An Electronic Device to Assist the Blind Using Ultrasonic Sensors

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Abstract- The blind people cannot get information of their surrounding environment for example they cannot see any obstacles and hazards in their path. According to World Health Organization (WHO) report there are 285 million visually impaired people among which 39 million are totally blind. Blind people mostly use a white cane or a guide dog for their assistance. However, these techniques are limited as they do not guarantee risk avoidance for the blind people.

This paper proposed to develop an electronic device for obstacle detection in the path of visually impaired people. The device assists the user to walk without colliding with any obstacles in their path. It is a wearable device in the form of a waist belt that has ultrasonic sensors. This device detects obstacles around the user up to 300 cm in three directions i.e., front, left and right using a network of ultrasonic sensors, three sensors on the belt and one on the head. This design is beneficial in terms of it is portability, low-cost, low power consumption and the fact that neither the user nor the device requires initial training. The device is tested, by placing various obstacles at different locations of sensors on the belt. The system has successfully warned a user about obstacles in their path. It can detect any object within the minimum preset distance in any direction.

Keywords: blind, ultrasonic sensors, electronic device, visually impaired, obstacle detection.

I. Introduction

According to World Health Organization (WHO) report there are 285 million visually impaired people around the world, out of which 39 million are blind. According to WHO the number of blind people will increase and will double by 2020.It is difficult to move or walk for blind people as they have no information about their environment.[1]
The eye is one of the most important senses that enables a person to perceive objects, their shapes and colors, and through them he can estimate distances and distinguish between objects and lights [2]. Because most partially sighted or blind people live in developing countries, the assistive device should be both relatively affordable, from a financial point of view, and easily available [6].

About 90% of people with visual impairment live in developing countries. Uncorrected refractive errors around the world are the main cause of low vision, but cataracts remain the most important causes of blindness in low- and middle-income countries.[3] And based on the previous percentages of the blind, which are almost high, we have directed our attention to thinking of what helps them to make their moves as naturally as possible. An assistance system has been proposed in this research work which aims to assist the blind, which will be based on ultrasonic sensors.

II. Literature Review

D. Vijendra [7] designed prototype of Wearable Technology that assist Visually challenged/Blind people Commutation using Ultrasonic mapping based on Ultrasonic Sensor. Main objective was to develop a small, comfortable and user-friendly device to detect obstacles ahead of a Blind/visually challenged person. The idea is to develop a Jacket with the belt to help to make the Blind/visually challenged people commutation easier and safe. The proposed model has the benefits over the conventional methods in terms of design time, production Cost & power consumption.

Aliaksei [8] reported about a low-cost, open-source navigational support system using ultrasonic sensors is developed. It utilizes one ultrasound sensor with one or two vibration motors in a 3-D printed case to make the system compact and easily fixed on the wrist as a bracelet. The developed Arduino software performs distance measurements in the full sensor range from 2 cm to 4 m according to the ultrasound sensor specifications and implements an algorithm that uses the motors as low- and high-frequency vibration sources. The system is quantified for range and accuracy to help visually-impaired people in distance measurement and obstacle avoidance including the minimal size of the object.

Sampath [9] followed different methodology which uses ultrasonic sensors which are mounted on a jacket. The design was capable of classify obstacle depending on their nature. Basic purpose was to satisfy three criteria. indoor targets such as edges, corner, plane and open area. ground level objects like pit, staircase or any other obstacle. object which has different shapes and surfaces areas like wall, window, chair etc. the experiment gave much better results. It is mainly because of the surface of the objects. Plain surface is a good reflector. Whereas the corners, edges failed to give a reflection.

III. Proposed Design

The proposed design makes use of Ultrasonic Sensor that detects objects by sending a short ultrasonic burst and then listening for the echo.
The Arduino Uno connected to the sensors calculates the distance from the object based on the time the echo took to come back. Next, we generate a Text output based on the distance calculated.
This text output is converted to audio or vibration format, and then transferred to the blind using a vibrating motor or alarm. This system could be integrated on top of a belt, making it portable.
This system is made up of five main components: (1) Ultrasonic Sensors, (2) Arduino Uno, (3) Power Source, (4) Motor, and (5) Buzzer as shown in Fig.1.

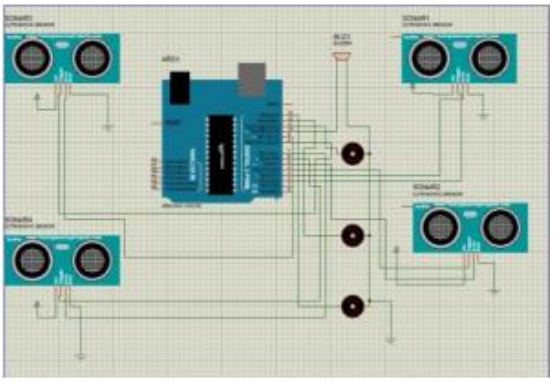

Fig. 1. Block Diagram of Obstacle Detection System

Ultrasonic Sensors: Ultrasound sensor is a convenient way to measure distances from objects. This unit contains a lot of applications such as parking sensors, obstruction and terrain monitoring systems, industrial distance measurements, etc. It has stable performance and high accuracy ranging from 2 cm to 450 cm with a precision of 0.3 cm.

The unit sends an ultrasound signal, eight pulses from a 40 kHz square wave from the transmitter; then the echo is captured by the receiver and the waveform is output with a time period proportional to the distance the connected controller accepts the signal and performs the necessary processing. [4]

Fig. 2. Ultrasonic Sensor (HC-SRO4).

Arduino Uno: Arduino Uno (Fig. 3) is Programmed by computer with a microcontroller and an electronic development board consisting of an open source electronic circuit which is designed to facilitate the use of interactive electronics in interdisciplinary projects and depends in its programming on the open source programming language and the programming codes for the Arduino language are similar to the C language and is considered one of the easiest programming languages Used to write microcontroller software. [5]

This minicomputer operates our algorithm, which helps to calculate the distance from obstacle based on the inputs it receives from the sensors. Then a motor or alarm is used to convert the text message (distance) into vibration or tone.

Fig. 3 Arduino Uno

Mechanism of Action: The timeline shows how the sensor is turned on. To start the measurement, the sensor must be deformed with a pulse that extends 5V for 10µS. This pulse will cause the sensor to transmit 8 pulses of ultrasound at a frequency 40KHz and then it will wait until it receives echo (bounce wave). When the sensor receives the reflected wave, the 5V voltage will drop on the echo leg (Echo Pin) with a time delay proportional to the distance. [4]

To get this distance you must measure the width of this pulse and use the following equations:

distance = time / 18.

Where we get the distance in centimeters.

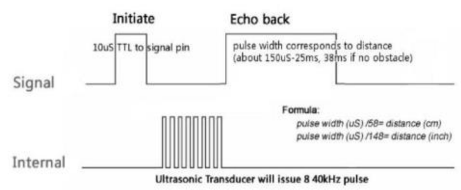

Fig. 4. Working of an Ultrasonic sensor.

IV. Methodology

The assistance system proposed in this research work based on ultrasonic sensors. Ultrasonic sensors with vibrator and bell are placed on multiple parts of the body such as the waist belt and on the front of the head (Fig. 5, Fig. 6), and a vibrator will also be connected to each sensor. Sensors scan the user's environment. When the ultrasonic sensor detects any obstacle within 300 cm in three directions, i.e., front, left and right, and in addition to 50 cm for the head sensor informs the user through vibration and buzzer depending on the sensor that detects the obstacle that helps the user change its direction, in addition to being sensitive to objects that are located in front of the patient's face such as road advertisements or tree branches that can be intercepted and harmed so that it senses all the bodies that are in front of the patient. The principle of the work of this device is based on four ultrasound sensors that are placed at specific angles that cover the entire field in front of the patient. By measuring the distance between the patient and the obstacle against it, it is possible to know the severity of this obstacle and thus the patient can be alerted accordingly through an audible alarm whose speed is inversely proportional to the distance of the body from the patient in addition to a small vibration motor.

Fig. 5. waist belt with head sensor.

Fig. 6. waist belt with head sensor

The process begins when the controller powers its operating system, it turns on the ultrasonic sensor to start signaling. All sensors operate at the same time, after the signal returns to the sensor receiver as an echo, the controller calculates the time taken to transmit and receive the echo. Using this time, we calculate an obstacle distance from any of the sensors. After that, we check if any of the calculated distance is less than the minimum set distance, within 300 cm in three directions and in addition to 50 cm for the head sensor. If any of the sensors does not have a distance less than the minimum distance, the whole process begins again. In the event that there is more than one obstacle, the alert is directed towards the obstacle closest to the blind. According to the following code:

```
#include <Ultrasonic.h>
Ultrasonic u_head(2,3);
Ultrasonic u_mid(4,5);
Ultrasonic u_right(6,7);
Ultrasonic u_left(8,9);

int head;
int mid;
int right;
int left;

int buz=10;
int m_motor=11;
int r_motor=12;
int l_motor=13;

void setup() {
pinMode(buz,OUTPUT);
pinMode(m_motor,OUTPUT);
pinMode(r_motor,OUTPUT);
pinMode(l_motor,OUTPUT);
Serial.begin(9600);
}
void loop() {
  head=u_head.Rang();
  mid=u_mid.Rang();
  right=u_right.Rang();
  left=u_left.Rang();
  //Serial.println(String(head)+"
"+String(mid)+"    "+String(right)+"
"+String(left));
  if(head<=50){
    //head=map(head,2,50,10,50);
    digitalWrite(buz,1);
    delay(head);
```

```
    digitalWrite(buz,0);
    delay(head);
    }
  if(mid<=300){
    mid=map(mid,2,300,50,200);
    digitalWrite(m_motor,1);
    delay(mid);
    digitalWrite(m_motor,0);
    delay(mid);
    }
  if(right<=300){
```

```
    right=map(right,2,300,50,200);
    digitalWrite(r_motor,1);
 delay(right);
   digitalWrite(r_motor,0);
   delay(right);
    }
  if(left<=300){
    left=map(left,2,300,50,200);
    digitalWrite(l_motor,1);
    delay(left);
    digitalWrite(l_motor,0);
    delay(left);
    }
    delay(2);
}
```

V. Result

An electronic device in the form of a waistband designed to detect obstacles. The device was tested by placing several obstacles at different positions and distances for the sensors on the belt. The system successfully warns the user of obstacles in his way. It can detect any object within a preset distance in any direction. For external testing, we set the maximum distance value at 300 cm for the waist sensors and 50 cm for the head sensors. What distinguishes this work, that it does not need to be carried by hand as a guiding stick in addition to being sensitive to objects that are located in front of the patient's face such as road advertisements or tree branches that can be intercepted and harmed so that it senses all the bodies that are in front of the patient.

Three vibrating motors and a head alarm are alerted. If there is any obstacle within the specified range, the patient is alerted and his movement path is changed, for example, when there is no obstacle, there is no warning and the patient continues to move, when there is an obstacle to the right of the patient, the alert is made through the right sensor and the patient has to move to the left or continue to walk forward, and in the event of several obstacles, the patient must stand in place. The test case results are documented in Table I.

Table I. Test Results of the Arduino UNO

Object Distance and Position (cm)	Sensor Reading				Output
	head	left	mid	right	
There is not obstacle	0	0	0	0	There is not warning
10cm, head	10	0	0	0	Lower the head down
10cm, left	0	10	0	0	Turn mid or right
10cm, mid	0	0	10	0	Turn left or right
10cm, right	0	0	0	10	Turn left or mid
20cm in left and mid	0	20	20	0	Move towards right
10cm in mid and 15cm in right	0	0	10	15	Move towards left
30cm in left and 10cm in right	0	30	0	10	Move forward
20cm in head and 50cm in left	20	50	0	0	Lower the head down and Turn mid or right
20cm in head and 80cm in mid	20	0	80	0	Lower the head down and Turn left or right
25cm in head and 260cm in right	25	0	0	260	Lower the head down and Turn left or mid
50cm in head and 170cm in right	50	0	0	170	Lower the head down and Turn left or mid
40cm in head ,right ,and mid	40	0	40	40	Lower the head down and move toward left
40cm in head ,260cm in left ,and 210cm in mid	40	260	210	0	Lower the head down and move toward right
35cm in head ,left ,and mid	35	35	35	0	Lower the head down and move toward right
25cm in left,100cm in right and 150cm in mid	0	25	150	100	Turn around
30cm in head and 205cm in left, right and mid	30	205	205	205	Turn around

VI. Conclusion and Future Work

This paper proposed to develop an electronic device in the form a waist belt (Fig. 5) As previously described, the current system is designed to be positioned on the belt of the visually impaired person. This increases the usability of the device. Improvements can be made to make the system more mobile compared to the current design and can be abbreviated in the following points:

- Use of better type of ultrasound sensor, such as the Polaroid sensor, which is characterized by high accuracy and sensitivity, but it is not available in our local markets and is also very expensive.
- Use of three-dimensional sound to give the blind an idea of the surrounding obstacles, as the blind becomes aware of the locations of the surrounding static objects that are standing in his way.
- Use more sensors to cover a larger angle.
- Use a ground-directed Infrared sensor to detect craters.

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