

# The Digitalization of the Walking Stick for the Blind

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**Abstract:** Blindness is a state of lacking the visual perception due to physiological or neurological factors. In this project, a simple intuitive blind navigation system is designed and implemented to improve the mobility and safety of blind people during their travels. The prototype includes a wearable glove to help the blind person to navigate alone safely and to avoid any obstacles that may be encountered, whether fixed or mobile, to prevent any possible accident. The main component of this system is the ultrasonic sensor which is used to scan a direction by emitting reflecting ultrasound waves. The reflected ping received from the obstacle is inputted to the microcontroller which is used to determine the distance of the object from the user. This distance then gets outputted by a vibrating motor which vibrates with more intensity as the obstacle gets closer. The current prototype is effective in terms of eliminating the use of a cane and also making it less embarrassing for the user to travel without being noticed.

**Index terms:** blind aid, digital walking stick, obstacle avoidance, obstacle detection, ultrasonic, vision glove, vibration response.

## 1 INTRODUCTION

The most common use of navigation among the blind is the walking cane. For years it has been used but it is very obsolete. Not only is it hard to navigate around in crowded places such as school hallways or city streets with a walking cane, but accidents are common and this shows it is unsafe as well as embarrassing to be used, mainly due to the size.

This project tries to address this need by replacing the walking cane with a digital solution that offers the same functionality, but makes it more intuitive and also much more portable and at the same time less visible.

## 2 BACKGROUND RESEARCH AND NEED

Every 5 seconds, somewhere, someone in the world goes blind. 20% of all blindness is not curable nor preventable. Around 7 million people in the United States are blind, 10% of those are between the ages of 4 and 20 and a further 10% of that age are registered at schools.

According to a study of 300 blind individuals by researchers at the University of Santa Cruz found that 13% of participants experienced head-level accidents at least once a month and 7 percent experienced falls while walking at least once a month. Further, they found that the use of a guide

dog did not decrease the frequency of falls. Individuals in the study also expressed that they are less confident to travel due to accidents occurring. One of the leading causes of these accidents were unexpected obstacles and the second was the misjudgment of distances.

The research done in this project further backs that canes have the right function to assist the blind in navigation, but users feel less confident to travel due to the inconvenience and also the embarrassment. As well as this, the cane presents safety concerns for the user as well as the people nearby.

Companies and researchers have tried to address the need to digitize the cane, but all have done it to provide more information to the user, such as colour and the type of obstacle. All of the designs continue to employ the use of a long cane, which this project will eliminate the use of.

## 3 DESIGN CRITERIA

To correctly address the need and come up with an appropriate solution it is important to establish a set of design criteria which will assist in designing solutions.

1. The device must be small and not get in the way of movement.
2. The device must be intuitive to be usable by anyone, with or without the experience of using a walking stick to navigate.

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3. The device must be able to identify and differentiate distances from an obstacle.
4. The device should not slow down the travel of the user compared to when using a walking stick.

#### 4 PRELIMINARY DESIGNS

The initial design (Figure 1) of the device was deliberately made to be the most basic this way the device will be minimalistic and will not overwhelm the user with complex functions.

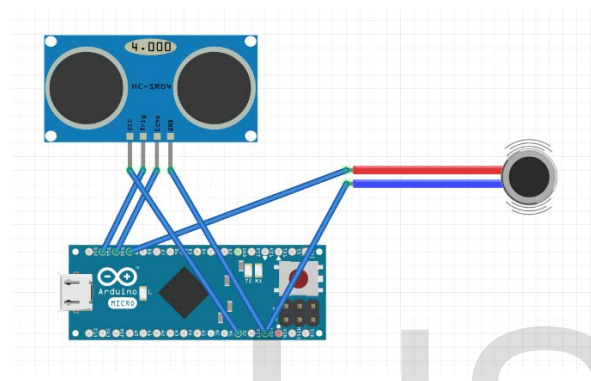


Figure 1 - Initial Design

Materials:

- 1 HC-SR04 Ultrasonic Distance Sensor
- 1 A-Star 32U4 Micro Microcontroller
- 1 Vibrating Motor
- 1 5V Portable Battery Pack

The basic idea was to design a device that can be strapped to the outside of the hand and the user can point it around to find the distance from their hand to next obstacle in the direction they are pointing in, the user will then feel a vibration which has different intensities depending on the distance of the obstacle. This way the device functions like a digital cane/walking stick.

The cane acts as a way for the user to be able to detect obstacles, this property will be referred to as obstacle detection. In order to satisfy design criteria 3 the obstacle detection mechanism must be able to measure distances. In order to achieve this the HC-SR04 ultrasonic distance sensor module will be used. The HC-SR04 is a sonar based sensor that uses ultrasound to send a ping and then if this ping hits an obstacle within its ping range of 4 metres it will bounce back and the module will

provide the time the ping took to travel from the module and to bounce back.

In order to process this information and to send an output a microcontroller is needed, in order to satisfy design criteria 1 the A-Star 32U4 Micro is used due to its tiny size of 1.5cm × 2.7cm × 0.45cm. The microcontroller will take the input and convert it to distance in centimetres by using the equation  $distance = speed \times time$  the speed in this case being the speed of sound in cms-1 and the time being the duration of the ping divided by 2 (going there and back). Upon obtaining the distance the microcontroller will then use an algorithm to control the intensity of vibration output depending on the distance. In specific, the distance of the object is inversely proportional to the vibration intensity, simply put, the closer the obstacle, and the more the intensity of the output vibration ( $vibration \propto \frac{1}{distance}$ ).

The vibrating motor is connected to pin 9 on the microcontroller, pin 9 has Pulse-width modulation (PWM) functionality meaning you can vary the voltage output that way you can control the intensity of the vibrating motor to produce different intensities allowing the user to differentiate between different distances.

To begin with, 4 distance intervals and their respective intensities are set:

Distance (m)	Intensity of output (0-255)
Less than 1m	255
More than 1m but less than 2m	205
More than 2m but less than 3m	153
More than 3m	102

#### 5 Results

After the initial prototype was working, testing was done in order to see if objects were recognized (obstacle detection), in which the prototype was 100% responsive.

Next objects were set up inside the 4 different distance intervals to test if the vibrations were at the correct intensively. In this test a computer was used to see the exact cm value recognized by the prototype and then this data was put on a table with the intensity of output the prototype gave

according to the computer (this is not based upon a human test). 100 trials were done on 3 different days and the average of all the data collected from each .trial of each test is shown.

Test 1: Actual distance compared to the distance measured by the prototype

Actual distance (cm)	Distance measured by device (cm)			Intensity of output (0-255)		
	9	10	10	255	255	255
10	9	10	10	255	255	255
110	112	110	110	205	205	205
250	245	249	250	153	153	153
380	350	375	378	102	102	102

The final test was to see if a human could tell the difference in distance between the objects with their eyes closed and only judge from the intensity (4/strong - 1/weak) of the vibrations felt on their hands.

Test 2: Intensity of output by device compared to the intensity felt by the human user

Actual distance (cm)	Intensity of output (0-255)			Feeling of intensity (1-4)		
	255	255	255	4	4	4
10	255	255	255	4	4	4
110	205	205	205	4	3	2
250	153	153	153	3	2	2
380	102	102	102	1	1	1

## 6 Data Analysis and Discussion

From testing done on the prototype it was possible to see that in theory the design functions perfectly, in that, it achieves the goal of accurately estimating distances at the same time be correct in terms of the human differentiation of the distance intervals set at this point. Test 1 shows that the device can differentiate distances with a maximum of 30 cm error which for a device in this case is really effective.

But the problem (seen in Test 2) now seems to be how the device can relay the output better to the user so that the user can differentiate distances at the same level as the device. A possible solution to explore in further design is the addition of a second vibrating motor so that the vibration is amplified in order to give stronger feeling of the

intensively so that the human can tell the difference.

But furthermore, the distance intervals set at this point are somewhat vague and so it is important to have a smaller interval such as having a different vibration intensively every 30-50cm, but this again can raise the problem from Test 2 where the wider range of intensities will not be felt by the human user. So this calls for a different output method such as an audio based system where the distance is read out to the user but this can also raise more issues such as slowing down the speed of the user's movement.

It is also important to work with the target user group, which in this case is the blind, and have user trials where proposed users test and provide their feedback on the prototype, this way the prototype can be further developed into an error-less product ready for release into the consumer market.

## 7 Conclusion

In conclusion and on reflecting back to the initial design criteria, the prototype satisfies design criteria 1, 2 and 4. Although 3 is somewhat satisfied, the prototype can be further developed so that it provides a more distinct output to the user. But it is impressive that the preliminary design has been able to fully satisfy most of the initial criteria set-up and this shows that the design is not only effective but on the right track to address the need it set out to fulfil. Also it is necessary to test the product more in a real world situation with real user from the target group.

## REFERENCES

- [1] National Federation of the Blind. (2014) Blindness Statistics. Available at: <https://nfb.org/blindness-statistics> (Accessed 01 December 2014)
- [2] National Eye Institute. (2012) Blindness, Statistics and Data [NEI]. Available at: <http://www.nei.nih.gov/eyedata/blind.asp> (Accessed 02 December 2014)
- [3] Manduchi, R, Kurniawan, S. (2011) 'Mobility-Related Accidents Experienced by People with Visual Impairment'. Insight: Research and

Practice in Visual Impairment and Blindness,  
4(2): 44-54.

- [4] Johann Borenstein and Yoram Koren, The Guide Cane -A computerized Travel aid for the Active Guidance for the Blind Pedestrians, proceedings of the IEEE international conference on Robotics and Automation, Albuquerque, 1997, page 1283-1288.
- [5] C. Gearhart, A. Herold, B. Self, C. Birdsong, L. Slivovsky, Use of ultrasonic sensors in the development of an Electronic Travel Aid, Sensors Applications Symposium, 2009, SAS 2009, IEEE, pp.275-280.
- [6] Shang Wenqin; Jiang Wei; Chu Jian; A machine vision based navigation system for the blind China Computer Science and Automation Engineering (CSAE), 2011 IEEE International Conference on 10-12 June 2011.
- [7] Hashino, S.; Ghurchian, R.; A blind guidance system for street crossings based on ultrasonic sensors. Information and Automation (ICIA), 2010 IEEE International Conference on June 2010
- [8] F. Gaunet and X. Briffault, "Exploring the functional specifications of a localized way finding verbal aid for blind pedestrians: simple and structured urban areas," Human Computer Interaction, vol. 20, no. 3, pp. 267-314, 2005.
- [9] J. M. Loomis, J. R. Marston, R. G. Golledge, and R. L. Klatzky, "Personal guidance system for people with visual impairment: A comparison of spatial displays for route guidance," Journal of Visual Impairment and Blindness, no. 99, pp. 219-232, 2005.
- [10] J. M. Benjamine, N. A. Ali and A. F. Schepis, a laser cane for the blind, proceeding of the San Diego
- [11] Biomedical Symposium, 1973, Vol. 12, pp 53-57.