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Design of Navigational Aid for the Visually Impaired Using Haptic Feedback

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ABSTRACT*:* The general aid used by the visually impaired for safe navigation outdoors is the white-cane. While the technologies today are striving to produce a solution for an easier and more reliable form of navigation, design and implementation of the same for a common user is still far-fetched. Although the use of advanced technologies like GPS is promising, the user is compelled to use a smart-phone which is largely designed for a sighted user. This paper proposes a minimal design that can be commercially viable and affordable to users in India. The system uses the basic idea of ultrasonic waves used to alert the user of obstacles in his way through haptic feedback. The sensing system is designed to add minimal bulk to the white cane while the haptic feedback system is installed in a glove worn in the free hand. The system will therefore aim at minimal yet effective addition to the accustomed system of using a white-cane.

KEYWORDS: Navigational Aid, Visually impaired, haptic feedback.

I. INTRODUCTION

The primary objective of the traditional white-cane is to ensure safe navigation of its user. Most white-cane users adoptthe two-tap method to find their way around an area.The two-tap method is one where the user taps the area in front of the foot before stepping forward such that if there is an existent obstacle in his path, the white-cane would meet with it first and alert the user. Although the two-tap method satisfactorily avoids injuries, it method has the following limitations:

a) On meeting an obstacle, multiple taps are required to identify the dimensions of the obstacle.
b) Identification of a turn around the block requires additional taps on the wall.

Thus the white-cane, though prevalent in its use, leaves large room for improvement. The white cane,

a) Doesn't help the user in avoiding obstacles above waist level.
b) Doesn't mitigate the possibility of bumping into approaching objects.

This paper is one that touches upon the basic additions to the white-cane that can reduce the risk factor and increase reliability and efficiency, thus strengthening the objective of the white-cane. The features of the proposed system will enable the users to:

a) Be aware of obstacles well before physically reaching them.
b) Detect obstacles above and below the waist level.
c) Assess the speed and position of an approaching object.
d) Wave the stick in desired direction to get a picture of surroundings on a whole from one spot.

The proposed system, while taking the white-cane one step ahead, does have its limitations.

a) Realisation of the nature of the walk-way requires the user to still depend on the two-tap method.
b) System is not useful in warning the user of fast approaching objects (an approaching vehicle). The alert system is limited to warning the user at the maximum, of a jogging person.

The system will use ultrasonic modules for the sensing of objects in the chosen path and based on the time of reflection of the waves, and distance of obstacles hence calculated, the user will receive a vibro-tactile feedback much before his cane reaches the obstacle. This will enable the user to conceive an approximate sketch of his surroundings and choose a safe path for navigation.

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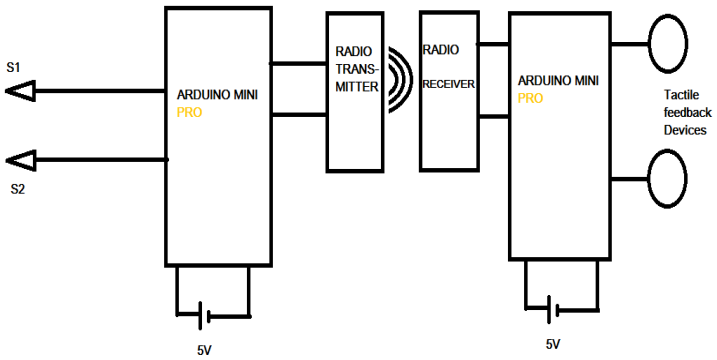

Fig.1 Architecture for obstacle detection

II.THE MOUNT MODIFICATION

The white-cane is the mount on which the sensing circuit is to be installed. The system will consist of two ultrasonic modules angled such that one covers the area with a beam angle of 15 degrees below the normal to the cane and the other covering the same area above the normal to the cane at that point. The positioning should thus ensure that the system can detect obstacles above and below the waistline of the user. This system will consist of the two ultrasonic modules, an arduino pro-mini and a RF transmitter, thus adding minimal weight to the original cane design. The arduino pro-mini will be programmed to calculate the distance of the obstacle from the user and transmit the value to the feedback system.

The ultrasonic module to be used has to be triggered by a 10us long pulse to initiate the transmission of 8 cycles of ultrasonic waves. The duration for which the ECHO pin of the sensor is high determines the time taken for the reflection of the wave from the object.

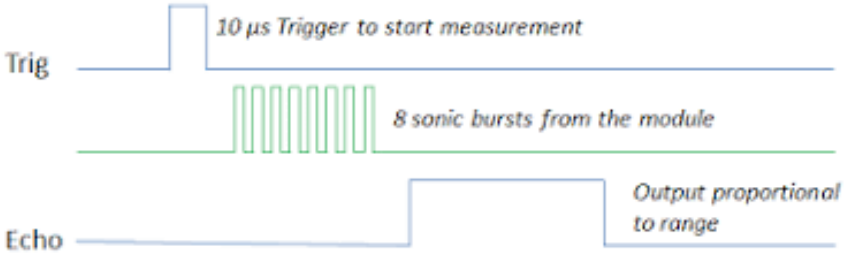

Fig.2. Timer diagram for trigger and Echo

The calculation of this time thus enables calculation of the distance between the cane and the object. Distance is to be calculated using the reflection time of the ultrasonic waves using the formula:

Distance= (time*speed of sound)/2

III.FEEDBACK SYSTEM

The alert system is in the form of vibro-tactile feedback. The system is to be incorporated in a glove on the free hand rather than on the cane itself in-order to allow the user to hold the cane in any position as he wishes. The glove will consists of another arduino along with two3V button vibrators, one positioned right below the fingers and the other positioned a little above the wrist corresponding to the two sensors. The lower button vibrator alerts the user about

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objects below the waistline while the upper one alerts the user about objects above the waistline. The vibrators are to alert the user in three different manners:
Alert1: Brief vibrations indicating that the object is 4 meters away.
Alert2: Intermittent vibrations indicating that the obstacle is within 2 meters away.
Alert3: Continuous vibrations indicating that the obstacle is within a meter away.
The vibrators are connected to the PWM pins of the arduino and the duty cycle of the input to the vibrators is altered based on the value of distance calculated. Thus the variation in the vibro-tactile feedback is achieved as mentioned. The alert system is thus capable of creating an idea of the obstacles in the path of the user well-in-advance, thus helping him navigate better.

VI. ALGORITHM

Controller: ATmega328 (in arduino pro-mini)
Language: C++
For the sensor circuit:
*Ste*p 1: Start
Step 2: Define trigger, echo pins of ultrasonic module and input pin of transmitter
Step 3: Intialise time and distance as variables
Step 4: Send 10us HIGH to trigger
Step 5: Calculate time by counting time period for which ECHO pin is set HIGH.
Step 6: Calculate distance using formula: distance= (time*speed of sound)/2
Step 7: Transmit the value of calculated distance
Step 8: Go to step 4
For the feedback circuit:
Step 1: Start
Step 2: Initialise variable distance.
Step 3: Define receiver and vibrator pins (use PWM)
Step 4: Get distance value from receiver
Step 5: If distance<4
If distance<1
Output pulse with 90% duty cycle to vibrator
If distance<2
Output pulse with 50% duty cycle to vibrator
Else
Output pulse with 25% duty cycle to vibrator
Step 6: Go to step 4

V. SYSTEM FLEXIBILITY

The system thus proposed is the basic modification to be introduced. However, the system is simple and hence will allow plenty space for modification and introduction of other technologies eventually. The system may be taken to the next level by incorporating a GPS aided mapping system that records the surroundings of any particular area, keeping in memory the important, user-defined check-points. The introduction of any such improvisations will not be hindered by the existing system while the existing system will function smoothly in parallel with the additions.

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VII.RESULT

The system, on operation, is expected to reflect its efficiency through the appropriate outputs given to the vibrators on calculation of the distance between detected obstacles and the cane.

Fig.3 is the output seen when the distance calculated is between 400 and 200 cm and corresponds to 25% duty cycle

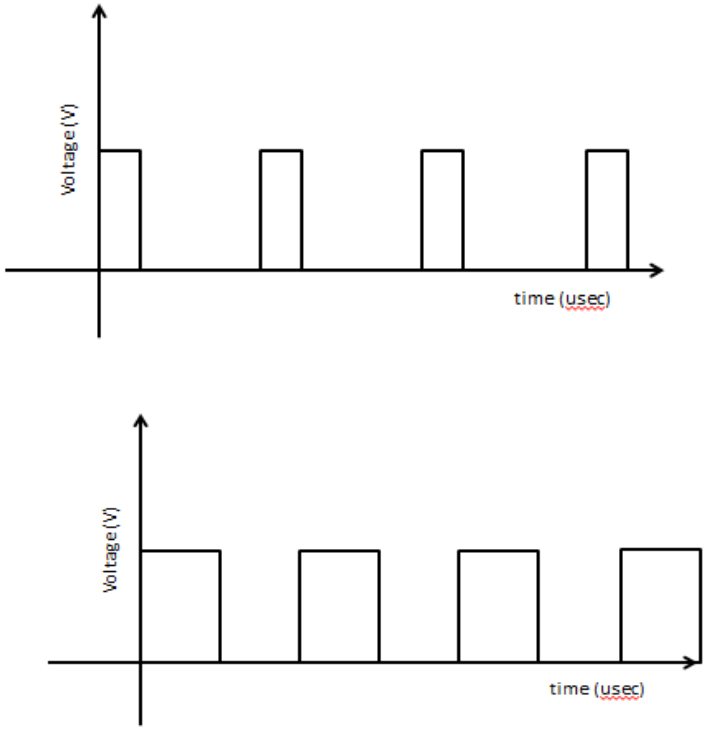

Fig.4 t 50% duty cycle pulse generated when calculated distance lies between 100 and 200 cm

The figures above show the output pulses at the PWM outputs connected to the vibrators. Fig.1 is the output seen when the distance calculated is between 400 and 200 cm and corresponds to 25% duty cycle. Fig. 2 corresponds to the 50% duty cycle pulse generated when calculated distance lies between 100 and 200 cm. Fig. 3 corresponds to the 90% duty cycle pulse generated when calculated distance lies within 100 cm.

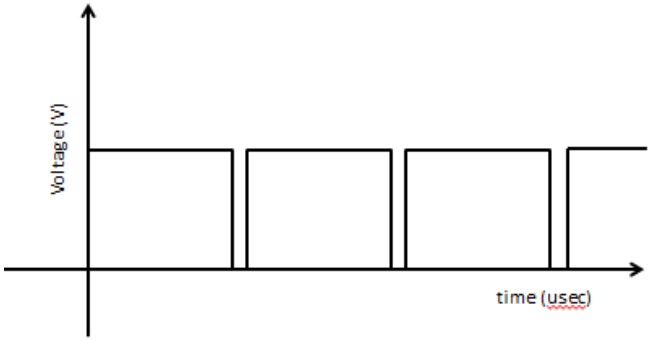

Fig.3. 90% duty cycle pulse generated when calculated distance lies within 100 cm

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VI.CONCLUSION

The design hence proposed is one that is efficient, commercially viable and cost effective all at the same time. The complexity and size of the system is minimal, making fabrication and implementation simple. The circuits used weigh well below 0.5 pounds and thus the useful addition is barely noticeable. The alert system that warns the user at different stages through the PWM pulses makes the system more reliable. While the system thus proposed is a basic addition that can be made to increase the reliability of the existing white-cane, it doesn't limit the use of technologies that can further build the efficiency of the same.

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