position”. When the obstacle is present on the bottom position of the visually impaired person the audio output become, “You have obstacle on the bottom position”.

7. IMPACT OF OUR DEVICE IN HUMAN WELL-BEING

There is no scope of denying that technology has emerged impact of furtherance in human lifespan. We have to congest all this technical feasibility into a practice for human well-being. Focusing on millions of visual impaired people who regarded as burden of the society as they can’t ensure doing any activities without help, to make their movement easier our navigation system is so much expedient for them. Our system can detect obstacle and measure three pin point distance from chest, knee and heel point of human impaired people and also give a voice alert notification of distanced obstacle to him by mobile application for mind awareness for calculating as which point he shouldn’t take steps or not. It’s very low cost and approachable for visual impaired people for better movement as they can get enhanced provision.

8. CONCLUSION

This paper proposes a new design which aids the blind people to walk without any collision with obstacles. The obstacle may reside on the still left, right or straight. The reactions will be given based on the obstacle’s position and distance. This developed prototype facilitates free and self-reliant movement by a blind person, a clear idea about obstacle in his native language. This device is light in weight and its operation is not very complex. This idea can play a vital role in the research of giving sights to millions of blind people throughout the world.

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Authors Biography

Saidur Rahman, is a Lecturer of the Computer Science and Engineering Department in Daffodil Institute of IT. He completed his B.Sc.in department Electrical and Electronics Engineering (EEE) at American International University of Bangladeshn (AIUB), M.Sc. in Electronics and Telecommunication Engineering (ETE) at Daffodil International University. His research interests are Computer Networks, artificial intelligence, communication systems, IoT, Robotics**.**

Chandan Debnath, is a student of the Computer Science and Engineering Department in Daffodil Institute of IT. He completed his B.Sc. in department of Computer Science and Engineering under National University. His research interests are Robotics, Machine Learning, and networks security.

Tahmina Aktar Trisha, is a Lecturer of the Computer Science and Engineering Department in Daffodil Institute of IT (DIIT). She completed her B.Sc. in department of Computer Science and Engineering (CSE), Dhaka City College, Under National University of Bangladesh, and M.Sc. in Computer Science (CS) at Jahangirnagar University, Savar Bangladesh. Her research interests are Machine Learning, Computer Architecture, Network Security and IOT.

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