Original Article

Design And Development Of Wearable Technology Using Ultrasonic Waves For Visually Impaired People

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Abstract

The rise rapid increase in the number of visually impaired people globally has led to the development of devices that can assist them to walk in a more feasible and reliable manner. There are numerous frameworks available in this field of research, viz., that are both reliable and efficient, but expensive, which not many can afford. In this paper, a device that is simple, easy-to-use, wearable technology working on ultrasonic waves, is presented. The person in subject needs to wear this device on the hand and begin to walk. The surrounding environment is provided to the visually impaired by the device-on-hand through audio, vibration or both. This device gathers information from the surroundings, recognizes the obstacle upon calculating its distance from user using the velocity of the obstacle. The obstacle might be stationary or in motion. The obstacles encountered in the pathway can then be audible to the person in the form of alarm ring and/or vibration produced in the device. The objective of this paper is to develop a reliable, feasible and efficient device to help the visually impaired navigate with greater comfort, speed and confidence.

Keywords: Visually Impaired — Wearable Technology — Ultrasonic Waves

I.INTRODUCTION

At least 2.2 billion people worldwide suffer from a near- or distance vision impairment. Amongst these, nearly 1 billion's vision damage might have been avoided or is still unaddressed [1]. These 1 billion individuals include those with moderate to severe distance vision impairment or blindness brought on by untreated refractive error (88.4 million), cataract (94 million), age-related macular degeneration (8 million), glaucoma (7.7 million), diabetic retinopathy (3.9 million), as well as near vision impairment brought on by untreated presbyopia (826 million).

According to the world report on vision, everyone, in their lifetime, shall experience atleast on eye condition. It may be either cataract surgery or refractive error. A huge investment (US$ 14.3 billion) is globally needed to treat the existing cases, particularly in the low- and middle- income groups. The poor integration of services rendering eye care into health systems are also observed. The implementation of eye care as an integral of health coverage globally, the promotion of high-quality research, monitoring the trends, evaluating the progress, raising awareness are some of the recommendations made by the report.

It is estimated that 253 million individuals worldwide experienced some form of vision impairment in 2015. This number included 36 million people who were completely blind and 217 million who had some degree of vision im-1 pairment (MSVI). There are 3.44 percent of persons who are visually impaired at a distance, including 2.95 percent who have multiple sclerosis and 49 percent who are completely blind. There are 3.44 percent of persons who are visually impaired at a distance; 0.49 percent are completely blind, and 2.95 percent have mild visual impairment. It is believed that one billion people have some degree of functional presbyopia. According to research, age is also a crucial factor in determining the global blindness rate. The frequency of vision and MSVI is substantially higher in the elderly since the risk among most eye disorders increases with age. Eighty percent of the world's 253 million individuals with visual impairments are 50 years or older.

The statistics of the global estimates stretching back to 1990 and the future estimates from 2020 to 2050 are furnished [2] in Table1.

Table 1: The statistics of the global estimates stretching back to 1990 and the future estimates from 2020 to 2050 with respect to blindness and MSVI

Year	Blindness	MSVI
1990	31	160
2000	32	176
2010	34	199
2015	36	217
2020	39	237
2030	55	330
2040	80	451
2050	115	588

The disappointingly increasing statistics of the number of absolute blind people or people having MSVI from the year 1990 to 2050 needs greater attention. Although the overall number of persons with visual impairment has increased over the past 25 years, this is not as much as may have been predicted given two very important demographic shifts that have taken place during this time. Someone who is visually impaired has a severe impairment in their eyesight that makes it difficult, if not impossible, for them to travel without assistance. Consequently, individuals have to resort to a broad variety of mobility aids. Specialists in orientation and mobility teach those with vision impairments or who are blind to rely on their other senses to go around safely and freely.

So by using this stick a person can walk with such a confidence more than using a conventional stick. As different advanced blind sticks are present in the market the blind stick discussed in this paper was built with a minimal cost and very easy to built. It can also have a scope to incorporate a Raspberry pi module and web can module to detect the presence of the object in front or any pot hole present in front. But this process requires a great knowledge on Raspberry pi and a complex process will be included to train the chip to recognize the objects or people in front of it by using deep learning training algorithms. It was more efficient and advanced. But mainly this paper will discuss about the blind stick using ultrasonic sensors.

II. METHODOLOGY

This section presents the block diagram of a device-on-hand wearable technology for the visually impaired. The block diagram presented in Fig. 1 shows a device-on-hand wearable technology for the visually impaired people. When a person in subject walks with this device on hand, the ultrasonic sensor senses the surrounding environment for any obstacles and pot-holes lying ahead in the path-way, which indicates that for any blind man, this pathway is not permissile to walk. The Atmega ARDUINO-UNO R3 microcontroller receives the signal from the ultrasonic sensor and sends a feedback signal to the user by the way of a bozzer sound and/or vibration that is sensed by the user, since the device is held by the hand, indicating an abnormal path for commute [3]. This mechanism is also illustrated in a self-explanatory flowchart given in Fig. 2. It is a three step process comprises of (i) switching on the device and start walking, (ii) the sensor senses for obstacles and pot-holes, and (iii) buzzer sound and vibration.
These gadgets function in the same manner

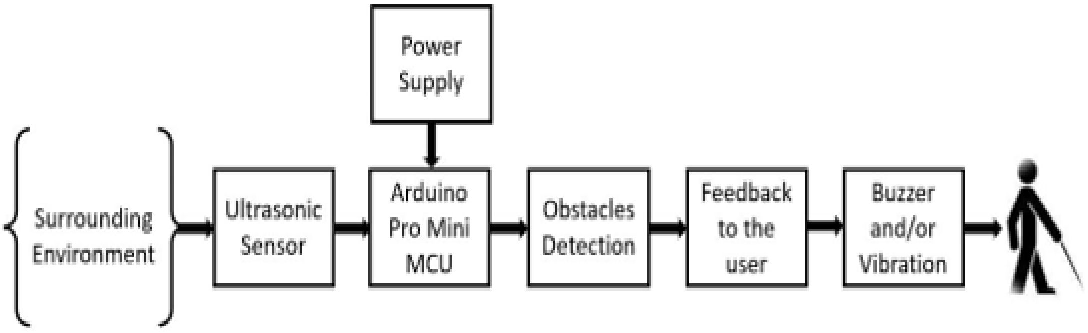

Figure 1: Block diagram representation of the device-on-hand wearable technology for the visually impaired

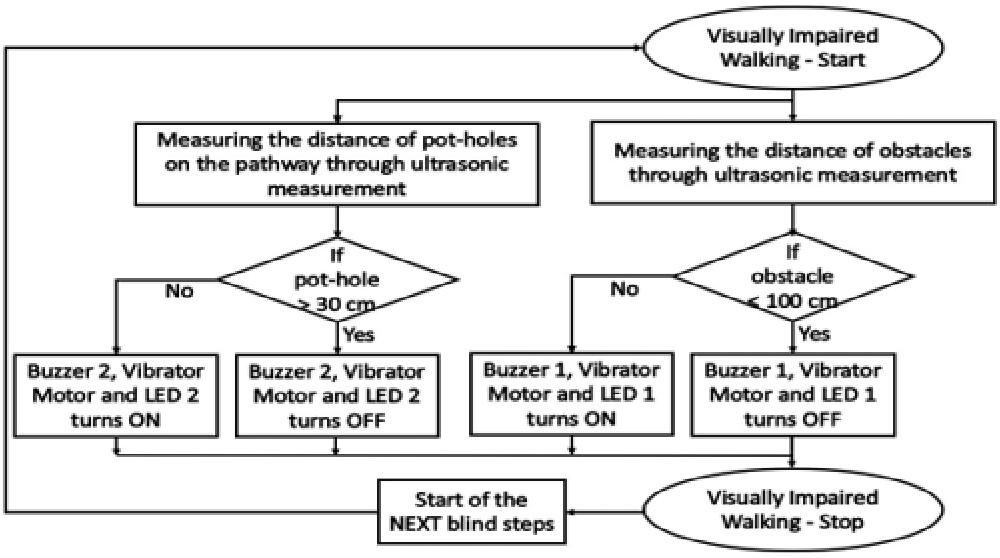

Figure 2: Flowchart

as a radar system, which employs ultrasonic fascicles, or sonar, to detect obstacles, both stationary and in motion.

None of the current solutions [4] do anything more than alert the visually impaired to the existence of an object within a given range in front of or close to them. A person's ability to perceive and remember their surroundings, as well as the objects inside them, can be improved with the help of information regarding the objects' properties This study provides a straightforward, effective, and adaptable electronic guiding solution for the blind and visually impaired, facilitating their mobility in both indoor and outdoor settings, therefore overcoming the restrictions indicated above. Wearable technology for the visually handicapped, depicted as a block diagram in Fig. 1, is exhibited on the hand. The suggested system is novel because it employs an embedded vision system comprised of three inexpensive ultrasonic sensors and consolidates all reflecting data in order to encode an obstacle using a PIC microcontroller (Arduino Uno R3). Thus, the suggested guiding system [5] permits the de- limitation of not only distance but also the substance and geometry of the barrier. In addition, the location of the user's current blind stick may be tracked by means of GPS, which is used to calculate the location and then sent by SMS. The schematic diagram of the ultrasonic sensor in a blind stick is depicted in Fig. 3.

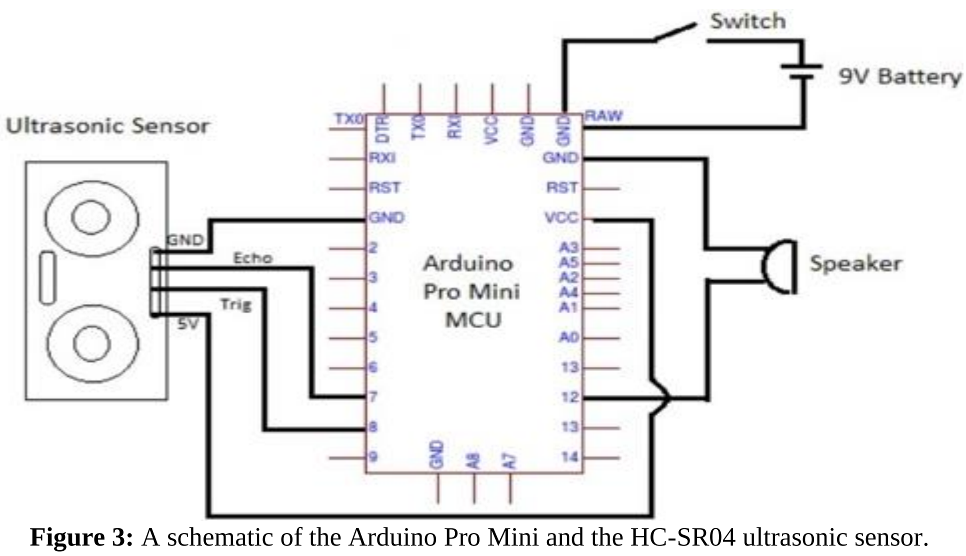

Figure 3: A schematic of the Arduino Pro Mini and the HC-SR04 ultrasonic sensor.

III. COMPONENTS

This section describes the components used in the design of this modern blind stick. The components used are: Arduino UNO R3, ultrasonic sensors and the buzzer.

i. Arduino UNO R3

In Fig. 4, we see the Arduino UNO R3, a microcontroller board that utilizes a dual-inline package (DIP) ATmega328 AVR microprocessor. There are 20 digital I/O pins (of which 6 can be utilized as PWM outputs and 6 as computer program inputs). The current version of the Arduino UNO is the R3, the third iteration [6].

General pin functions: The description of the pins are given under:

Figure 4: Atmega328

- LED: Digital pin 13 powers an integrated LED. The LED is activated by a high pin value and deactivated by a low one.
- V_{IN}: When an external power source is connected to an Arduino or Genuino board, its input voltage, denoted by the symbol "VIN," is shown (as opposed to 5 volts from the USB connection or other regulated power source). This pin is used to either deliver power or to get access to power supplied by the power connector.
- 5V: The board's regulator provides a stable 5V at this pin. Power may be provided to the board through the DC power jack (7–20V), the USB connector (5V), or the VIN pin (7-20V). Powering the board directly from the 5V or 3.3V pins will destroy the regulator.
- 3V3: Internally produced 3.3V from a 5V source. The maximum allowed amperage is 50 mA.
- GND: Ground terminals are labeled with the GND symbol.
- IOREF: The voltage reference for the microcontroller is provided via the Arduino/Genuino board's IOREF pin. A shield with the right settings may detect the voltage on the IOREF pin and switch to the correct power supply, or it can activate voltage translators on the outputs so that they can be used with either 5V or 3.3V [7].
- Reset: Usually used when a shield prevents access to the on-board reset button.

Special pin functions:

Some pins have specialized functions and they are:

- Serial / UART: Pin 0 (RX) and 1 (TX) are used for serial communication on a UART (TX). Used for both receiving and sending TTL serial data (RX and TX). There are wires running from here to the equivalent pins on the ATmega8U2 USB-to-TTL serial chip.
- External interrupts: Two of the pins can be used for external interrupts. These pins can be set to interrupt on a change in value, a low value, a rising edge, or a falling edge.
- PWM (pulse-width modulation): Pins 3, 5, 6, 9, 10, and 11 are used for pulse-width modulation (PWM). Provides 8-bit Pulse Width Modulation (PWM) output through the analogWrite() method.
- SPI (Serial Peripheral Interface): Pins 10 (SS), 11 (MOSI), 12 (MISO), and 13 (CS) are used for the Serial Peripheral Interface (SPI) (SCK). With these terminals, you may send and receive SPI data using the SPI library.
- TWI (two-wire interface) / I2C: Two-wire interface (TWI) / I2C; pins SDA (A4) and SCL (A5). Allow for communication via TWI by utilizing the Wire library.
- For the analog inputs, the reference voltage is denoted by the symbol AREF (analog reference).

Technical specifications

Table 2: The technical specifications of an Arduino UNO R3 Microcontroller

Parameter	Specification
Microcontroller	Microchip AT- mega328P
Operating Voltage	5 Volts
Input Voltage	7 to 20 Volts
Digital I/O Pins	14 (of which 6 can provide PWM output)
PWM Pins	6 (Pin # 3, 5, 6, 9, 10 and 11)
UART	1
I2C	1
SPI	1
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash memory	32 KB of which 0.5 KB used by bootloader
SRAM	2 KB
EEPROM	1 KB
Clock Speed	16 MHz
Length	68.6 mm

Width	53.4 mm
Weight	25 gms
ICSP Header	Yes
Power Sources	DC Power Jack USB Port

ii. Ultrasonic Sensor

As a very reliable method of sensing closeness and detecting levels, ultrasonic sensing is a must-have tool. Fig. 5 depicts an ultrasonic sensor, a device that uses ultrasonic sound waves to determine the distance to an item. Using a transducer, this sensor transmits and receives ultrasonic pulses to determine how close an item is and to provide that information back. Distinct echo patterns are created when highfrequency sound waves bounce off of barriers. Sensors with ultrasonic range operate by emitting a sound wave at a frequency beyond that at which humans can hear it. This sensor's transducer functions as a microphone to pick up and transmit ultrasonic waves [8]. Similar to other types of ultrasonic sensors, the ones used here just require a single transducer to both transmit and receive a pulse. The sensor calculates the distance to the target by timing the duration of the ultrasonic pulse's transmission and reception.

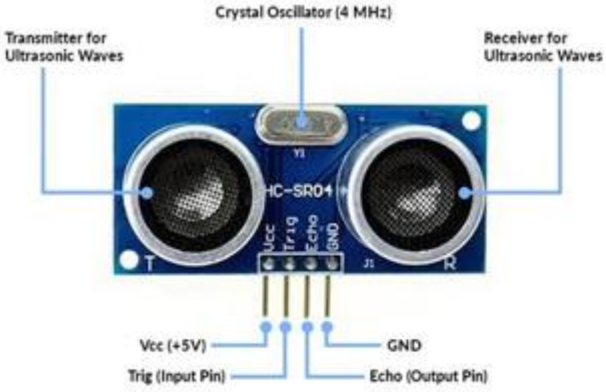

Figure 5: Ultrasonic Sensor

iii. Buzzer

Adding a buzzer, like the one seen in Fig. 6, which is a small but effective component to provide sound elements to the device, is a great idea. Due to its modest size and 2-pin design, this component is useful in a broad variety of electrical projects. It plugs directly into a breadboard, Perf Board, or PCB. To use this Buzzer, just plug it into a DC power source that outputs between 4V and 9V. A 9V battery will work, but a controlled +5V or +6V DC source is ideal [9].

An audible signaling device, such as a buzzer or beeper. It may produce an audible signal anywhere from 1 kHz to 7 kHz. This is the highest audible frequency range for humans. Therefore, a buzzer's sound is so loud that it stands out even in a busy setting. Alarms can be set off with the buzzers or beepers. There are a wide variety of uses for them, but the most common is to provide an audible indicator in reaction to an action or occurrence. Buzzers can provide a variety of sounds, including a click, beep, or ringing [10]. The buzzer is easy to use, compact, and compatible, and it has an excellent frequency response. Low energy consumption and a flexible voltage and decibel output range makes it an attractive option.

Figure 6: Buzzer

IV. Wearable Technology for Visually Impaired - Prototype

For the visually challenged, the theory behind the wearable device depicted in Fig. 7 is straightforward. It broadcasts a 40kHz ultrasonic pulse into the air, which, if it encounters an obstruction or an item, will cause the pulse to reflect back to the sensor. We can figure out how far something is by adding up how long it takes to get there and how fast sound travels. The sensor's ultrasonic signals shouldn't be disrupted, therefore make sure the ultrasonic transducer's face is always clean.

Dirt, snow, ice, and other forms of condensation are frequent impediments [11, 12]. The

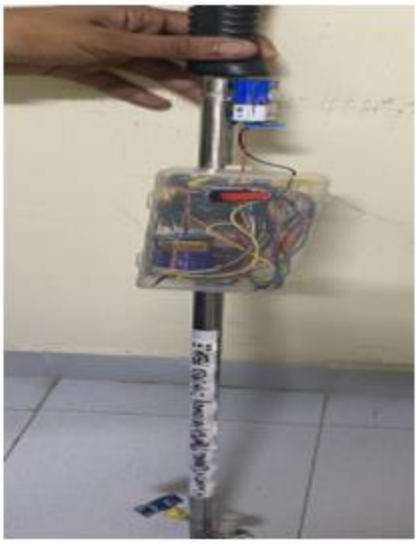

Figure 7: A prototype model of the wearable technology using ultrasonic waves for visually impaired people

sensors that clean themselves are employed in this scenario. Specifically, their self-cleaning function is built to operate constantly so that it may be effective in applications that demand resistance to condensation in high moisture situations. Microcontroller boards like the Raspberry Pi, ARM, PIC, Arduino, Beagle Board, and more frequently make use of ultrasonic distance, level, and proximity sensors. Ultrasonic sensors work by sending out sound waves in the direction of a target and then using the time it takes for those waves to return to the receiver to calculate its distance. This electronic sensor sends out ultrasonic sound waves and receives an electrical signal proportional to the distance to the target. Proximity sensors are a common use for our devices.

In addition to its applications in manufacturing and obstacle avoidance systems, ultrasonic sensors find value in the field of medicine. If you require a sensor that can detect items as near as 2 centimeters away, our Short Range sensors can help. These are made for low-power use in noisy settings where interference must be minimized.

V. CONCLUSION

The Modern Blind Stick serves as a foundation for a new generation of assistive devices that will allow the colour blind to move around independently and securely in both indoor and outside settings. It accomplishes its purpose while being reasonably priced. The findings are promising at a range of two meters, allowing the user to identify obstructions in their way. In spite of being packed with detectors and other electronic components, the device is surprisingly portable. The range of the ultrasonic sensor and the use of technology for assessing the speed of oncoming obstacles are two additional characteristics of this system that may be improved by wireless communication between the system components. The prototype of this device for the vision handicapped can identify hazards in all directions. And therefore it can let a blind person get around his environment independently. The walking stick, however, is unable to gauge how far away an obstacle is in a dimensional space. In some ways, this may be preferable than the current state of affairs with this three-pronged implement.

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