Embedded Navigation Assisting Cane for the Blind

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ABSTRACT
Vision is one of the most significant parts of human physiology due to the fact that about 83% of the information obtained from the environment is with the help of our eyes. Blind people suffer from many difficulties and one of the most common is their independent navigation. The widely used White cane is ineffective in terms of navigation. In this project a walking stick has been designed to help the blind person to detect obstacles and navigate towards the destination. The proposed walking stick consists of a microcontroller, ultrasonic sensors, a GPS receiver, wet surface detection, a headphone and a vibrating motor. The detection of obstacles is done by an array of ultrasonic sensors. The GPS receiver has been used for navigation purpose. In order to make this stick useful for a blind as well as a deaf person a vibrating motor is used to generate vibrations near the handle of the stick to detect the presence of obstacles. This whole setup will be mounted on the cane. Every effort is being made to make this cane cheaper as well as user friendly.

General Terms
Walking stick, GPS sensor, Ultrasonic sensor.

Keywords
Obstacle detection, independent navigation, walking stick, electronic travel aid.

1. INTRODUCTION
According to the data provided by the World Health Organization (WHO), 285 million people are estimated to be visually impaired worldwide: 39 million are blind and 246 million have low vision. About 90% of the world's visually impaired live in low-income settings, 82% of people living with blindness are aged 50 and above [1]. A lot of efforts have been taken to develop Electronic Travel Aids (ETAs) and many ETAs have been developed but they have been unable to penetrate into the market [3]. One of the main reasons for low acceptance of these travel aids is due to their high prices since 90% of visually impaired people are basically poor people. Another drawback of the existing ETAs is that they require a lot of training before they can be efficiently used. Since 82% of the blind people are aged 50 and above, the priority be given to make the design simple to use. White cane is widely used even though it has many limitations because of the simple reason that it is cheaply available as well as simple to use. To summarize, the high price and the complexity of the existing ETAs have led to their poor reception among the blind.

The difficulties caused due to blindness in mobility are obstacle detection, obstacle avoidance and navigation. In order to assist the blind people the following information are essential: the presence, location and nature of obstacles; the texture, slope and boundaries of the travel path; as well as the spatial orientation [2]. When the blind person is travelling independently, he/she has a very short time to interpret the codified information, take a decision as to how to respond and then give an appropriate response [2]. Hence the developer of travel aid must be careful not to provide redundant information to the user as it may become difficult for the user to respond spontaneously.

Many of the existing ETAs are able to help the user in obstacle detection and hence help in obstacle avoidance. However it will be very useful if the user is given additional information of whether he/she is moving in the right direction or not. If in case the user is moving in the wrong direction then the device should be designed in such a way that it helps the user to correct his/her path. GPS can be one of the devices that can be used for navigating the user towards the destination.

2. PROPOSED BLOCK DIAGRAM
From the literature review that has been done the proposed block diagram of the system is shown below as follows:

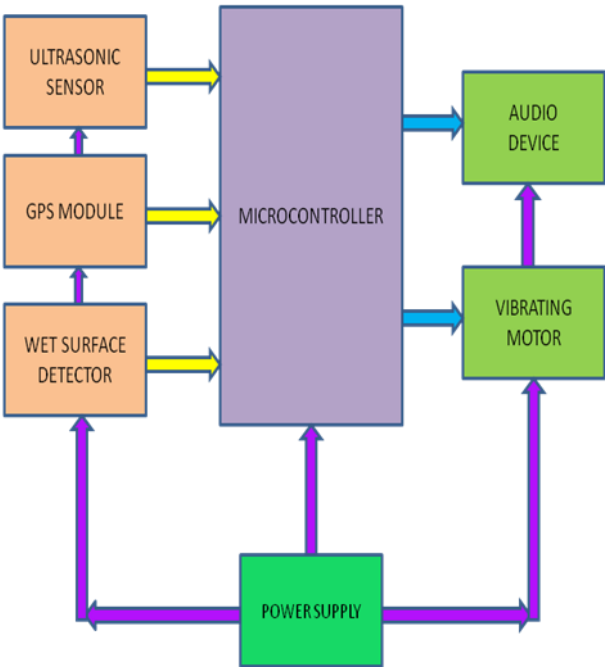

Fig 1: Proposed block diagram of the system

Arduino mega 2560 microcontroller unit was selected due to its cost effectiveness and simple design. Also available are dedicated pins for obtaining pulse width modulation (PWM) waves which can be used for generating vibration patterns on vibrating motor. It also has 4 universal asynchronous reception transmissions (UARTs) for Serial communication and also 256KB of programmable memory which can easily fit the complete program as well can be used for future

modifications [4]. Ultrasonic sensor HC-SR04 was selected as the obstacle detection sensor due to its good resolution, lower price, compact size and a detection range of 4 meter which is adequate for the proposed system [5]. Ublox NEO-6M-0-001 GPS receiver was selected as it has better sensitivity, lesser current consumption, more number of channels for acquiring the signals hence better time to first fix, a backup battery and lastly it has a compact size and is cost effective[6].

The real time latitude and longitude readings of the current location of the system will be given by the GPS receiver. In order to navigate the user from the current location to the destination effectively a navigation algorithm has been developed using these GPS coordinates. The user will be directed to move in the right direction by giving an audio feedback. An array of ultrasonic sensors is used in the cane for obstacle detection; 3 sensors will be located at the front side of the stick to detect the floor level, knee level and waist level obstacles respectively.1 sensor each will be located at the left and right side of the cane to detect the obstacles at the left and right side of the user. The audio feedback will indicate the location of the obstacle. The wet surface detector will warn the user if in case the surface is wet.

3. PRELIMINARY IMPLEMENTATION

As a first step towards the implementation of the system, the ultrasonic sensor was interfaced with Arduino board. The distance of the obstacle from the sensor was measured and displayed on the Arduino IDE serial monitor. The screen shot of the observed distance is as given below:

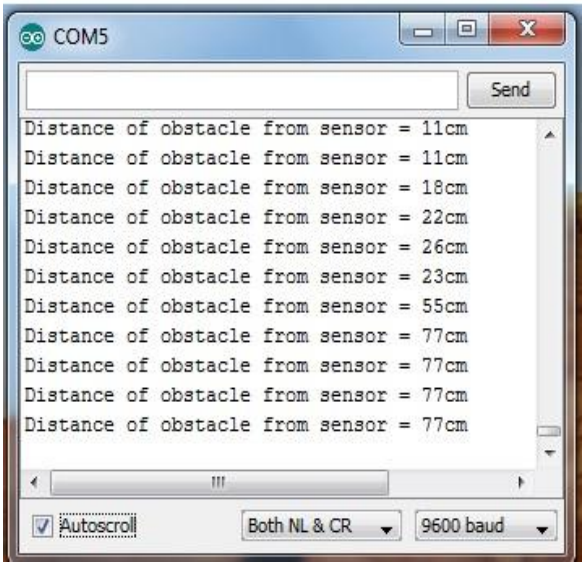

Fig 2: Distance of obstacle observed on serial monitor of Arduino IDE

The designed cane has 3 sensors namely S1, S2 and S3 in front at various heights from the ground level as well as 1 sensor each namely S4 and S5 at left and right side respectively. Shown below is a prototype of the arrangement of the 3 ultrasonic sensors:

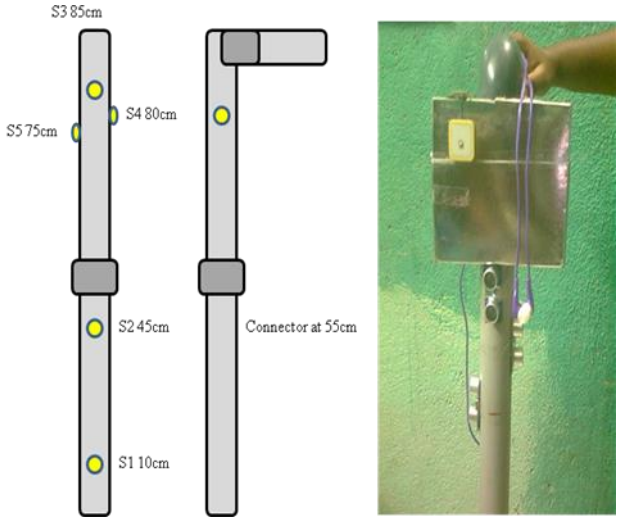

Fig 3: Final design of the cane

The height of the stick will be 100 cm and its handle will be of 18cm. A connector is provided at 55cm to make the stick detachable when not in use. This arrangement of the ultrasonic sensors is done so as to detect floor level obstacles, knee level obstacles and waist level obstacles respectively. In order to detect the overhead obstacles the stick needs to be lifted upwards once in every few seconds. The walking stick has been tested in the college campus. In order to facilitate the testing, 7 locations of the campus were selected and their respective latitude and longitude readings were noted down and stored in our program. The locations have been highlighted and are shown below:

Fig 4: Various locations for testing the proposed system with 3 destinations

From the 7 locations mentioned above, 3 locations are destinations namely the Entrance, Baalbhavan and Canteen. 3 switches have been provided to the user for selecting a maximum of 8 destinations using the binary combinations. The first step is to locate the current location of the user out of the 7 locations which are stored in the system. The current position of the user denoted the current place where the user is situated. The distance of the current position from the 7 predefined locations are calculated. The location which has the shortest distance from the current position becomes the current location of the user. Then according to the selected destination the user is navigated from the current location to

the immediate next location and then to the next location and finally reaching the destination. The heading direction of the user is calculated in terms of degrees with respect to the immediate next location. Here 0, 90, 180 and 270 degrees denote North, East, South and West respectively. If in case the user moves towards left or right direction which is away from the correct course while navigating, appropriate audio feedback is given to bring the user to the right course. Also the user is notified about their current location. This makes them confident that they are moving in the correct direction rather than the opposite direction. If in case they are moving in the opposite direction, they themselves can correct their path without the system needing to correct them.

Wetness detection sensor provides data on the wetness of the floor. The user will be given a warning audio signal once a wet floor has been detected. A vibrating motor is another feedback for the user for obstacle detection and this feedback can be extended for wet surface as well. Efforts have been put to make the system user friendly, compact, power efficient and cost effective.

4. CONCLUSION

An extensive literature review has been done which concluded with the proposed block diagram. The algorithms for obstacle detection and navigation have been developed and implemented in the stick. The stick has been designed to be light weight, cost effective as well as user friendly.

The future work is to use a microphone based module to take a voice input from the user for selecting the destination instead of the switch system that has been used in the current system. One more important aspect is the high current consumption which will be taken care of by making use of power saving modes of Arduino in the future design. Also a 220V plug point needs to be added to the design so that the battery can be recharged whenever it gets low.

5. REFERENCES

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