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AN ULTRASONIC SENSING SYSTEM FOR ASSISTING VISUALLY IMPAIRED PERSON

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Graphical abstract

Abstract

This paper presents a design and analysis of ultrasonic sensing system for visually impaired person. This system operation consisting of ultrasonic sensor and a microcontroller as the brain for the system. The experimental measure been done to calibrate the sensor to produce accurate measurement of distance. Basically, the prototype device produce is a portable device which can be kept in user's front pocket or can be wear using lanyard. Device will assist the user according to the range of obstacle. Whereby the user is closer to an obstacle the connected buzzer will beep at different rate according to the range of the obstacle. The project is designed and developed using P18F1330 microcontroller and programmed using C language.

Keywords: Blind, Microcontroller, Ultrasonic, Visually impaired

1.0 INTRODUCTION

Visual impairment and blindness is a factor that significantly decreases portability among people. With using some commercially available technology, it is been possible to extend support and reduce their disability [1]. The method used in this project is measurement of distance using ultrasonic wave in air medium. It is based ultrasonic working principle, whereby the transmitter transmits a burst of ultrasonic wave and it is reflected by an obstacle of certain distance. The time taken for the pulse to propagate from transmitter and back to the receiver is directly proportional to the distance of the object. Based on this method the distance of the obstacle from the user is calculated. This project focuses mainly on the analysis, design and the development of ultrasonic sensing system for guiding visually impaired person with commercially available sensor. In other words, the device developed will act as a portable guiding device which assists the visually impaired person to move around from one place to another place safely.

The most common method used by the blind currently is white cane also known as a walking stick. White cane has been in used since decades [2]. White cane has its own limitations. It has a very short range of detection and detects obstacles only below waist height, it is also physically tiring to constantly swing the cane from side to side while walking. It also doesn't provide information about the geographical surrounding [3]. A white cane user, thus, requires assistance of sighted persons or guided dogs to navigate to their destinations. Walking sticks we know it today, was promoted as a symbol to alert everyone to the fact that they are visually impaired [4].

2.0 BACKGROUND STUDIES

There is quite a number of research done previously based on the ultrasonic sensing system which utilizes ultrasonic sensor to alert in the means of sound and vibration to aid and guide the visually impaired and the blind.

2.1 A Navigation System For The Visually Impaired

Sethu Selvi *et al.* [5] constructed a navigation system in 2008 to guide the blind which has a similar concept for my current project. They research techniques to find the obstacle in the user's path by various ways, such as infrared sensor and ultrasonic sensor. Their design focusses mainly to design a practical system rather than complicated and expensive. Their principle design process is a practical gadget that cautions a visually impaired walker on their path which is similar to the current project. The visually impaired require straight path and hence require surveillance of path about 25° on both sides. It the sensor detect an obstacle, it will warn the user by the means of vibration. Their navigation system is strapped to both knees of the user so as to detect obstacles on ground, obstacle on steps and hanging obstacles. The final prototype was tested with the blind persons and a very positive feedback on the prototype system. The visually impaired and the blind are comfortable wearing the proposed device.

2.2 An Ultrasonic Ranging System Technique

Batarseh *et al.* [6] developed a portable ultrasonic ranging system for the visually impaired person. In their project, an ultrasonic sensor which is commercially available is used. They implemented the use of Sonar SwitchTM1700 to expand the surrounding detection range for the blind individuals. This sensor has distance measured proportional to DC voltage output. The DC voltage from the sensor is converted into an AC frequency that produce a frequency of chirps from two small headphones by using a monolithic voltage-to frequency (V/F) converter. The frequency of chirps output will be higher if larger the DC voltage input into the V/F converter. This leads the system to produces a variable frequency of chirps which is inversely proportional to the measured distance.

In the project, a light weight helmet is used where the sensor is located, this will able the user to obtain the distance measurement from the direction the head turns. The power supply for the circuitry is attached to user belt. The project was tested with the blind students and the response was positive which aid them enhanced his visualization.

2.3 Sight For The Unsighted People

Bhardwaj *et al.* [7] proposed a device with an ultrasonic sensor which is interfaced with AVR microcontroller. Their design is to help the visually impaired and the blind people to walk from one point to another point which is more helpful to them without hitting any obstacle with the help of the ultrasonic sensor.

The ultrasonic sensor transmitter sends a pulse and return again by impacting any obstruction in the way and the receiver gets the echo and send it to the microcontroller and it analyzed the distance and make the vibrating motor activated which is fitted in the wristband. By this means, the visually impaired and the blind individual can sense utilizing his touch senses.

2.4 Smart Guide For Method

Manoufali *et al.* [8] developed a prototype of an intelligent guiding device for the visually impaired and blind. Their project was successfully designed, tested and implemented. The prototype is to analyze the movement of the visually impaired and the blind person by warning them of any obstacles in order to guide them during daily activities. The feedback is provided in the mean of sound instructions via the headset and based on real-time situation for the indoor and outdoor environments. The prototype was successfully tested with Emirates Blind Care Association in Sharjah, UAE.

2.5 Vibration and Voice Operated Navigation System

Mahmud *et al.* [9] designed and implemented novel navigation system which helps the blind people to navigate safely. They have make use of PIC microcontroller to develop the smart obstacle detection system which can guide the blind person to avoid obstacle where by the user receive feedback through vibration and voice. Their main objective is to design a navigation system which cost effective and user friendly for the blind.

In order to make it user friendly for the user, the navigation system is make use of sonar sensor for obstacle detection from particular direction. This makes the user to navigate without the moving around the cane or walking stick to move from one place to another. The system is equipped with vibrating sensor and voice feedback which to warn the user is it detects any obstacle within 70 cm. The sonar is put in such way to ensure convenience of the user in detecting obstacle from three different direction. As an example when the sensor detects obstacle on right, it will the motor will vibrate and the voice will warn the user to move left. The device produced is a low-cost and user friendly solution to overcome problems of visually impaired person.

3.0 MOTIVATION

This paper presents the design and analysis of ultrasonic sensing system for the blind and visually impaired. Even though there are many approaches to solve this matter but it is either complicated or expensive to implement. In the proposed solution, we make use of the commercially available ultrasonic sensor which is small, flexible, simple and very cost effective yet still meets the criteria of a guiding aid for the blind and visually impaired [10]. It has the capacity of measuring distance range and giving output in the form of sound from buzzer attached to warn the visually impaired depending on the range of the obstacle.

4.0 METHODOLOGY

The primary scope for this work is to design and analyses the ultrasonic sensing system for assisting the blind and visually impaired person. To achieve the scope, this project is divided into two sections, which is the development of software part and development of hardware part. The software development part is basically used to program the PIC18F1330, which is the microcontroller used in this project.

The software used to program the microcontroller is MPLAB X meanwhile to display the output, which is the distance measurement, Teraterm software is used; it is an alternative terminal for windows 7 as HyperTerminal is not available in Windows 7 operating system. The serial communication technique is used to communicate between PC and the microcontroller. Whereas the hardware development part consists of the design of the prototype of the ultrasonic sensing system.

5.0 SYSTEM OVERVIEW

The system block diagram comprises of parts as shown in Figure 1. It consists of microcontroller (PIC18F1330), ultrasonic sensor (HC-SR04), and Buzzer.

The stiffness matrix of composite sandwich plate is formed by combining the stiffness matrix of the top facesheet with the upper half of honeycomb core and the bottom facesheet with the lower half of honeycomb core.

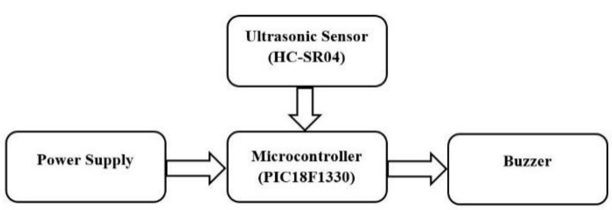

Figure 1 Block Diagram of System

5.1 Ultrasonic Sensor

The frequency of an ultrasonic is too high for humans to hear. Audible sound that is too high frequencies refers to ultrasonic. An ultrasonic sensor will trigger short and high frequency sound waves at regular intervals. The sound waves will travel in the air, according to the speed of sound. The distance is obtained through the time of flight. Almost every object can be detected, and it is not affected by colours and light. The formula used to calculate speed of sound is shown in (1).

$$Vs \approx (331.4 + 0.6Tc)ms^{-1} \quad (1)$$

where Tc is temperature in degree Celsius. By using 25 degrees Celsius as temperature, the speed of sound is shown in (2). Figure 2 shows the ultrasonic sensor interpretation.

$$Vs \approx [331.4 + 0.6(25)]ms^{-1} \quad (2)$$

$$\approx 346.4ms^{-1} \quad (3)$$

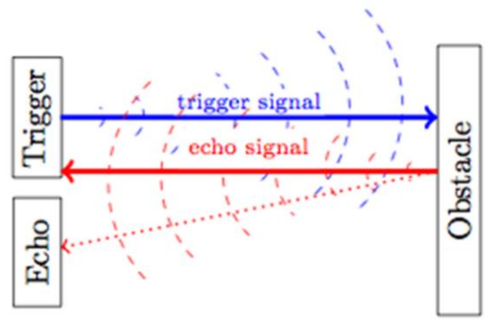

Figure 2 Ultrasonic Sensor Interpretation

The ultrasonic sensor model used is HC-SR04 as shown in Fg. 3 is a low cost solution for non-contact distance measurement function sensor which is the same as bats or dolphins which utilizes sonar to estimate the distance of an object. It is an excellent non-contact piezoelectric range detector with stable readings and high accuracy in a simple to-utilize pack. This sensor can measure distance from 2cm to 400cm.

Figure 3 HC-SR04

HC-SR04 can be activated by giving it a pulse of 5V for a minimum of 10 us (micro second). This will start the sensor to burst 8 cycle of 40 kHz ultrasonic waves and wait for the reflected echo signal [11]. When the receiver sense the echo from an object, it will make the Echo pin high (5V) and delay for a time period of which is proportional to distance travelled in the form of pulse width.

6.0 ULTRASONIC SENSING TECHNIQUE

Ultrasound uses high frequency sound and uses air as a medium of propagation. It uses time to calculate the distance of the obstacle, whereby the time taken for the ultrasound to travel from the transmitter and back to receiver is the distance between the obstacle and the sensor [11]. The distance is then can be calculated from the speed equal to distance formula, whereby the speed is the speed of sound in air medium.

6.1 Ultrasonic Sensing System

A continuous pulse of 10 microsecond (us) pulse of high (5V) will be given to the trigger pin of the HC-SR04 sensor. The sensor then will initiate the transmitter to transmit 8 cycle of 40 kHz of ultrasonic wave. Once the wave reflected back to the receiver as an echo signal, it will set high on the echo pin to (5V).

The width of the echo is the time taken for sending and receiving ultrasonic burst which is directly proportional to 2 times the distance from the user to the obstacle. To calculate the distance travelled by the ultrasonic wave, standard speed of sound is utilized which is 340 m/s in a normal condition.

The calculation for distance between the user and the ultrasonic sensor can be calculated using the speed of sound in air which 340 m/s. The distance can be calculated from speed equals to the distance divided by time formula.

7.0 WORKING PRINCIPLE OF PROTOTYPE DESIGN

The prototype design should be a portable device, which will be powered by a rechargeable battery power source. The prototype design will be cost effective and user friendly as well, it will be equipped with power on/off button which can easily sense by the user by touch sense. The device will be used with a lanyard whereby the user can wear it around their neck. The sensor can typically detect object such as table, chair and any hanging objects such as sign board. As proposed, the device consumes less power and energy efficient. The PIC18F1330 is chosen because it comes with Nano Watt technology features that can significantly reduce power consumption during operation. By clocking the microcontroller to internal oscillator block, during code execution, power consumption is reduced by as much as 90%.

8.0 RESULTS AND DISCUSSIONS

Ultrasonic Sensor is calibrated by interfacing the microcontroller to HyperTerminal. The microcontroller is connected using the serial port to transmit serial data. The measured distance of sensor will be displayed on HyperTerminal. Data for the measured distance of the sensor to the actual distance is shown in Figure 4. It can be seen that the result vary slightly after 140 cm, this is due to the external factor such as wind and sound that affects the reading of the sensor. Overall, the sensor has a small error about 2.22 cm which is fairly acceptable for real time application of the device. Figure 5 shows the prototype model.

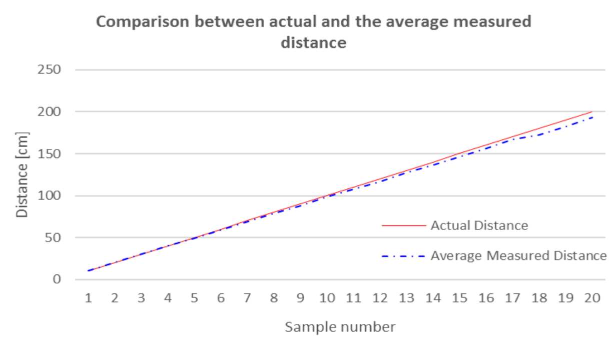

Figure 4 Comparison between the Actual Distance and the Measured Distance

Figure 5 Prototype Design

The practice for this ultrasonic sensing device is in the range of 20 cm to 200 cm. The experiment is done outdoor and the result of the experiment is show in Table 1.

Table 1 Behavior of the System

Distance	Beeping Sound
20-70	Very fast
70-120	Fast
120-200	Slow
>200	No sound

From the table, it can be see that with distance (20-70 cm) alert signal will be very fast beeps as in car sensor which means that there is no safe distance between the user and object. While with distances between ranges (70-120 cm) the alert beep fast when the obstacle closed near from person. When the range increased to (120-200 cm) alert signal will be very slow beeps. If in the range more than (200 cm) there will be no beeping sound, which will be the safety distance between person and obstacle. Figure 6 shows the pictorial presentation of the device to detect overhanging object. The prototype is tested in several condition as shown in Table 2. Figure 7 shows Mr. Thomas is trying the final prototype.

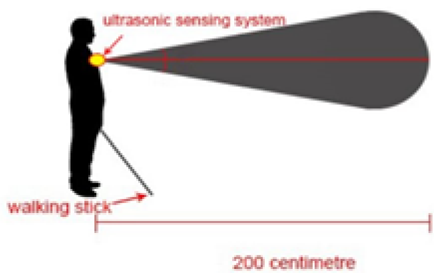

Figure 6 Pictorial presentation of device detect overhanging object

Table 2 Detection of ultrasonic sensing device

Obstacle	Object Detection		
	Test 1	Test 2	Test 3
Flat Concrete Wall	Detects	Detects	Detects
Overhanging Cloths	Detects	Not Detect	Not Detects
Overhanging Signboard	Detects	Detects	Detects
Human	Detects	Detects	Detects

Figure 7 Mr. Thomas and the Final Prototype

9.0 CONCLUSIONS

The prototype of the ultrasonic sensing system has been successfully developed. From the experiment, the prototype is able to help the visually impaired person's portability. The distance coverage is 2 meters which is sufficient for the user. The beeping sound helps user to identified obstacle in the front and therefore provide safe path to visually impaired patient.

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