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A Navigation Tool for Visually Impaired and Blind People

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Abstract: Visual disability or blindness is a common issue in the whole world. Visually impaired people normally rely on senses other than sight to guide them such as touching, hearing, or feeling. This paper describes a tool to help blind and visually impaired people to be able to move around with comfort and confidence. The paper proposes a development of a product that is easy to use by blind and visually impaired people to detect any obstacles accurately and efficiently. The system should allow the blind person to navigate with reasonable speed and confidence by detecting the nearby obstacles. The proposed system implements a device embedded with advanced technology which will give the blind person the needed confidence to perform his/her own work by him/herself rather than depending on others. The system uses ultrasound sensors and raspberry pi to detect any obstacle around the blind person. The system will inform the blind person in case of existence of obstacle through a buzzer or a vibrator. The ultrasonic sensor is used to detect the real time while the blind person is walking. It gives feedback as a sound or a vibration as indication of detecting an obstacle. A prototype blind aid system that can help blind and visually impaired people to move around with leisure has been implemented and tested. It performed as expected.

Keywords: Blind, Visually impaired, Raspberry pi, Ultrasonic sensor

Introduction

A blind person is a person without sense of sight, or a person who has no ability to see anything. Blindness is a condition of lacking the visual perception due to physiological or neurological factors (Vinod, 2018; Nawer et al., 2015). This causes full absence of the visual light perception. On the other hand, partial blindness or visual impairment means the lack of integration in the growth of the optic nerve or center of the eye. Partial or full blindness is a situation that affects many people around the world (Phirke, 2015). This situation causes the loss of the valuable sense of vision. In general, blind people do not see objects in front of them. This situation makes them exposed to many serious problems such as bumping into a wall, other people, or even a parked or a moving car. Without any aides, blind people must rely on others to move around which means that they cannot travel independently to any place without the help of others.

The World Health Organization (WHO), reported in 2021 that there are more than 2.2 billion suffer from vision impairment persons around the world (Batool and Naz, 2021). Therefore, the need to have aided tools for the blind people will be continuous. To date, there are several navigation systems and helping aides for the blinds and visually impaired people.

Batool and Naz (2021) proposed a third eye for blind people using the Arduino Pro Mini 328 and ultrasonic sensor. Their product was made using five ultrasonic sensors, consisting five modules linked to different parts of the blind person's body. Thumma et al. (2017) proposed the development of a smart stick for the visually impaired people. The stick includes a global positioning system (GPS), Global System for Mobile (GSM) tools and obstacle detection system. The GPS is used by the blind person to find the current location. The GSM will send a message to notify some of his/her relative of the current location. Kupade et al. (2020) proposed a third eye for blind people using an open source IOT platform node MCU microcontroller, GPS, ultrasonic sensor, and buzzer. They interfaced the GPS module with the node MCU microcontroller to track the location of the person when a request is sent to controller. The GPS will determine the location by calculating the longitude and latitude values. Bousbia and Fezari (2007) proposed a navigation aid to help blind and visually impaired people to navigate easily. The system involves a microcontroller with synthetic speech output. The system consists of two vibrators and two ultrasonic sensors mounted on the blind person's shoulders and one inserted into the blind person's helping tool such as cane. Singh et al. (2017) proposed a walking stick to help blind people to navigate and detect obstacles. The proposed tool consists of a microcontroller AT89S52, infrared sensors (IR), GPS receiver, label surface detection, GSM, and a buzzer. The system starts by detecting obstacles by an array of infrared sensors. The GPS receiver is used for navigation purposes. The GSM is used to inform in case of a danger occur to the blind person. In this paper, we propose a navigation tool for visually impaired and blind people using raspberry pi 3 and ultrasonic sensor. The tool can be placed on a walking stick or it can be mounted on the hand of the user.

Proposed System

Blindness or visual disability is a common issue in every country of the world. Without any aides, blind people must rely on other people to move around which means that they cannot travel independently to any place without the help of others. There are several systems exist to help visually impaired people move around (Sharma & Chatterji, 2015; Maragatharajan et al., 2019).

This paper proposes an aiding tool for the visually impaired and blind people to be able to navigate and move easily without the help of others. The proposed aiding tool will be able to detect any obstacle nearby the blind and visually impaired persons. The proposed system implements a device embedded with advanced technology which will give the blind person the needed confidence to perform his/her own work by him/herself rather than depending on others. The system uses a raspberry pi which is embedded with ultrasonic sensors, buzzer module, and vibrator motor. The ultrasonic sensor is used to detect the real time while the blind person is walking. It gives feedback as a sound or a vibration as indication of detecting an obstacle. The device is inexpensive, efficient, and reliable.

The main components of the proposed device are raspberry pi 3, ultrasonic sensors, buzzer, and vibration motor. These components are described as follows. The block diagram of the proposed system is shown in Figure 1.

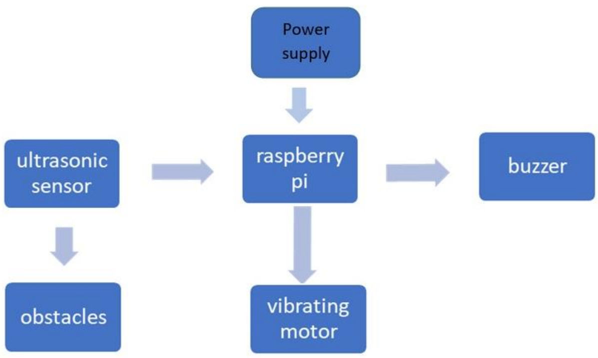

Figure 1. The block diagram of the proposed system

Raspberry Pi 3

Raspberry pi microcontroller is a small single board computer developed by the Raspberry Pi Foundation towards teaching basic science. Raspberry pi 3 model is the third generation Raspberry Pi (White, 2016). Raspberry pi microcontroller supports various programming languages such as python. It has been widely used to build hardware projects. It can perform as a minicomputer that connects all peripherals used by any computer such as mouse, keyboard, and monitor. It can accomplish tasks that can be carried out by desktop computers. Raspberry pi 3 microcontroller is shown in Figure 2.

Figure 2. Raspberry Pi 3 microcontroller (White, 2016)

Ultrasonic Sensor

It is a transducer which is a type of acoustic sensor that works as sound transmitter or receiver (Al-Smadi et al., 2020; Al-Smadi & Msallam, 2022). The transmitter converts electrical signal into sound waves while the receiver converts the sound waves back into electrical signal. It emits ultrasonic wave at high frequency (at 40 000 Hz which is too high for humans to hear and observe) that travels in the air. When the signal is detected by an object, it gets reflected back toward the ultrasonic sensor. The receiver will observe the reflected signal. The pins of the HC-SR04 ultrasonic sensor module are shown in Figure 3. Ultrasonic module HC-SR04 is provided with 2cm-400cm measurement with a ranging accuracy that can reach up to 3mm.

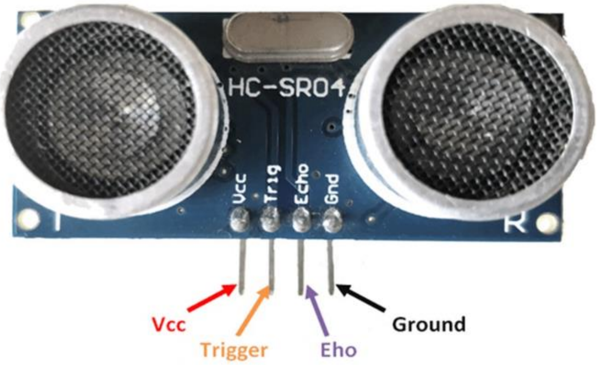

Figure 3. Ultrasonic sensor HC-SR04 module receiver (Al-Smadi et al. 2020)

Buzzer

A buzzer or beeper is one of the most common tools for audio communication. It is a sounding device that converts audio signals into sound signals. It is usually powered by DC voltage. A buzzer may be mechanical, piezoelectric, or electromechanical. Typical uses of buzzers and beepers are timers, alarm devices, and other electronic products (Scalet et al., 2017). Figure 4 shows a typical buzzer device.

Figure 4. Buzzer

Vibration Motor

Vibration motor is a DC motor in compact size vibrates when an obstacle or object is detected by ultrasonic sensor. Vibrators are used mainly in mobile phone technology (Yang et al., 2018). A typical vibration motor is shown in Figure 5.

Figure 5. Vibration Motor

System Implementation

The block diagram of the proposed system is shown in Figure 1. The circuit diagram of the system is shown in Figure 6. The figure shows the connection of ultrasonic sensor HC-SR04 module with the raspberry pi controller. The raspberry pi is connected to the buzzer and the vibrator motor. A slide single pole double throw (SPDT) switch is connected between the buzzer and the vibrator motor to give the user the choice of using either alarming type. The connection is also shown in the schematic diagram in Figure 9.

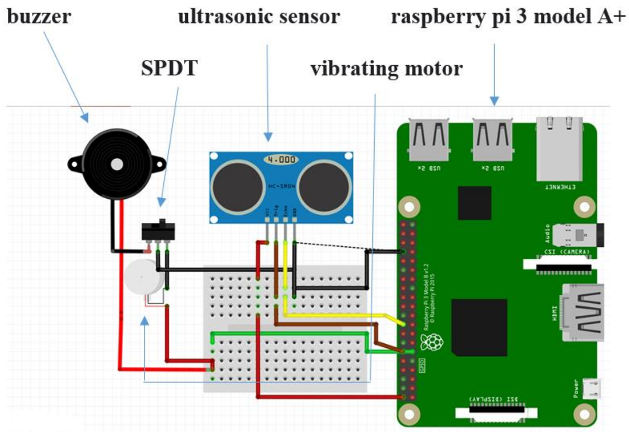

Figure 6. Circuit diagram of the proposed tool

When an obstacle faces a walking blind person, the ultrasonic sensor will detect the obstacle. The raspberry pi microcontroller will calculate the measured distance and check if it is within the threshold set by the code in the raspberry pi board. If the distance is within the threshold, the microcontroller will alert the blind person by activating the buzzer or the vibrator motor. The buzzer will make a sound and the vibrator motor will vibrate. As shown in Figure 6, the user has the choice of using the alarming state; i. e., the sound from the buzzer or the vibration from the vibrator motor. This is done by sliding a single pole double throw (SPDT) switch to change the type of alarming. To operate the system, a portable power source (power bank) has been used.

```
import time
import RPi.GPIO as GPIO
GPIO.setmode (GPIO.BCM)
GPIO_TRIGGER  = 18
GPIO_ECHO = 24
GPIO.setup(GPIO_TRIGGER, GPIO.OUT)
GPIO.setup(GPIO_ECHO, GPIO.IN)
def distance ( ):
GPIO.output (GPIO_TRIGGER, True)
time . sleep(0.00001)
GPIO.output (GPIO_TRIGGER, False)
StartTime = time . time( )
StopTime = time . time
while  GPIO . input ( GPIO_ECHO )  ==  0;
StratTime  =  time . time( )
while  GPIO . input ( GPIO_ECHO )  ==  1;
StopTime  =  time  . time( )
TimeElapsed  =  StopTime  - StartTime
distance  =  ( TimeElapsed  *  34300 )  /  2
return distance
if  _name_  ==  '_main_' :
try  :
while   True  :
dist   =  distance( )
print  (" Measured Distance  =  %.1fcm"  %  dist)
time . sleep(1)
except keyboardinterrupt :
print  ("measurement  stopped  by  user ")
GPIO . cleanup ( )
```

Figure 7. Python code

Working Voltage	5 Volt Dc
Working Current	A5m A
Working Frequency	40KHz
Max Range	400 centimeters
Minimum Range	2 centimeters
Trigger Input Signal	10 µs

Figure 8. The parameters or the ultrasonic sensor HC-SR04 Module

Figure 7 presents the software program code using python to calculate the distance being measured using the HC-SR04 ultrasonic sensor module. The program operates as user friendly device. The distance between the sensor and the object can be calculated by the total time taken for sending a pulse and receiving an echo from the boundary of the object. That is,

$$\text{Distance} = V \times T/2 \qquad (1)$$

where V is the speed of sound and T is the time it takes from emission to reception. The universal speed of sound is 340 meter/second. The time T in Equation (1) is divided by 2 since it is the time for go-and-return distance. In order to generate ultrasound, the pin Trig of the ultrasonic sensor should be set on a High State for 10 µs which will send out an 8-cycle sonic burst at 40 KHz. This signal will travel at the speed sound and it will be received in the Echo pin of the ultrasonic sensor. The Echo pin will output the time in microseconds. The time is measured using the inbuilt circuity model. Figure 8 shows the parameters of the ultrasonic sensor HC-SR04 module. A prototype for the proposed tool is shown in Figure 10 and 11. Figure 12 shows a sample of the measured distance between an obstacle and a person with the proposed tool. The tool can be placed on a walking stick or can be mounted on the hand of the user. The user can wear four modules of the tool; namely, on both hands and on his/her knees.

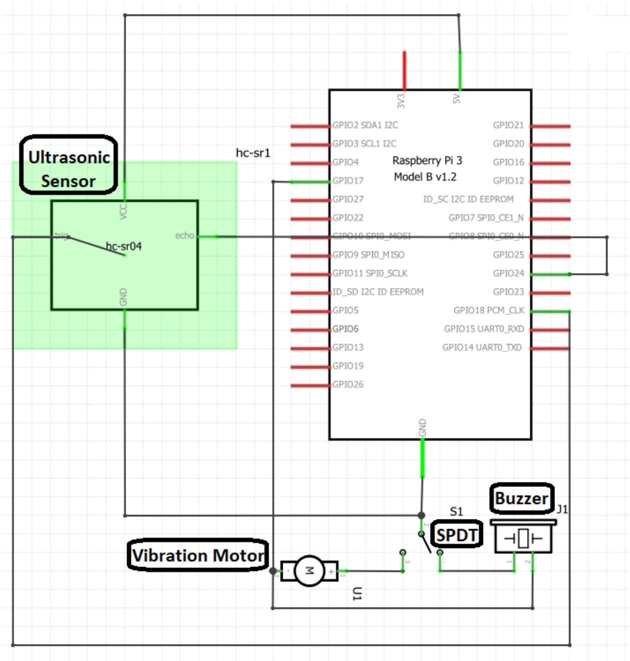

Figure 9. Schematic diagram

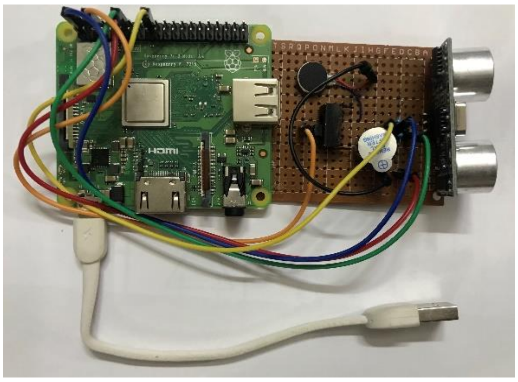

Figure 10. A prototype navigation tool

Figure 11. Final Product for helping blind people

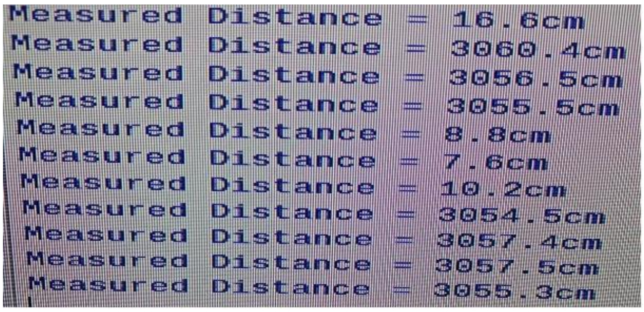

Figure 12. A sample of measured distance using the ultrasonic sensor

Conclusion

A helping aid for blind people using Raspberry pi microcontroller was proposed. The device is simple, low cost, efficient, and easy to carry and use. The device should provide constructive assistance and good support for the visually impaired and blind persons. It should also have the capability to specify the source and distance of any obstacle that may encounter the visually impaired and blind person. The device is able to detect any obstacle in the area that surrounds the blind person regardless of its height. With this device, the visually impaired and blind persons will be able to navigate and move around with reasonable speed and confidence. The user can choose the type of alert: sound beep using buzzer or vibration using vibrator motor. A prototype blind aid system has been implemented and tested. It performed as expected.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

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