Sound and Touch based Smart Cane: Better Walking Experience for Visually Challenged

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***Abstract*—Moving with the help of a white cane is an elusive task for the visually challenged unless they create a mental route map with recognizable reference elements. The smart cane is intended to provide the visually challenged a better walking experience. The design is incorporated with Bluetooth enabled Obstacle detection module, supported with heat detection and haptic modules. The ultrasonic range finders help in detecting obstacles. The distance between the obstacle and the user is sent to an Android device via Bluetooth. The user gets voice alerts about the distance through Bluetooth headset. Haptics module is included to warn the user of moving obstacles with the help of vibratory motors. This research work explains about the setup we used for the implementation, design details and experimental results of the measured parameters.**

***Keywords*—Ultrasonic Range Finder, Haptics, Bluetooth.**

I. INTRODUCTION

A white cane is the most common mobility aid for the visually challenged. However, it does not give information about the obstacles above knee level and those which are at a distance greater than 1m. Even though guide dogs were the initial companion of the blind, later on technologies played a vital role. Walking sticks with adjustable length, elbow canes, were developed in the market to guide the visually challenged. However, these attempts were not completely successful in assisting the user.

According to WHO, there are about 36.9 million visually impaired in the world. Out of these, 75% of the people wishes to get rid of the cane because of the feeling of frustration. The Chairman of National Association for the Blind, Kottayam suggested that it would be a great improvement in their society if the use of cane can be avoided. They pointed out that the people on the road never considered the difficulty of a visually impaired while navigating. Most of them, especially two wheelers slid past them while travelling. They also proposed that if each traffic signal is given a different buzzer, that could help them in crossing the road. However, they are worried that the people rarely abide by the traffic rules in India. One member from the Association conveyed his difficulty in navigating through his familiar route because of the puddles and pits formed due to rain.

To alleviate these issues the Smart Cane is designed in such a way that it includes a Bluetooth enabled Obstacle Detection module where the distance information from the Arduino board is send to the Bluetooth Headset. The design also supports a temperature detection module and Haptics module. While the user gets voice feedback about the static obstacles, vibratory motors are used to inform about the moving obstacles. The intensity of vibration depends on the speed of the moving obstacles. Despite the simplicity, the integrated module will emphatically be a solution for the visually challenged.

II. RELATED WORKS

A lot of study and research are being done to design a fine instrument that provides the user a better walking experience. One of them is Smart Vision [3]. It is an efficient design which can detect path borders using canny edge detector and an adapted version of Hough transform. The device can detect stationary as well as moving obstacles. The former is done through a camera attached on the user's chest and the latter is achieved by multi-scale, annotated, and biologically-inspired keypoints. Another work is done by Fernandes, Costa**,** Filipe, Hadjileontiadis and Barroso [2]. The device can detect specific landmarks and will inform the user the distance from the obstacle. Depths are identified using two cameras which generate images suitable to extract both the position and distance of objects according to their relative brightness. HALO is another device that can be mounted on the existing white can and candetect low hanging obstacles such as branches of trees[1]. It consists of ultrasonic range sensor with an eccentric-mass vibrating motor which vibrates distinctly for ground obstacle and low hanging obstacle.An intelligent guide stick detects obstacles using ultrasonic sensors but it is unable to tell whether the obstacle is in motion or not[4]. A wireless ultrasonic ranging system detects obstacles using an ultrasonic sensors and the PIC16F877 microcontroller finds out the distance from the obstacle[5]. The phone that is linked to the microcontroller converts the information to speech and the data is sent to the Bluetooth earphone to alert the user.In the work by Amirhossein Tamjidi, Cang Ye and Soonhac Hong a portable indoor localization aid for 6 Degree of Freedom device post estimation is proposed[9]. This method is used as an indoor GPS system for position estimation of the visually impaired. It also supports obstacle detection and help the visually impaired to move around freely.In another work by C.Ye and X.Qian a RANSAC based plane detection method is proposed wherein the complex geometry of the 3D data ensures accuracy[8] .This method would be used by a robotic navigational device assisting the visually challenged.

The work done by S. Gallo, D. Chapuis, L. Santos-Carreras, Y. Kim, P. Retornaz, H. Bleuler and R. Gassert, "Augmented White Cane with Multimodal Haptic

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Feedback" involves Haptics feedback to imitate the behavior of a longer cane [6]. The feedback is given by a shock generating module which releases the kinetic energy stored in a spinning wheel in a controlled amount. In case of a moving obstacle, the spatiotemporal vibration pattern, stimulated on the user's hand creates the sensation of an apparent movement. A different approach is seen in the work presented by Larisa Dunai, Guillermo PerisFajarnes, Victor Santiago Praderas, Beatriz Defez Garcia on "Real–Time Assistance Prototype – a new Navigation Aid for blind people" involves stereo-vision technology integrating real time static and moving obstacle and free path detection [7]. The system offers three dimensional information of the environment, relaying it to the user by transmitting acoustical signals. The device consists of a helmet fitted with a pair of stereo camera, which captures the image. The image is processes by a laptop and the user is alerted through a headphone.

III. SYSTEM ARCHITECTURE

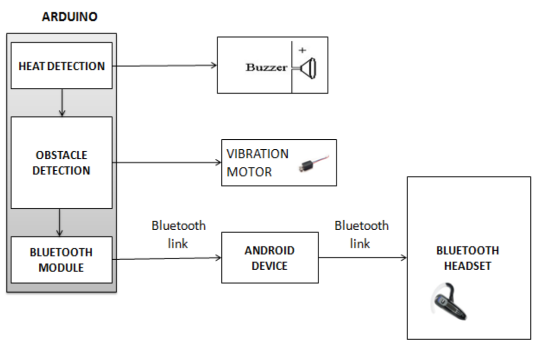

Fig.1. Overall System

Smart Cane consists of 3 modules namely Heat Detection, Obstacle Detection and Bluetooth Module. The presence of an obstacle in front of the user is identified by using an SRF05 Ultrasonic Sensor. The distance is measured in centimeters and corresponding to the distance the user hears 'Stop' and 'Obstacle' for nearby and distant obstacle respectively in the Bluetooth headset. Arduino board which holds the sensor communicates to the Bluetooth headset via an Android phone. If the obstacle is in motion, the vibration motor attached vibrates. The intensity of vibration would be high for fast moving obstacles. The presence of hot objects (above 70 deg. Celsius) is informed to the user by the sound of a buzzer. The temperature is measured using an LM35 temperature sensor.

IV. IMPLEMENTATION

A. *Hardware tasks:*

The hardware tasks can be divided into three namely motor vibration, heat detection and Bluetooth feedback.

1) *Obstacle Detection Module:*

The cane is designed in such a way that each time the obstacle moves, a motor vibrates. The intensity of vibration depends on the speed of the moving obstacle. The obstacle detection is carried out using dual transducer SRF05 Ultrasonic Range Finder Sensor. Once triggered, the ranger produces an eight cycle sonic burst at 40 kHz frequency. Simultaneously the echo pulse is raised high until the last sonic pulse sends back the reflected wave. Once the duration of this echo pulse is found, distance can be easily calculated using this time and the speed of sound. The module is also incorporated with motor vibration intended for moving objects. As the obstacle approaches the user and reaches close proximity, the intensity of vibration increases.

2) *Bluetooth Feedback*

Once the Arduino board is connected with an Ultrasonic Range Finder, it detects the distance information and prints it on the serial monitor. In order to transfer this information to an Android phone, we use a Bluetooth Shield. This Bluetooth Shield enables the pairing between Arduino Board and the Android Phone. Once the distance value is obtained, it is send to an android device via Bluetooth. Itead v2.2 Bluetooth shield is used for pairing the android device with Arduino board. The Arduino board sends and receives data using TX/RX UART interface on the Arduino chip. Even though the shield is compatible with baud rates 38400 bps, 19200 bps, the default baud rate of the Bluetooth shield is set as 9600 bps. This asynchronous transmission includes 8 data bits and a single stop bit.

3) *Heat Detection*

The heat detection is carried out using LM-35 Temperature Sensor. It helps in detecting the surrounding hot objects within the range -55 to 150 degree Celsius. LM 35 absorbs thermal radiations around the hot objects and converts it into voltage. The voltage is converted back into degree Celsius with the help of an Arduino program.

B. *Software Tasks*

1) *Algorithm for obstacle detection*

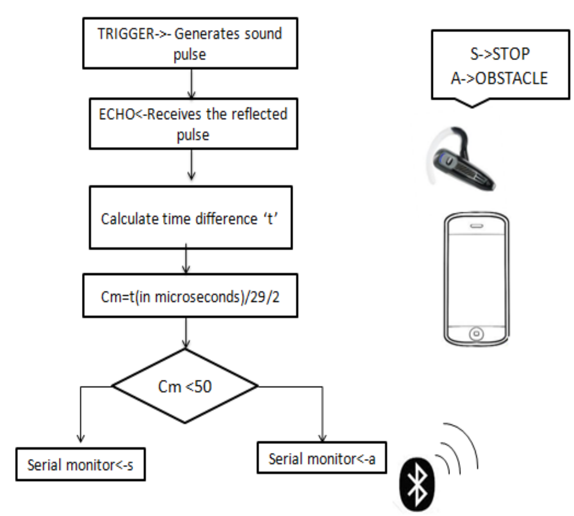

Fig.2. Flowchart for Obstacle Detection

A continuous stream of pulses is sent out through the trigger terminal of the Ultra sonic Sensor. The pulses reflected from the obstacle are received at the echo terminal.

The time duration for which the echo pulse remains low gives the time takes by the ultrasonic pulse to travel twice the distance. Thus relating the time taken (t) and distance between the obstacle (d), 2d=s*t; where s=340 m/s (speed of sound).converting speed to cm/us and time to us, we can write the distance d in cm as

(d=microseconds/29/2)

If the distance d is less than 50cm a message 's'is sent to the android through a Bluetooth link and If the distance d is greater than 50cm but less than 100 cm a message 'a' is sent. On receiving 's' android is programmed to speak out "STOP" and in case of 'a' it speaks out "OBSTACLE".

1) Algorithm to detect moving obstacle

The distance received from the Ultrasonic Sensor for that particular obstacle is measured 5 times. Each reading is subtracted from the previous reading and the absolute value is taken. If the measured value is within 55 cm which is equal to the average footstep of the user implies that the obstacle hasn't moved and vibration given to the motor is zero. If the difference increases and lies between 55 cm and 150 cm, it means that the obstacle is moving at a faster rate and medium vibration is given. Finally, if the difference measured is greater than 150 cm, it gives an idea that the obstacle is moving at a greater rate and maximum vibration is given.

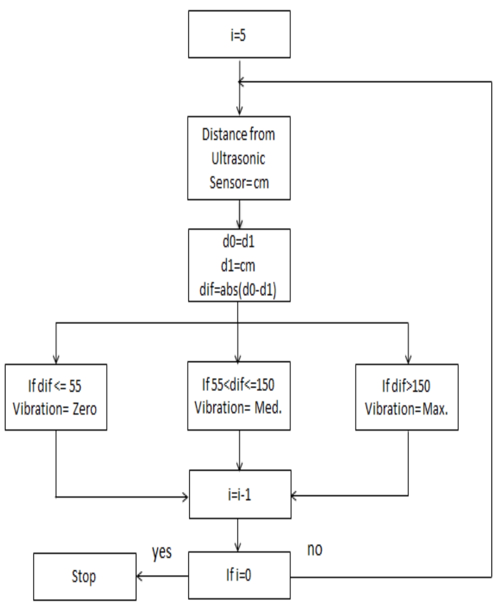

Fig.3. Flowchart for Moving Obstacle Detection

2) Algorithm to detect hot objects

The temperature of the obstacle is measured using LM35 temperature sensor. The voltage corresponding to the temperature is received at the Arduino pin. To get the temperature reading from the board, the conversion,

*(tempC = (5*Voltage*100)/1024)*

is used. The transistor gives 10mV for every degree rise in temperature. So the value measured by the analog pin needs to be multiplied by 100. To scale the voltage to 5V, again the value needs to be multiplied by 5 and divided by 1024 since analog reading will be in the range of 1024 (10 bit).

3) Arduino- Android interfacing

Arduino is interfaced with the Android phone to support the obstacle detection module. If the obstacle falls in the range of 50-100 cms, it is mapped to 'a', indicating an approaching obstacle and if the obstacle falls in the range 10-50cms it is mapped to 's' indicating a nearby obstacle. Distance information is sent to the Android device using a Bluetooth shield mounted on the Arduino board.

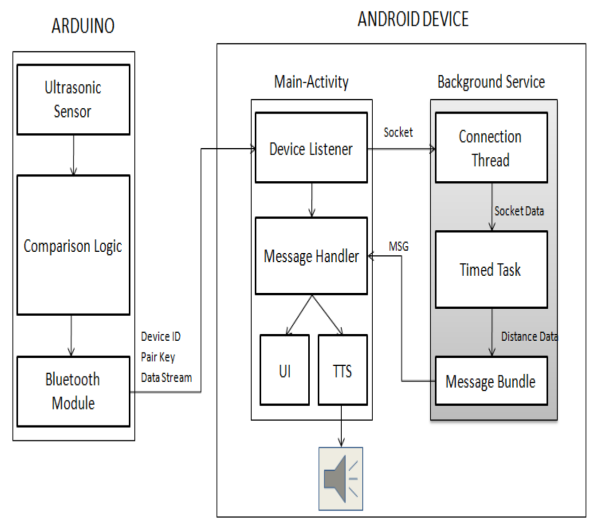

Fig.4. Arduino-Android Interfacing

The Device listener scans for all possible Bluetooth devices and pairs with that device with which the key is found to match. A socket connection is then established through the Connection thread. The timer block is required to collect data in a timely manner that is data is collected after every 500ms.The received data can be considered as a bundle and reaches the Message handler. Message handler receives and processes the messages. Each instance in the Message handler can be associated with a thread (process of speaking out 's' or 'a' in this case). The received text is converted to speech. The UI gets updated automatically.

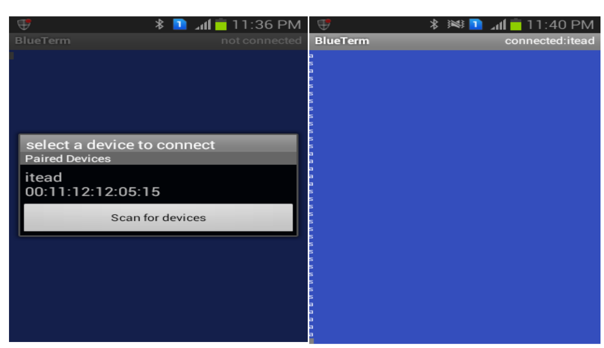

Fig.5. (a) Searching for available Bluetooth Devices (b) Received Bluetooth data on Android phone

V. EXPERIMENTAL RESULTS

The time delay in hearing each warning message was calculated using a stopwatch. The range for each messages are as follows:

TABLE.I. DISTANCE TO RANGE MAPPING

Distance (cm)	Range
< 50	1
50-100	2
>100	3

The count starts at the moment the obstacle comes in the range of the wielder and the count stops when the warning message is heard. Values are taken for four scenarios (a) a far away obstacle comes in range 2. (b) The obstacle comes in range 1. (c) The obstacle moves from range 2 to range 1. (d) The obstacle moves from range 1 to range 2. The observations are plotted using MATLAB. The average response time was found to be 1.96 s

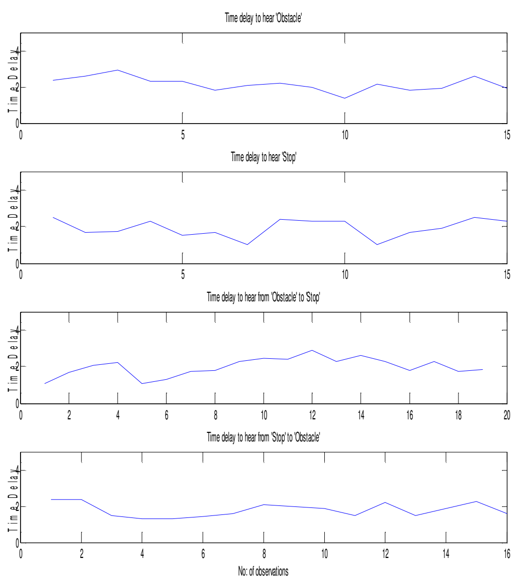

Fig.6. Plot of Time Responses

The distance measured by the ultrasonic sensor was verified using a measuring device.The detection of moving obstacle was simulated with the help of a small manually operated car. Three test cases were carried out and the following observations were verified.

TABLE.II. SPEED TO VIBRATION MAPPING

Speed (cm/s)	Vibration Intensity
4.9-49.01	Small
49.01-196.08	Medium
196.08-490.01	Maximum

VI. FUTURE WORK

In this paper we have presented the development and design of Smart Cane which includes four inevitable modules. The temperature detection module is tested using lm35 sensor. Testing using a contactless sensor is in progress. Further we are working on including a pit detection module and modifying the haptics module such that the person would get the feel of holding a cane without having to hold it physically.

VII. CONCLUSION

The paper details the architecture and working algorithm of a device that scans the path of a visually challenged and alerts them in the event of any danger. An Arduino based algorithm is constructed to detect hot objects and obstacles ahead of them. The Arduino algorithm combined with android interfacing warns the user of respective dangers through a Bluetooth headset. Bluetooth technology is exploited here to link android to the Arduino. In the event of an approaching obstacle, a tactile feedback is given on the hand. The vibratory motor attached to the hands vibrates with varying intensity depending on the speed of the approaching obstacle.

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