DEVELOPMENT OF WALK SAFE CANE FOR THE REHABILITAION OF BLIND PEOPLE

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CERTIFICATE

This is to certify that the thesis entitled "**DEVELOPMENT OF WALK SAFE CANE(WSC) FOR THE REHABILITAION OF BLIND PEOPLE**" submitted by **Mr. Krishna Kumar** in partial fulfillment for the requirements for the award of Bachelor of Technology Degree in Biotechnology at National Institute of Technology, Rourkela is an authentic work carried out by him under the supervision of the undersigned.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma.

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Date: Krishna Kumar

CONTENTS

ABBREVIATIONS

WSC-Walk Safe Cane

ETA-Electronic Travel Aid

NOD-Nottingham Obstacle Detector

FM-Frequency Modulation

PWM-Pulse width Modulation

I/O- Input/Output

GPS-Global Positioning System

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ABSTRACT

WSC will be meant for the rehabilitation of the blind people. The product is based on the distance measurement property of the ultrasonic sensors. It will measure the distance and velocity of the obstacle in the way of the person and will alarm the person about any obstacle (moving/stationary). There are ~4million blind persons across the world. Many of these persons use products similar to the WSC as travel aid for the blind. WSC will allow detection of obstacles on the ground, holes and pits, uneven surfaces, steps, and other typical obstacles in the path of the person. Apart from other similar products the WSC will also allow detection of potentially dangerous obstacles at head level. Since the device is incorporated with wireless module it will be very handy and will be much easier to use as compared to the similar products available in the market.

Keywords: Ultrasound, Sensor, Rehabilitation, blind, WSC

CHAPTER 1
INTRODUCTION

1. INTRODUCTION

Out of a number of severe disabilities blindness is one of them which a person is bound to bear despite of a number of technological advancements. World Blind Union, in the year 2009, released a number of 160 million blind and partially sighted persons living throughout the globe [1]. Blindness is a type of disability in which the sufferer needs a continuous assistance even for the most basic needs of the life. An individual, how much attentive he may be, some way or the other will fail to attend the blind person at several occasions and therefore rehabilitation for this particular disability has been a challenge and is resistant to the benefits of the limited rehabilitation techniques present [2]. Despite of such challenges there are a large number of people who use the traditional white cane for their assistance [1, 2]. White cane has been in use since decades [3]. White cane has its own limitations. It has a very short range of detection and detects obstacles only below waist height. It also doesn't provide information about the geographical surrounding [4]. A white can user, thus, requires assistance of sighted persons or guided dogs to navigate to their destinations. Such shortcomings have always pushed the researchers for a better advancement in the field of blind rehabilitation [5].

So a number of other solutions were introduced in the form of Electronic Travel Aids (ETA) [6]. These solutions have improved the mobility and live of the visually impaired persons but only upto a little extent. The device was hence not considered successful widely.

The type of communication introduced describes some features of a blind rehabilitation system, which is developed as an aid for visually impaired section of the society who acquire almost constant assistance for the most elementary needs. Such a device, it is hoped, will return a measure of independence to many such persons as well as reducing the number of those in need of constant assistance .

CHAPTER 2 LITERATURE REVIEW

2. LITERATURE REVIEW

A huge number of research works are being performed in various institutions across the globe to provide with a cost effective and efficient navigation aid for the blinds. Initially the visually impaired persons were assisted by sighted persons for their basic needs and mobility then came the era of guiding dogs. Guiding dogs are trained dogs and they help the blind person for an assisted mobility. But this solution was not effective. Researchers put in their effort and designed a number of Electronic Travel Aids (ETA). This section contains a review on devices developed so far.

White can is regarded as world's most widely used navigation aid for blinds. White cane can detect obstacles present on the ground, pits, puddles, uneven surfaces and also steps [7]. White canes are made up of very light materials and provide an ease of carrying it as it is foldable and easily fits into ones pocket [8]. As a result, the initial cost for white cane is very less. But speaking of overall cost, the case is not the same. A user requires a practice session of about 100 hours to get comfortable with the device so that he can walk safely and properly. Now the "100 hours" investment is considered the extra cost which is very high [9].

Apart from this device several other devices have been developed over the years and are still developed for a better support to the blind people. Few of the devices are discussed below.

Attempts for the rehabilitation of blind people have been made since decades. The past three decades have seen a number of electronic devices being developed for the purpose. The aim behind development of all the devices though have been the same, safety, confidence and speed in mobility of a blind person [10]. List of few ETAs are:

C-5 Laser cane [11]: It was introduced in 1973 by Benjamin et al. It is based on optical triangulation by three laser diodes and three photodiodes acting as receivers. These photodiodes are silicon photodiodes [12]. The cane is capable of detecting obstacles at head level; ground level as well as in-front of the user. The device can detect obstacles in between a range of 1.5-3.5 m ahead of the user [13].

There are several disadvantages attached with use of a laser cane [14]. The use of laser cane can be harmful if proper precautions are not taken and can affect the eyes of an individual without any proper eye wear. The photodiodes used at the receiving ends are most likely to respond to various ambient sources, the sun light etc. Moreover, in hot and smoky areas the efficiency of the cane droops drastically [14].

The Mowat sensor [15] and the Nottingham obstacle detector (NOD) [16] both are hand held devices used for obstacle detection. The Mowat sensor uses ultrasonic based distance measurement system [17] whereas the NOD is a sonar device. Mowat sensor requires engaging both hands of the user for an effective scanning for the obstacles.

The Binaural Sonic Aid (Sonicguide) [18] is a device wimilar in appearance to a pair of spectacle frames. These frames allow the placement of ultrasonic transreceivers. The transmitter is sitted in the middle of the frame with two receivers, one each mounted on side of the frame [19]. Its principle of distance measurement is based on the frequency shift and hence the receivers have an interaural amplitude difference which thus helps user in the determination of the result in the form of distance and direction of the obstacle [20].

Another sonic system is Kaspa [21]. It is much complex system consisting of a sweep FM ultrasound emitter and three sensors whch are purposefully displaced [22]. The echo signal is rich in obstacle information and when received can be used to extract various properties of the obstacle. The frequency of the obstacle is inversely proportional to the range [23].

Apart from these a number of other devices were also developed but unfortunately they could not get enough popularity.

Drawbacks of these navigation devices are numerous [24]:

--Requirement of conitnuos scanning by some devices reults in a lot of time consumption [25].

--Expenses involved were high for some devices as they required conspicuous installation and maintenance cost [26].

--The amount of information is not sufficient for the user.

--Reduction of noise signals and training were the basic necessity need to be focused upon [27].

--The devices developed were many steps to lower the difference between the mobility of a sighted person and a visually impaired person. But still they could not develop the confidence among the deprived and hence the devices could not achieve success in the market.

CHAPTER 3
MATERIALS AND METHODS

3. MATERIALS AND METHODS

3.1. MATERIALS

A. Arduino UNO (Arduino, Italy)

Arduino UNO is a microcontroller board based on ATmega32. It consist of 14 digital I/O pins out of which 6 pins can be used as PWM pins. In addition to this it contains 6 analog input pins.

Figure 1: Arduino Uno

Table 1: Specifications of Arduino UNO

Microcontroller	ATmega328
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328)
EEPROM	1 KB (ATmega328)
Clock Speed	16 MHz

B. Ultrasonic Sensor

The model of the US used - HC-SR04. This sensor is owned by Cytron Technologies and is manufactured in Malaysia. The sensor uses sonar to calculate distance to an object in a manner similar to bats or dolphins. It excellently detects objects without making any contact with them. Range of the device varies from 2cm to 400cm or 1'' to 13 feet. Its efficiency of distance measurement is not affected by sunlight or any black material e.g. Sharp rangefinders. Although sound absorbing materials are most likely to be not detected. HC-SR04 is a complete set of both transmitter and receiver module.

Table 2: Features of HC-SR04(Ultrasonic sensor)

• Power Supply	+5V DC
• Quiescent Current	<2mA
• Working Current	15mA
• Effectual Angle	<15°
• Ranging Distance	2cm – 400 cm/1" 13ft
• Resolution	0.3 cm
• Measuring Angle	30 degree
• Trigger Input Pulse width	10uS
• Dimension	45mm x 20mm x 15mm

Figure 2: Ultrasonic Sensor

C. X-Bee

X-Bee (ZigBee) is a transmitting module manufactured by Digi International, USA and is compatible with Arduino UNO. This particular module was used in the development of the alarm system of the entire setup. Hence, two X-Bee modules were used, one on the detecting end which acted as the transmitter and other on the alarm setup which worked as receiver.

Model: S1

Manufacturer: Digi International

Country: USA

Figure 3: X-Bee S1

D. X-Bee Shield

Arduino X-Bee shield helps rather allows X-bee to communicate over air i.e wirelessly with the Arduino or vice-versa. X-bee shield was used in both detecting and transmitting unit. Arduino X-bee shield is manufactured by Arduino in collaboration with Libelium.

Manufacturer: Arduino and Libelium

Country: Italy and Spain

Figure 4: X-Bee shield

E. Battery

A typical rechargeable 9V battery was used.

Figure 5: 9V Duracell Battery

F. Walking Cane

A simple walking cane was used to build the proposed device.

G. Buzzers and Led

3 buzzers and 3 LEDs were coupled together in alarm unit.

H. Baby Bibs

A Baby Bib was used to develop the alarm system.

3.2. METHODS

A. Sensor Calibration

The ultrasonic sensors were calibrated by obtaining and comparing the output of the serial monitor to the actual distance. This calibration was required for the absolute distance measurement of the obstacle otherwise which might lead to incidents during the use of the WSC.

B. Development of the device

The proposed design of the WSC is shown as a schematic in Figure 4 and the overall functioning of the device is also shown as a flow chart (Figure 5). Three pair of ultrasonic transreceiver modules were arranged in a fashion to detect obstacle in front, at head level and at foot level. A trigger signal was given to the transmitting end of the US module which after echo was received at the echo end.

This echoed signal was then analysed to extract information regarding the obstacle present. The received signal had the information in terms of time period which was deciphered in terms of distance by using the formula:

$$\mathbf{D = T/58.2,}$$

D→distance of the obstacle;

T→time period of the signal.

This cycle of transmitting and receiving was repeated every 100ms hence a continuous obstacle detecting system was established.

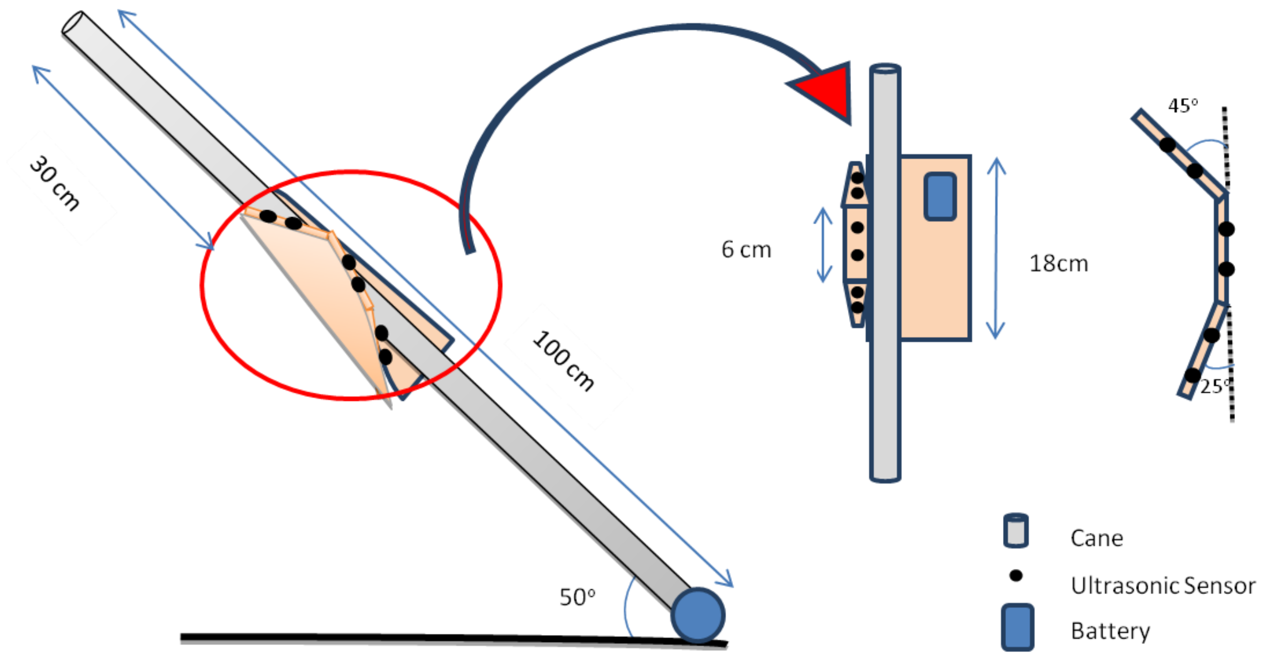

Figure 6: Schematic diagram of WSC

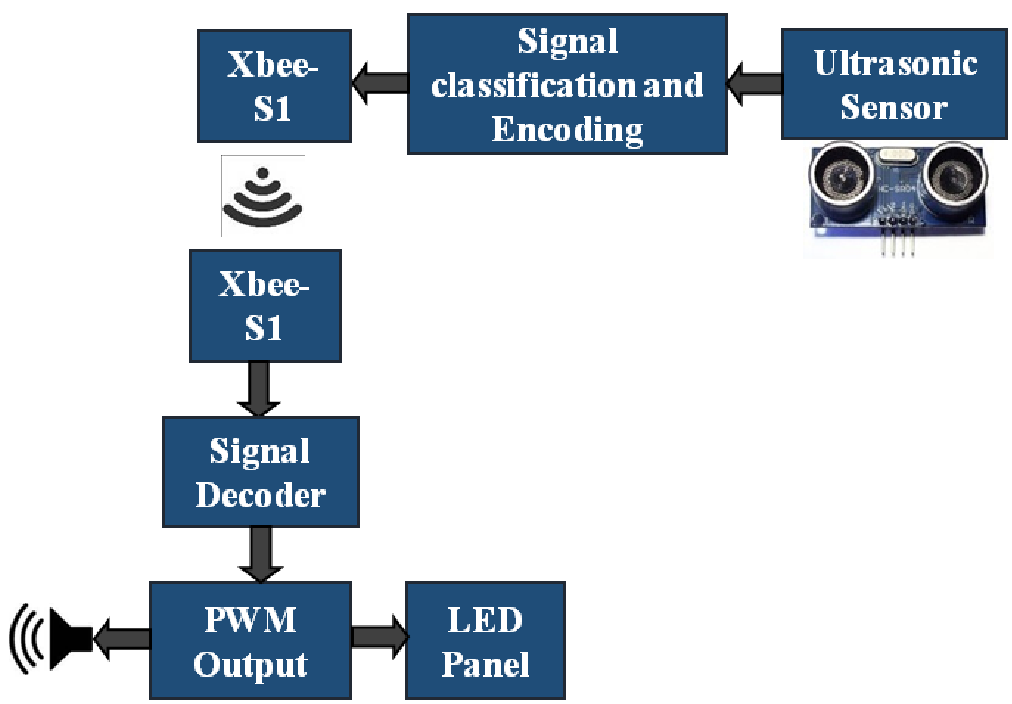

Figure 7: Flow chart of functioning

The same logic and concept was used for the product development. Following the schematic diagram a number of prototypes were made. The cane was attached to a wooden base in the middle which was to attach the Arduino and the power source to the cane. The initial prototype developed lacked a basic thing, the angle of the in front sensor with horizontal was supposed to be 90^o but since the cane was attached directly without any angle provided when the user held the cane the angle between the vertical axis and the cane was the angle by which the sensor was rotated and hence the same measurement was used to elevate the sensor. Once the correction angle was implemented the design of the cane matched to the theoretical approach.

Figure 8: Initial Prototype of detecting device

Furthermore, the device was designed as such so that the complex circuiting could be eliminated from being visible and interred hence the setup was put in a wooden box.

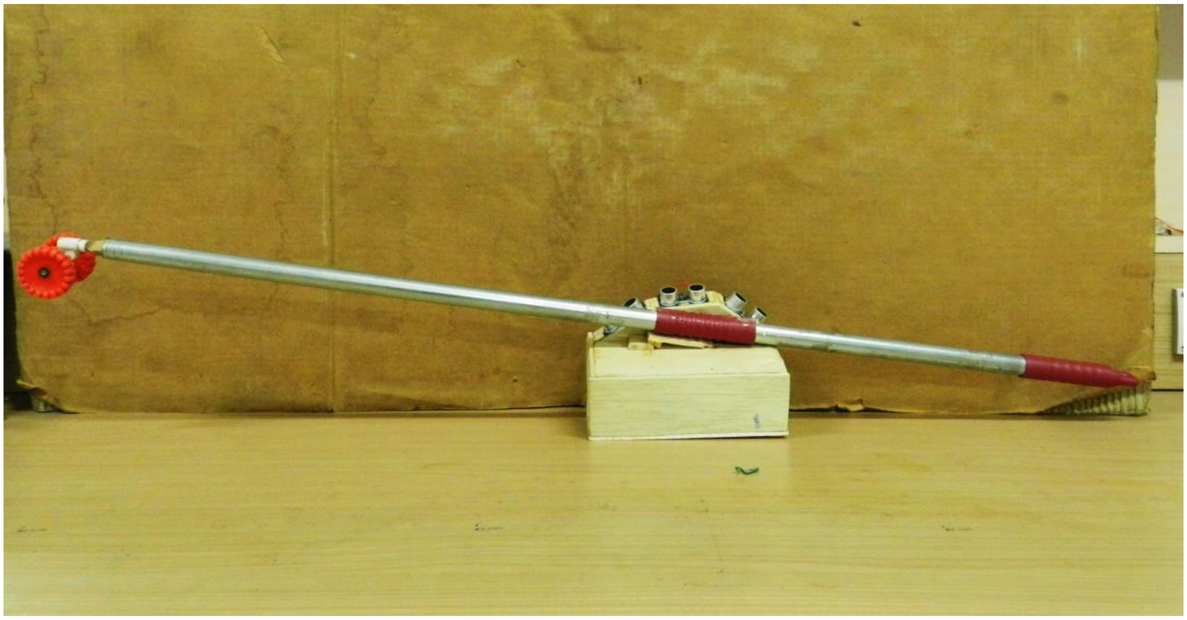

Figure 9: Final prototype of detecting device

The alarming system was established in the similar fashion and thus a number of prototypes were made. The first prototype was an alarming system mounted on a belt with three buzzers coupled with three LEds. The buzzers were placed in a fashion where they indicated an alarm whenever there was obstacle detection from Head to Toe, they buzzed from right to left respectively.

Then the prototype developed was very much simple. The system was to be worn around the neck and was built in a thermoplastic material of very light weight.

Figure 10: Initial prototype of alarming setup

The buzzer on the right shoulder buzzed for the obstacles detected in front of the user, the middle one for obstacle detected at head high level and the buzzer on the left shoulder was for obstacles detected at drop-off level.

The model though light weight, was very large and not very flexible to go along the body folds and hence the model was change. A baby bib was used for the development of the system which exactly fit the need. It was flexible enough to go along with the body folds and body movements. The buzzers were placed in a fashion similar to the initial prototype.

Figure 11: Final protoype of alarming setup.

CHAPTER 4
RESULTS
AND
DISCUSSIONS

4. RESULTS AND DISCUSSIONS

The conventional navigation aids were lacking to produce the amount of information required for safe and speedy mobility of blind people. On the other hand the ETAs proved to be of very much importance as the amount o information they were capable of collecting from the surrounding was much more than any conventional navigation aid. ETAs are device which are designed to be light weight so that it does not put an extra effort on the user. Moreover, these devices need to be of such a shape and size that describes them to be portable.[28]. The portability also means that the device should be a standalone device which requires it to be available with a portable power source as well. The power source, hence needs to be of optimum capacity so that the device can run for a long duration before it gets drained which implies that it is must for the device to be less power consuming [29]. Going for the above mentioned important points which can't be overlooked, it is necessary for the device to be cost effective so that even the weaker section of the society can avail it easily [30].

With reference to the above concern a portable cane was designed based on the distance measurement principle of ultrasonic sensors. The range of the device was set to 5-150 cm for the upper and middle sensors which were responsible for detection at head level and waist level respectively. However, for detection of holes and sudden bumps the same logic was applicable but with a not logic added. The lower sensor was found to have an ability to easily detect bumps of a height greater than 10cm e.g. steps, and pits as well.

The alarm system was designed keeping in mind to lower the complex wired system and for the same purpose wireless transmission of the control signals was adapted.

The buzzer and LED characteristics based on distance range are shown in Table-3.

Table 3: Sound and LED variation with distance of the obstacle

Distance (cm)	Sound characteristic			LED characteristics		
	Middle sensor	Lower sensor	Upper sensor	Middle sensor	Lower sensor	Upper sensor
0-5	--	--	--	--	--	--
5-30	5 V	--	5 V	+++	--	+++
30-75	3V	--	3 V	++	--	++
75-150	2V	--	2V	+	--	+
5-95	--	4V	--	--	+++	--
>120	--	3 V	--	--	+++	--

-- Sensor does not respond; +++ LED glows to the peak intensity; ++ LED glows in the medium intensity; + LED glows at a low intensity

CHAPTER 5
CONCLUSION

5. CONCLUSION

The study of the device used 3 pairs of US module used for the distance measurement function of the device. The device design supposed to detect the both aerial and ground obstacle was efficient. The range set for the efficient distance measurement by the device was set purposefully to 5-150 cm. In this range the device detected the obstacles and generated corresponding visual and audio signals to alarm the user. The visual signal though was just to ensure the audio signals were working as required. The results obtained by trial from a group of volunteers who walked an obstructed path blindfolded were promising and furthermore trials will be conducted. The results were promising to an extent that ensures the safety and speed of the mobility of the deprived user. The WSC is supposed to be integrated with a GPS system to ease the navigation in unfamiliar pathways via a central monitoring system. The WSC being cost effective is thus expected to be used by majority of the visually deprived section of the society.

CHAPTER 6
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REFERENCES

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