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Design and Development of a Kit for Visually Challenged People

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ABSTRACT: The advent of electronics particularly sensors have invaded every domain of the industry with their versatility in the fields of non-destructive testing, automotive control units and many more domestic applications. It became the talent of engineers to harness the power of these sensors effectively to cater the industrial and social requirements. The objective of this work is to design and fabricate a smart but low cost walking stick for visually challenged people, which is equipped with Global Positioning System (GPS), Global System Module (GSM), DF Mini Player, Water and obstacles detector, by harnessing the full potential of the current technology. The features of the stick include identifying obstacles, pits with the help of ultrasonic sensors and the water puddles is with water sensor. This stick is also facilitated with a smart location sharing device which would be activated in case of emergencies by pressing a button. Once the button is pressed the location of the individual concerned will be sent to his/her relatives or close friends whose phone numbers have already been fed into the system. The stick is also embedded with a radio frequency which would help them to track the stick in case of missing

KEYWORDS: Sensors, GPS, GSM, DF mini player and RF

I. INTRODUCTION

People with complete blindness or low vision often have many difficulties in self-navigating even in the well-known environments. Traveling or simply walking through a crowded street would pose a great difficulty in the minds of these differently abled personalities. In fact, world access for the blind ascertains that the physical movement of these visually challenged people is one of the biggest challenges. Because of this, many people with low vision will bring a sighted friend or family member to help them to navigate the unknown environments. But at times when it is not possible to get the help a companion it will lead to an awkward and even accident prone situation. This work attempts to eliminate if not at least to alleviate the pains incurred by the visually challenged people by providing them a smart walking stick.

Challenges to be addressed

The challenges to be addressed by the proposed design of smart walking stick is as follows,

- (a) Obstacles which are at a distance of 50cm should be detected.
- (b) The pit or ditch and any water bodies should be detected.
- (c) Facility of sharing the current location of the holder to his/her friends or relatives at the time of emergency.
- (d) It should also have a mechanism to detect itself and inform the location to the owner.
- (e) It should be of low cost, less weight but durable and ergonomical.

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II. REQUIREMENTS FOR THE PROPOSED DESIGN

Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensors. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object. Ultrasonic is like an infrared where it will reflect on a surface in any shape. However, the ultrasonic has a better range detection compared to infrared. In robotic and automation industry, ultrasonic has been accepted well because of its usage. Comparing with other sensors, the ultrasonic is more accurate. Experiments have proven that the distance and angle measurements of ultrasonic are highly reliable by proving that the relative errors and variances of the measurements are within a reasonably small range. These discussions explain that the ultrasonic is suitable for developing the walking stick.

Microcontroller

Microcontroller is a single chip that contains the processor (CPU), non-volatile memory for the program (ROM or flash), volatile memory for input and output (RAM), a clock and an I/O control unit and time. It is designed for a small set of specific function to control a particular system. For example, microcontroller is used in wheelchair to controller the motion using remote control. The reason of using microcontroller is because the microcontroller has the ability to store and run unique programs make it extremely versatile. Arduino board helps to use the microcontroller easily. A water detector is a small electronic device that is designed to detect the presence of water. The water sensor, as soon as it touches the water, it will short the circuit and this will cause a closed circuit then obtain the output that we desired. The water sensor is useful in a normally occupied area near any appliance that has the potential to leak water.

The aim of this paper is to develop an assistive tool for the visually-impaired people that alerts them of the obstacles in front in the form of audio.

III. DESIGN AND DEVELOPMENT

Sensor Selection:

Ultrasonic sensor:

This section describes the sensor selection process which ranging from information to the transmission frequency.

A 40 kHz transmission ultrasound signal is finally decided to be used. In the proposed system we use 4 ultrasonic sensors. Three sensors are placed at a distance of 20cm from bottom. The three sensors are placed adjacent to each other with each sensor facing a different direction. Each ultrasonic sensor detects the obstacles in a range of about 160cm. The distance of the obstacle is determined based on the delay between the emission of sound and the arrival of an echo. The distance of the obstacle can be measured as:

$$\text{Distance} = (\text{time} * \text{speed of sound in air}) / 2$$

Where, time is the time duration for which the ultrasonic waves have travelled and Speed of sound in air is 340 m/s. We divide the product of time and speed by 2 because the time is the total time it took to reach the obstacle and return.

The input from sensor is used for providing audio message from the speaker like LEFT, RIGHT, STRAIGHT indicating which direction the person should move. Another sensor is projected at the bottom facing the ground in order to detect the presence of pits. The audio output PIT is played in the speaker.

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1. Ultrasonic sensor

Water Sensor:

A water detector is a sensor that is designed to detect the presence of water. This sensor relies on the electrical conductivity of water to decrease the resistance between the contact surfaces. The change in resistance can be measured signalling the presence of water. The audio output WATER is played in the speaker.



2. Water Sensor

GPS module:

The GPS based device proposed, with user input interfacing get alert the blind person when he reaches the destination by voice. A GPS module consists of GPS receiver and an antenna. GPS antenna is a device that helps to boost the reception signal to a GPS unit. GPS (Global Positioning System) is a satellite system originally developed by the United State Department of Defense. It utilizes more than two dozen satellites orbiting the Earth to allow receivers to tell exactly where they are. Using this location, devices can detect not just latitude and longitude, but also altitude and even speed. A GPS unit is used in the smart stick to obtain the latitude and longitude of the location of the blind person. The data obtained are used to find the address of the blind person's location. While the person navigates with the stick, the latitude and longitude data are updated. Thus, these data are helpful to keep track of the blind person.

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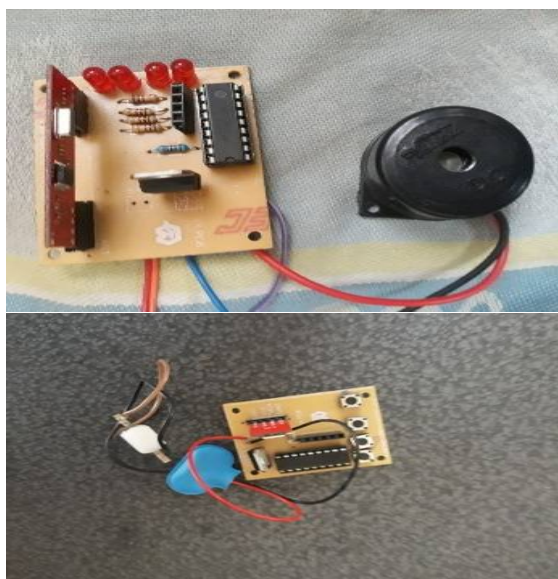
GSM/GPRS module:

GSM (Global System for Mobile communications)/ GPRS (General Packet Radio Service) module is an embedded piece of hardware which can be integrated with an equipment to make use of the module's functionalities. GSM module requires a registered SIM card to be inserted into it in order operate. It facilitates making and receiving voice calls, sending SMS messages wirelessly. These features of GSM/GPRS module can be made use of in the smart stick which imparts great advantage for the blind person in emergency situations. A visually impaired person during urgent or risky situations may use a switch on the stick that allows the GSM module to send an emergency message (which also specifies his location) to the concerned person, whose number has been saved already, requesting help. The blind person can also make an emergency

call or receive any calls to his number. The GSM module's extended technology GPRS provides a service which connects to the internet. The GPS module can use GPRS for connecting to internet, to gather the data regarding the current location of the person using the smart stick. The blind person can be tracked using the location data provided by the GPS module.

RF Transmitter and receiver

An RF module (radio frequency module) is a small electronic device used to transmit and receive radio signals between two devices. An RF transmitter module is a small PCB sub-assembly capable of transmitting a radio wave and modulating that wave to carry data. Transmitter modules are usually implemented alongside a microcontroller which will provide data to the module which can be transmitted. An RF receiver module receives the modulated RF signal, and demodulates it. In order to help the visually challenged to find the stick, transmitter is placed in the band which can be worn and receiver is placed in the stick. While pressing the button in the band a beep sound is given as output which helps them to find the stick.



3. RF Transmitter and Receiver

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Arduino Uno:

The Uno is a microcontroller board based on the ATmega328p. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller.

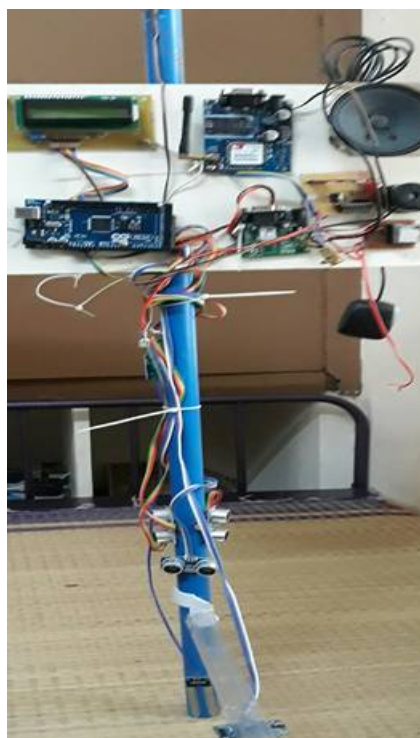
DF mini player with speaker

The DF Player Mini MP3 Player is a small and low price MP3 module with an amplified output directly given to the speaker. The module can be used as a stand alone module with attached battery, speaker and push buttons or used in combination with an Arduino or any other device with RX/TX capabilities. The order we copy the mp3 into micro SD card will affect the order in which the mp3 is played.

SD card:

The internal memory is of 8GB and it is of the flashcard type. The audio files are stored in the memory card.

The prototype of the walking stick:



4. Prototype of the stick

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Cost estimation

1. Arduino board	-	Rs.500
2. DF Mini player	-	Rs.500
3. GSM module	-	Rs.700
4. GPS module	-	Rs.1500
5. Ultrasonic sensors(4)	-	Rs.1000
6. Radio Frequency transmitter	-	Rs.200
7. Water detector	-	Rs.200
8. Speaker	-	Rs.100
9. Jumper wires	-	Rs.100
10. SD card	-	Rs.200
11. 12V Lead acid battery	-	Rs.500
12. 9V Battery	-	Rs.20
TOTAL	-	Rs.5520

Dimensions:

Length of the walking stick = 90cm

Length of the board in which Arduino mega , GPS, GSM modules are placed = 15cm

Breadth of the board = 10cm

Weight of the stick = 630g

Distance from the top of the stick where GPS switch is placed = 7cm

Distance from the top of the stick where board is placed = 14cm

Distance from the bottom of the stick where ultrasonic sensors facing left and right directions are placed = 25cm

Distance from the bottom of the stick where ultrasonic sensor facing straight direction is placed = 20cm

Length of the projection = 10cm

Breadth of the projection = 1.5cm

Distance from the bottom of the stick where the projection is fixed = 10cm

Outer Diameter of the stick = 2.5cm

Inner diameter of the stick = 2cm

Thickness of the stick = 0.5cm

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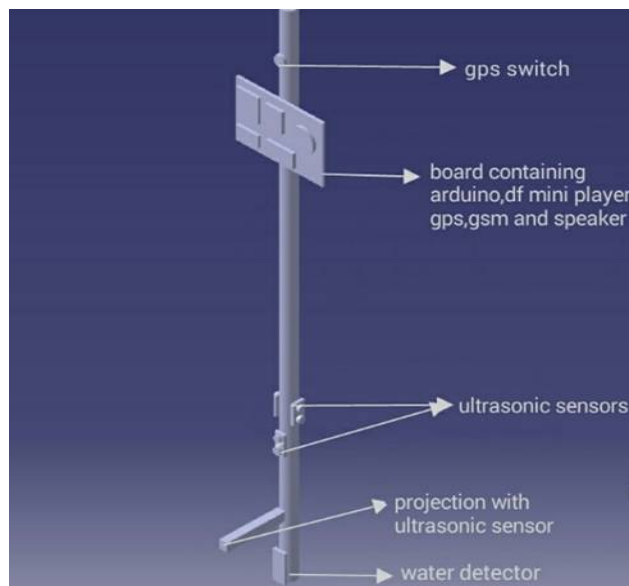
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Though the prototype will be difficult for the visually challenged people to use, further modifications such as reducing the size of the board by using smaller sized modules and wiring done on the interior of the stick will be effective.

The expected product that will be used by the visually challenged people after size reduction:



5. Catia model of the stick

The program used:

```
#include <SoftwareSerial.h>
#include <DFPlayer_Mini_Mp3.h>
#define trigPin1 11
#define echoPin1 12
#define trigPin2 A4
#define echoPin2 A5
#define trigPin3 10
#define echoPin3 9
#define water_sensor 8
SoftwareSerial mySerial(2, 3); // RX, TX
long duration1, distance1, dis1;
long duration2, distance2, dis2;
long duration3, distance3, dis3;
int water_val=0;

void setup ()
{
  pinMode(trigPin1, OUTPUT);
  pinMode(echoPin1, INPUT);
```


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```
pinMode(trigPin2, OUTPUT);
pinMode(echoPin2, INPUT);
pinMode(trigPin3, OUTPUT);
pinMode(echoPin3, INPUT);
pinMode(water_sensor,INPUT);
Serial.begin (9600);
mySerial.begin (9600);
mp3_set_serial (mySerial); //set softwareSerial for DFPlayer-mini mp3 module
mp3_set_volume (25);
}

// void loop ()
{
  water_val=digitalRead(water_sensor);
  SonarSensor1(trigPin1, echoPin1);
  dis1 = distance1;
  mp3_stop ();
  if(dis1>=160)
  {
    dis1=160;
  }
  // Serial.println(dis1);
  SonarSensor2(trigPin2, echoPin2);

  dis2 = distance2;
  // Serial.println(dis2);
  if(dis2>=160)
  {
    dis2=160;
  }
  SonarSensor3(trigPin3, echoPin3);
  dis3 = distance3;
  // Serial.println(dis3);
  if(dis3>=160)
  {
    dis3=160;
  }
  if(dis1<100)
  {
    // Serial.println("Left");
    mp3_play (1);
    delay(1000);
  }
  if(dis2<100)
  {
    // Serial.println("Straight");
    mp3_play (2);
    delay(1000);
  }
}
```


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```
if(dis3<100)
{
// Serial.println("Right");
mp3_play (3);
delay(1000);
}

if(water_val==1)
{
Serial.println("Water detected");

mp3_play (4);
delay(3000);
}
}
void SonarSensor1(int trigPin5,int echoPin5)
{
digitalWrite(trigPin5, LOW);
delayMicroseconds(2);
digitalWrite(trigPin5, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin5, LOW);
duration1 = pulseIn(echoPin5, HIGH);
distance1 = (duration1/2) / 29.1;
}
}
```

IV. TESTING OF ULTRASONIC SENSORS

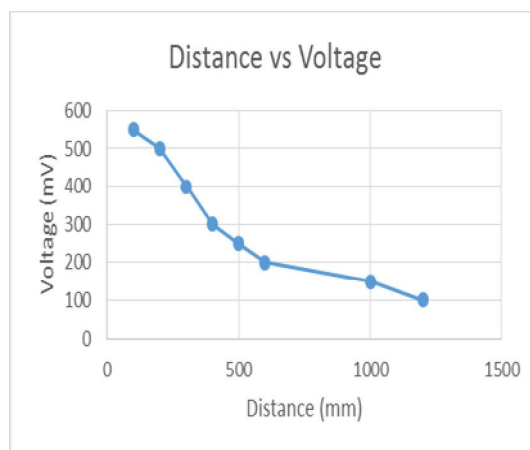
Length (cm)	Time (ms)	Objects
23	1208	Tree
46	2552	Tree
19	5955	Plastic bag
67	4114	Clothes
160	10763	Wall

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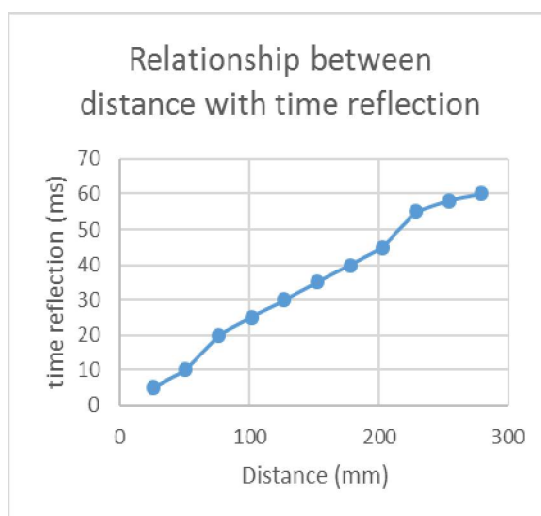
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6. Distance vs voltage



7. Distance vs time reflection

V. CONCLUSION

The purpose of the proposed work is to develop a product which acts a aid for visually challenged people. By analysing the existing sticks, three improvements have been identified and done in this system. The three improvements include: obstacle detection, location tracking, SMS alert. All modules are inserted in the stick and the the output is given in the form of audio.

The further improvements can be done is:

1. Bluetooth can be used in place of speaker to provide audio output via Head phones.
2. DC batteries can be replaced by solar batteries.

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