Substitute eyes for Blind using Android

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Abstract:
Our aim is to develop an affordable technology which is cheap and can be a substitute eyes for blind people. As a first step to achieve this goal we decided to make a Navigation System for the Blind. Our device consists of the following 2 parts:
1) **Embedded Device:** can be used to detect local obstacles such as walls/cars/etc. using 2 ultrasonic sensors to detect the obstacles and vibrator motors to give tactile feedback to the blind.
2) **Android App:** will give the navigation directions. Can be installed on any android device: cellphone/tablet/etc.

1. Introduction

From a survey of W.H.O. **[1]**, 285 million people are visually impaired worldwide: 39 million are blind and 246 have a problem of low vision. About 90% of the world's visually impaired live in developing countries. As an engineer it is our responsibility to develop technology for bringing comfort to these people. Thus as a start, the goal of our project is to develop a device which the blind can use to navigate independently.
We also set our goal to make this technology accurate, comfortable, easy to implement and affordable.

1.1 Technical Background

People have tried to develop similar technology using SONAR, RADAR or ultrasonic sensors. The ultrasonic sensors serve as the cheapest solution which we could find. As seen in **[2]**, ultrasonic sensors can be used to detect obstacles. Ultrasonic sensors can operate well up-to a range of 2-3 meters but have a very small cone angle. Secondly, to give the feedback to the blind person **[3]** uses a matrix of solenoids. But such a system would become heavy and bulky which cannot be carried while walking. Thirdly navigation systems on android operating system are available but don't contain any interface which can be used by a blind person.

1.2 Proposed solution

The proposed solution is as shown in fig.1

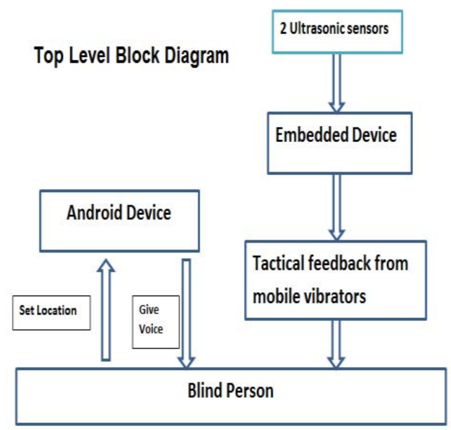

Fig.1.Top level block diagram

The embedded device detects the local obstacles from two ultrasonic sensors which overcomes the drawback of smaller range of ultrasonic sensors. The embedded device gives a feedback to the blind person using vibrator motors (used in cell-phones) instead of solenoids to give tactile feedback. These are very small in size and consume less power. We also developed an Android Navigation Application which has a very convenient interface that can be used by blind people.

1.3 Organization of the report

In Section 2 we have given the proposed solution followed by hardware and software implementation which is done in Section 3. The results and conclusion is given in Section 4 and 5.

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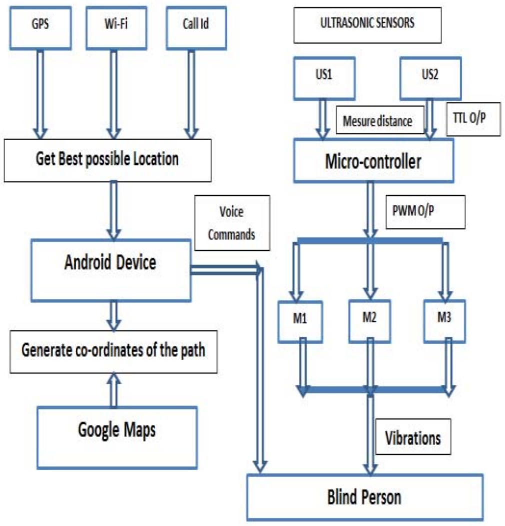


Fig.2 System level block diagram

2. Proposed Solution

2.1 Embedded Device:

The right hand side of Fig.2 indicates proposed algorithm for ultrasonic sensor mechanism. We have made use of HC-SR04 ultrasonic sensors to detect the obstacles as shown in Fig.3.

Fig.3: Ultra-sonic sensor

The ultrasonic sensor finds the distance of the obstacle by transmitting an ultrasonic pulse sequence and calculates the time taken by it to come back when it is detected by the receiver. Distance can be calculated as shown by (1):

$$2 \times \text{Distance} = \text{Velocity of sound} \times \text{time} \quad (1)$$

Each sensor has a cone angle of 15 degrees. As shown in Fig.4, using a combination of these sensors, we not only get the distance of the obstacle but also a rough estimate of its locations; i.e. whether it lies in region 1, 2 or 3.

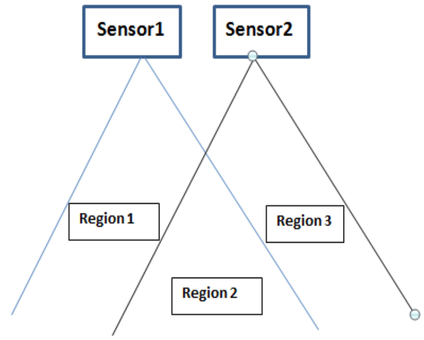


Fig.4: Range of ultra-sonic sensors

The readings from the ultrasonic sensors are processed by the micro-controller. The distance is calculated for each sensor as per the following cases indicated in table 1:

Table 1: Outputs of sensors

Left Sensor	Right Sensor	Motor to be switched ON
0	0	None
1	0	Left
0	1	Right
1	1	Center

Where,
1 = Obstacle Detected
0 = Obstacles Not detected

Thus, this information is given to the blind person by means of three vibrator motors which will be placed on three finger tips of the blind person. Based on the readings from the sensors the micro-controller actuates the corresponding motor as shown in Table 1.

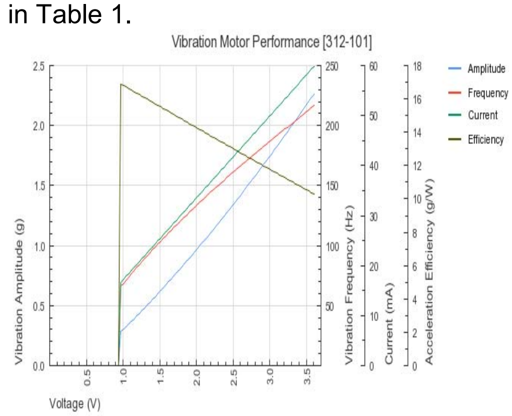


Fig5: Characteristics of Vibrator Motor

As shown in fig.5 the frequency and the amplitude of the vibrator motor increases with respect to voltage.

The vibrators are actuated by giving a Pulse-Width-Modulation (PWM) output from the micro-controller; the duty cycle of which increases as the distance of the obstacle decreases.

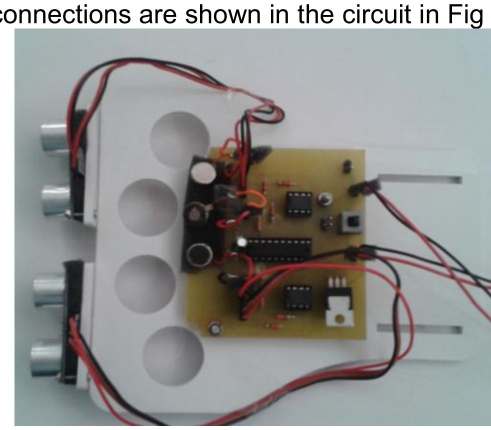
Advantages of the design:

- Low Weight: The use of small vibrator motors and Ultra-sonic sensors highly reduces weight.
- Low Power: It can be seen from the fig.5, that these vibrators operate at really low power which means larger battery life.
- Requirement motor driver or power transistors is eliminated as the vibrators operate at very low current and 3V, so it can be directly connected to the micro-controller.

3. Implementation

3.1 Hardware Implementation

We have used TI MSP430G2553 microcontroller as our embedded device. This is Ultra low power consuming microcontroller. For obstacle detection we used Ultrasonic sensors (HC-SR04) .These sensors have their Echo (feedback signal) 5v but the microcontroller needs 3.3V on its input output ports. So we have used register divider along with high precision and low noise op-amp(OPA227P) to increase the stability of the circuit .The we have chosen this op-amp because it works on low voltage Vcc supply and its biasing current is also very low(~10nA). All the details of the connections are shown in the circuit in Fig 6.



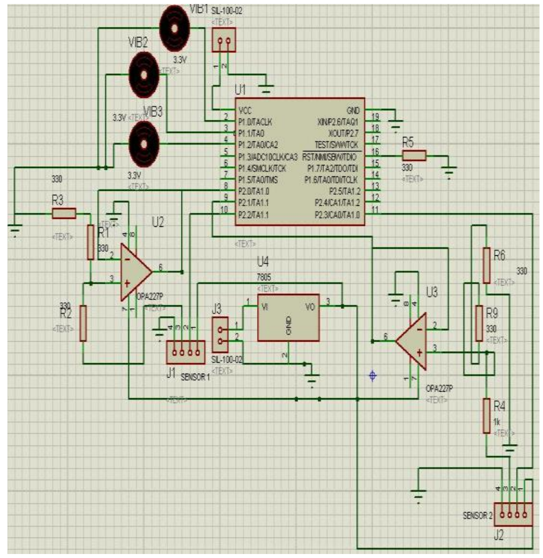
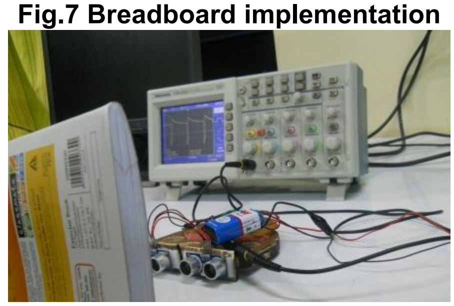


Fig.6: Circuit Diagram

For haptic feedback we have used mobile vibrators (VB1, 2, 3) which are used in mobile phones. These motors have variable frequency vibrations on the cost of very low current consumption. The frequency of the vibrations is changed is using pulse width modulations explained before. The fig.7 shows the breadboard implementations of the circuit where we have replaced the connections of vibrator motors with LEDs. The Launchpad is just used to get the 3.3V and 5V power supply. We also tested the waveforms of input and output on a Digital Storage Oscilloscope.

Fig.7 Breadboard implementation



As stated before the final product is intended to be comfortable, light weight so we fabricated the housing of the embedded device using wood. We got the idea of this design from a knuckle punch. Further we have used a 9V Radio Battery with a TI's UA7805CKCS voltage regulator and a pair of AA batteries to power the MSP430G2553 with 3V supply and mounted batteries with a power switch. The final device without the app is shown in fig. 8

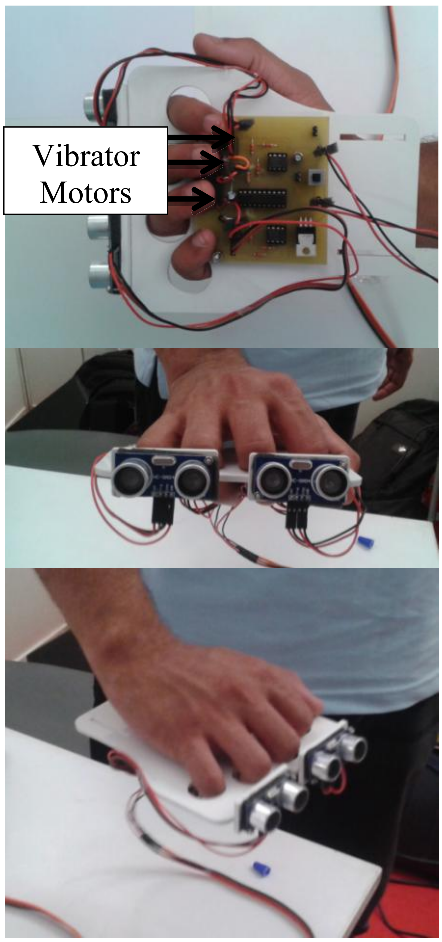


Fig.8 Final device

3.2 Software Implementation

The fig.9 shows the algorithm Implemented on MSP430G2553 microcontroller. Fig. 10 shows the algorithm which we have implemented in the android application.

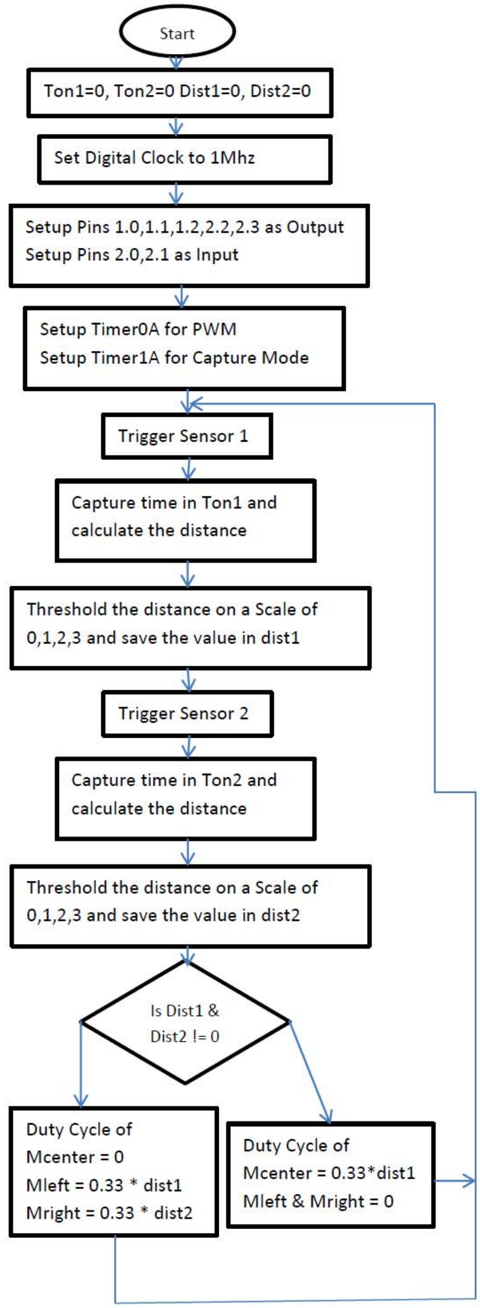


Fig.9 Microcontroller algorithm

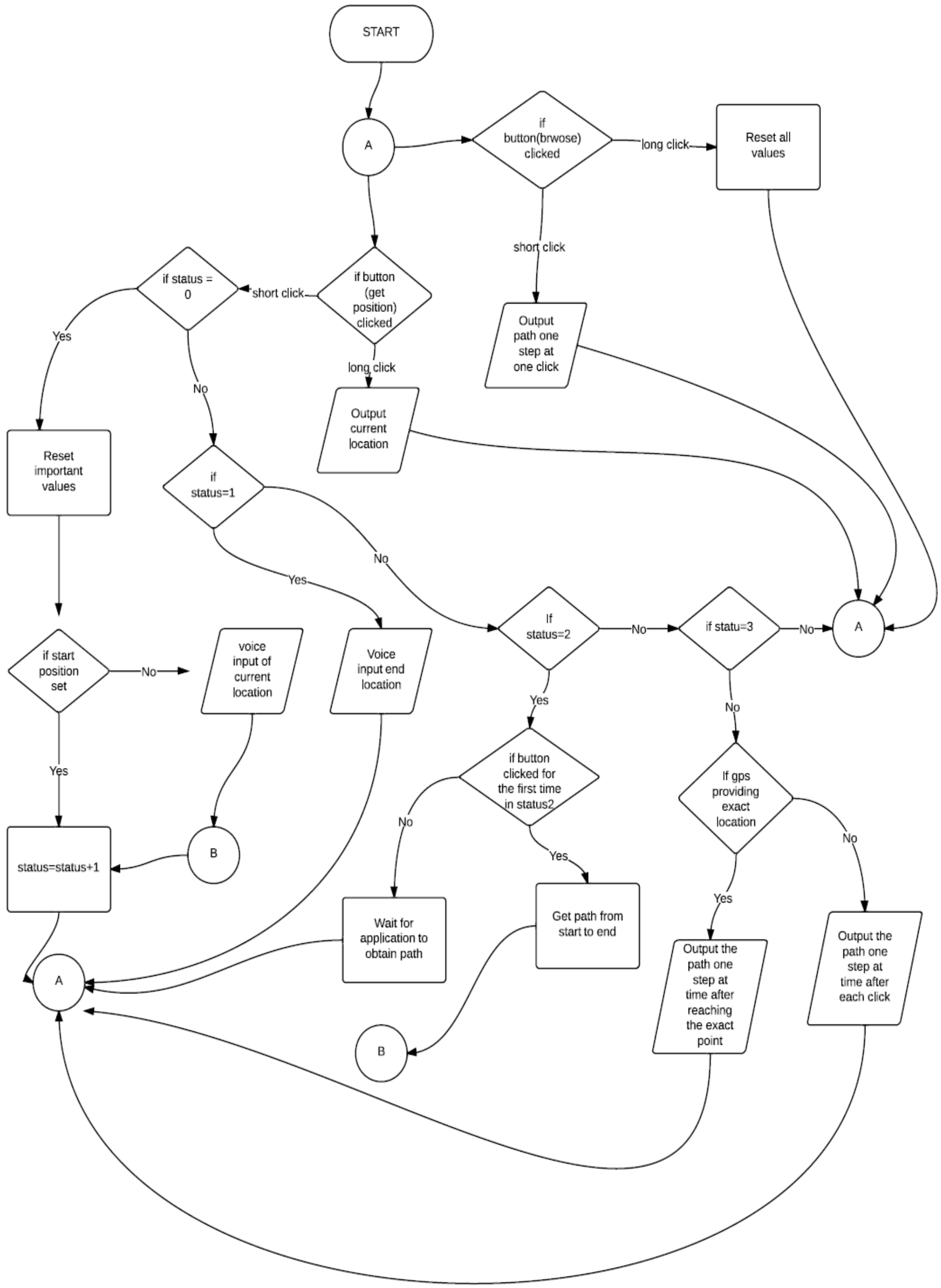


Fig.10 Android App Algorithm

4. Results:

We have tested the device by blindfolding a person with black cloth and navigating in our college campus the result can be seen in the link[5]http://inobotics.blogspot.in/2013/01/blind-navigator-video.html

5. Conclusions

Looking at the fig.8 it is clear that we have made a complete prototype of our idea which is a light weight, comfortable and accurate device which can be used to navigate by blind people. The working of this device is shown in the link [5] under References.

A plane extraction algorithm in OpenCV within an android application would be the next step of this project. This will warn blind person if there is any step or pothole in the path. In this project we have used only 3 motors for haptic feedback. Instead of this one can use a 2-d array of such actuators so that we can develop methods to give feedback about more details which we will obtain from the camera in the android device by image processing.

References

[1] Statistics of population of blind people: http://www.who.int/mediacentre/factsheets/fs282/en/

[2] "An Ultrasonic Ranging System for the Blind", T. 0. Hoydal, J. A. Zelano at Bioengineering Conference, Proceedings of the 1991 IEEE Seventeenth Annual Northeast

[3] "Tactile Web Navigator Device for Blind and Visually Impaired People" , Alaeldin A. Ahmed, Mustafa A. A. Yasin & Sharief F. Babiker at 2011 IEEE Jordan Conference on AEECT

[4] Graph of showing the characteristics of a typical vibrator motor from the following website: https://catalog.precisionmicrodrives.com/order-parts/product/312-101-12mm-vibration-motor-3-4mm-type

[5] Video of the working of the device can be seen at: http://inobotics.blogspot.in/2013/01/blind-navigator-video.html

[6] Launchpad Website: www.ti.com/launchpad

Appendix – Bill of Material

	Component	Cost per component (INR)	Qty	Total cost of component (INR)
1	Vibrating motors	100	3	300
2	Ultrasonic sensors(HC-SR04)	500	2	1000
3	Op-amp(OPA227P)	100	2	200
4	UA7805CKCS	40	2	40
5	MSP430G2553	50	1	50
6	Miscellaneous	200	1	200