SMART HELMET

-FOR BLIND PEOPLE

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ABSTRACT

Visually blind people find difficulties detecting obstacles in front of them, during walking in the street, which makes it dangerous. The smart helmet comes as a proposed solution to enable them to identify the world around. In this paper we propose a solution, represented in a smart helmet with three ultrasonic sensors to detect obstacles in front side, right side and left side of the user, within a range of four meters. Moreover, LED is placed at the helmet for the sake of battery of the device is full. The Piezo(buzzers) are activated when any obstacle is detected. This proposed system uses the Arduino Uno R3 embedded system, Piezo. The helmet is capable of detecting all obstacles in the range 4 meter during 39 ms and gives a suitable respect message empowering blind to move twice his normal speed because he/she feels safe. The smart helmet is of low cost, fast response, low power consumption, light weight and can be carried easily.

INTRODUCTION

Visually blind people are the people who can't identify smallest detail with healthy eyes. Those who have the visual acuity of 6/60 or the horizontal extent of the visual field with both eyes open less than or equal to 20 degrees, these people are considered blind. Such people are in need of aiding devices for blindness related disabilities. As described in 10% of blind have no usable eyesight at all to help them move around independently and safely. The electronic aiding devices are designed to solve such issue.

To record information about the obstacle’s presence in a road, active or passive sensors can be used. In case of a passive sensor, the sensor just receives a signal. It detects the reflected, emitted or transmitted electro-magnetic radiation provided by natural energy sources. In case of using an active sensor, the sensor emits a signal and receives a distorted version of the reflected signal. It detects reflected responses from objects irradiated with artificially generated energy sources. These kinds of active sensors are capable of sensing and detecting far and near obstacles. In addition, it determines an accurate measurement of the distance between the blind and the obstacle. Overall, in the obstacle detection domain, four different types of active sensors may be used: infrared, laser, ultrasonic, in addition to radar sensors.

Bat K Sonar , Smart Cane , Smart vision , Guide Cane , use ultrasonic sensors or laser sensors to detect obstacles in front of blind by transmitting the wave and reception of reflected waves. It produces either an audio or vibration in response to detected obstacles to warn blind. Systems like voice , Soundview , SVETA and CASBLIP , use single camera or stereo video cameras mounted on a wearable device to capture images. These captured images are re-sized, processed further and converted to speech, audio, musical sounds or vibrations. In such systems, the frequency of warning sound signal is correlated with the orientation of pixels. Some advanced systems use Global Positioning System (GPS) integration with the main system. It's also noteworthy that GPS receiver is useful for understanding the current location of the subject and nearby landmarks. Some solutions are already available in the market such as: UltraCanne , Isonic , and Teletact and others

These products help blind people by collecting information through sensors and then transmitting recommendations through vibration or sound message to the user.
These solutions still have many disadvantages for example;
They can’t detect obstructions that are hidden but very dangerous for the blind such as right and left side of the user, downward stairs, holes etc. Usually, the feedback information comes out as either vibration or sound signals. Thus, these systems communicate their recommendations to the user through sound or frequency vibration.

Consequently, training is then necessary to help the user understand the signals and to react to them in real time. Otherwise, the information is transmitted as a sound it may be embarrassing for the blind person in public. In our work we tried to overcome some of disadvantage:

- We designed helmet to detect obstacles and its able to recognize and beep aloud the upward and downward stairs or puddles.

- The training of our product isn’t as expensive as training in other product. Our training is just description of helmet component and usage position.

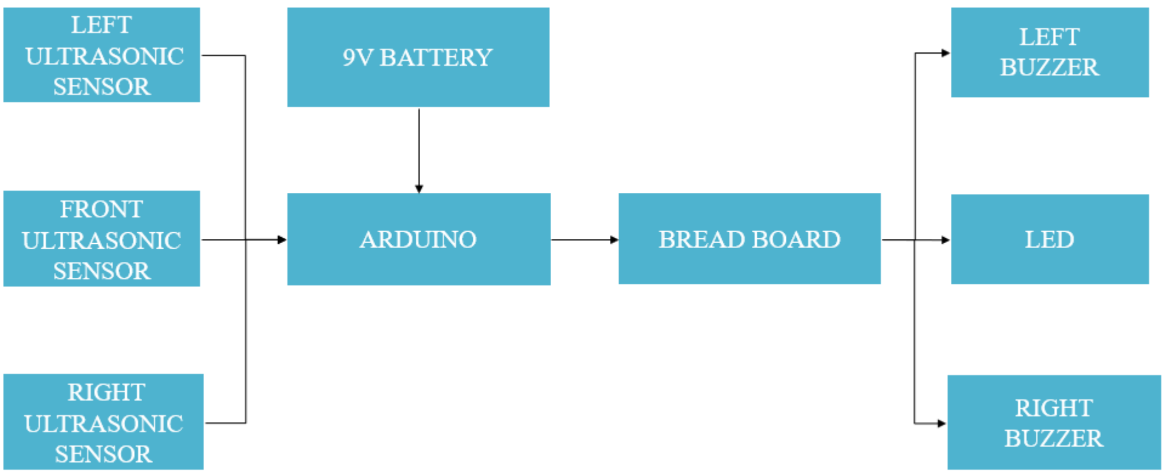
- We use two facilities to transmit information to the blind. We integrated ultrasonic sensor in the helmet and buzzer warning message that preserving it’s natural dimension to keep it user friendly.

- We achieved very fast response time calculated as 39 ms in average distance ≤400 cm before hitting the obstacles.

PROPOSED SYSTEM

We have many reasons to design smart helmet for blind; firstly, the blind to feel free, isn't surrounded by wires as in belt and its content. Secondly, is easy to use because it is familiar and affordable. Thirdly, to be able to detect obstacles that exist on the ground (this is not available in glasses), which he walks indoor and outdoor is faced by obstacles such as stairs, puddles and sidewalks.

The smart helmet, is basically an embedded system integrating the following: three ultrasonic sensors to detect obstacles in front, right and left side of the blind from ground level height to head level height in the range of 400 cm a head, Ultrasonic sensors collect real time data and send it to Arduino Uno R3. After processing this data, the Arduino Uno R3 actives the buzzers. Rechargeable battery to power the circuits.



BLOCK DIAGRAM OF SMART HELMET

Sensors

The selection process of appropriate sensor depends on several factors such as, cost, atmospheric condition, kind of obstacle to be detected, detection range, and the desired precision of measurements collected information and its transmission frequency as shown in Table I. I have used a infrared and ultrasonic sensors for the following reasons:
Ultrasonic sensor work well for close obstacles unlike laser one, when an object is so close the laser sensor (less than 15 cm) can’t get an accurate reading. Moreover, it should be noted that radar sensors can easily detect near and far obstacles with equal perform once, but their medium accuracy doesn't allow them detecting small obstacles.

TABLE I. GENERAL CHARACTERISTIC OF SOME ACTIVE SENSORS

	Laser	Infrared	Radar	Ultrasound
Principle	Transmission and reception of light wave	Transmission and reception of pulse of IR light	Transmission and reception of microwave	Transmission and reception of acoustic waves
Range	SLR: 15cm to 120cm LLR: about 10- 50 m	From 20 cm to 150 cm	About 150-200 m	From 3 cm to 10 m
Beam width	Narrow	Fairly thin	Depended on size of antenna	Wide
Atmospheric condition	Affected	Affected	Affected	Not Affected
Cost	Very High	Low	High	Low

SLR: short laser range, LLR: Long laser range

Ultrasonic sensor used 40 kHz transmission signal. The 40 kHz frequency is produced by a transmission sensor of two-centimeter diameter; it can generate 2.4644 beams of narrowness. This is a reasonable size to be installed in the helmet.

We use three ultrasonic sensors. One at a front side of helmet to detect front side obstacles and another one at a right side of helmet to detect right side obstacles and another one at a left side of helmet to detect left side obstacles.

Detection using ultrasonic sensor is based on two factors:

• Time of flight (TOF), the amount of delay between the emission of a sound and the arrival of an echo depending on the distance of an obstacle, which is directly proportional to the distance.

• Beam size: Obstacle size is depending on amount of reflected wave. Obstacles whose dimensions are larger than the beam size, all of the sound waves will be reflected to receiver. If the obstacle size small as compared to the beam size, the part of the ultrasonic sound wave will be reflected to the receiver and the rest will be lost as shown in Figure.

The speed at which sound travels depends on the medium it passes through. Broadly, the speed of sound is proportional to the square root of the ratio between the stiffness of the medium and its density. The speed of sound also changes with the atmospheric conditions. All obstacles reflect some part of the wave through. The amplitude of the wave reflected is relatively proportional to how much available surface there is on the obstacle, concerning coherent reflection. Also, surface area, shape and orientation, are major factors contributing to the strength of the reflected signal.

Arduino Uno R3

The Arduino Uno R3 is a microcontroller board based on a removable, dual-inline-package (DIP) ATmega328 AVR microcontroller. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs). Programs can be loaded on to it from the easy-to-use Arduino computer program. The Arduino has an extensive support community, which makes it a very easy way to get started working with embedded electronics. The R3 is the third, and latest, revision of the Arduino Uno.

The Arduino Uno is a microcontroller board based on the ATmega328. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs), a 16 MHz resonator, a USB connection, a power jack, an in-circuit system programming (ICSP) header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.
The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features an ATmega16U2 programmed as a USB-to-serial converter. This auxiliary microcontroller has its own USB bootloader, which allows advanced users to reprogram it.

The Arduino has a large support community and an extensive set of support libraries and hardware add-on "shields" (e.g. you can easily make your Arduino wireless with our Wixel shield), making it a great introductory platform for embedded electronics. Note that we also offer a Spark Fun Inventor's Kit, which includes an Arduino Uno along with an assortment of

components (e.g. breadboard, sensors, jumper wires, and LEDs) that make it possible to create a number of fun introductory projects.
This is the 3rd revision of the Uno (R3), which has a number of changes:

- The USB controller chip changed from ATmega8U2 (8K flash) to ATmega16U2 (16K flash). This does not increase the flash or RAM available to sketches.
- Three new pins were added, all of which are duplicates of previous pins. The I2C pins (A4, A5) have been also been brought out on the side of the board near AREF. There is a IOREF pin next to the reset pin, which is a duplicate of the 5V pin.
- The reset button is now next to the USB connector, making it more accessible when a shield is used.

PIEZO (BUZZER)

In simplest terms, a piezo buzzer is a type of electronic device that’s used to produce a tone, alarm or sound. It’s lightweight with a simple construction, and it’s typically a low-cost product. Yet at the same time, depending on the piezo ceramic buzzer specifications, it’s also reliable and can be constructed in a wide range of sizes that work across varying frequencies to produce different sound outputs.

For instance, at APC International, Ltd., we offer piezo buzzers without signal generators, self-oscillating buzzers that have signal generators and even multi-tone sound generators — often used in alarms and sirens. Regardless of the model you choose, our piezo buzzers offer high sound outputs. Plus, since they can be mounted on circuit boards, they're highly useful in a wide range of applications and assemblies.

Despite different construction methods that affect the cost of piezo buzzers, all of our prices are highly competitive. In addition, thanks to our state-of-the-art production facility, our delivery times are some of the fastest in the industry.

How to Use Piezoelectric Buzzers

The use of the piezo ceramic buzzer was discovered thanks to an inversion of the piezoelectricity principle that was discovered by Jacques and Pierre Curie back in 1880. They found that electricity could be generated when a mechanical pressure was applied to particular materials — and the inverse was true as well.

So, when certain piezoelectric materials are subjected to an alternating field of electricity, the piezo buzzer element — often a manmade piezoceramic material — stretches and compresses in sequence with the frequency of the current. As a result, it produces an audible sound.

Unlike magnetic buzzers that have a narrow operating voltage of somewhere between one and 16 volts, piezo buzzers can typically operate anywhere between three and 250 volts. In addition, magnetic buzzers have a higher power consumption of 30 to 100 milliamperes, while piezo buzzers normally consume less than 30 milliamperes — even at higher rate frequencies. And although piezo buzzers require a larger footprint than magnetic buzzers, they produce a higher sound pressure level.

Typical Applications of a Piezo Buzzer

Thanks to both the reliability and flexibility of piezoelectric vibration plates to produce audible signals — ranging from monotone buzzes and alarms to multi-tones and melodies — their applications in small, high-density assemblies are wide-ranging. What's more: Their low power consumption makes them ideal for many battery-operated devices.

With such characteristics, piezo buzzers are regularly used in alarms, warning devices and automobile alerts. In addition, since they can produce a wide range of audible signals, they're also used in pest deterrent devices. And in the consumer electronics field, some of their most popular applications include sound generators in computers, telephones, toys and games — to name just a few.

LED

A light-emitting diode (LED) is a semiconductor light source that emits light when current flows through it. Electrons in the semiconductor recombine with electron holes, releasing energy in the form of photons. The color of the light (corresponding to the energy of the photons) is determined by the energy required for electrons to cross the band gap of the semiconductor.[5] White light is obtained by using multiple semiconductors or a layer of light-emitting phosphor on the semiconductor device.[6]

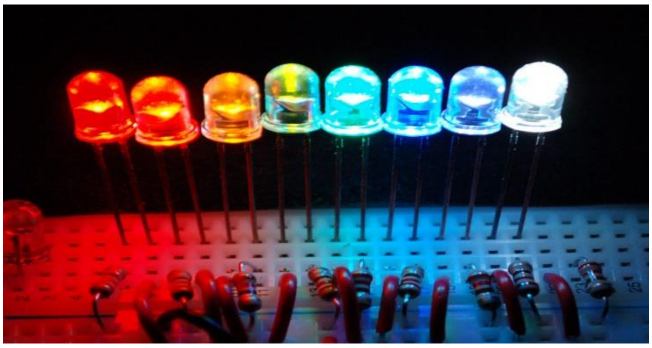
Appearing as practical electronic components in 1962, the earliest LEDs emitted low-intensity infrared (IR) light.[7] Infrared LEDs are used in remote-control circuits, such as those used with a wide variety of consumer electronics. The first visible-light LEDs were of low intensity and limited to red. Modern LEDs are available in visible, ultraviolet (UV), and infrared wavelengths, with high light output.

Early LEDs were often used as indicator lamps, replacing small incandescent bulbs, and in seven-segment displays. Recent developments have produced high-output white light LEDs suitable for room and outdoor area lighting. LEDs have led to new displays and sensors, while their high switching rates are useful in advanced communications technology.

LEDs have many advantages over incandescent light sources, including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. LEDs are used in applications as diverse as aviation lighting, fairy lights, automotive headlamps, advertising, general lighting, traffic signals, camera

flashes, lighted wallpaper, horticultural grow lights, and medical devices.

Unlike a laser, the light emitted from an LED is neither spectrally coherent nor even highly monochromatic. However, its spectrum is sufficiently narrow that it appears to the human eye as a pure (saturated) color.[9][10] Also unlike most lasers, its radiation is not spatially coherent, so it cannot approach the very high brightness's characteristic of lasers.



BREAD BOARD

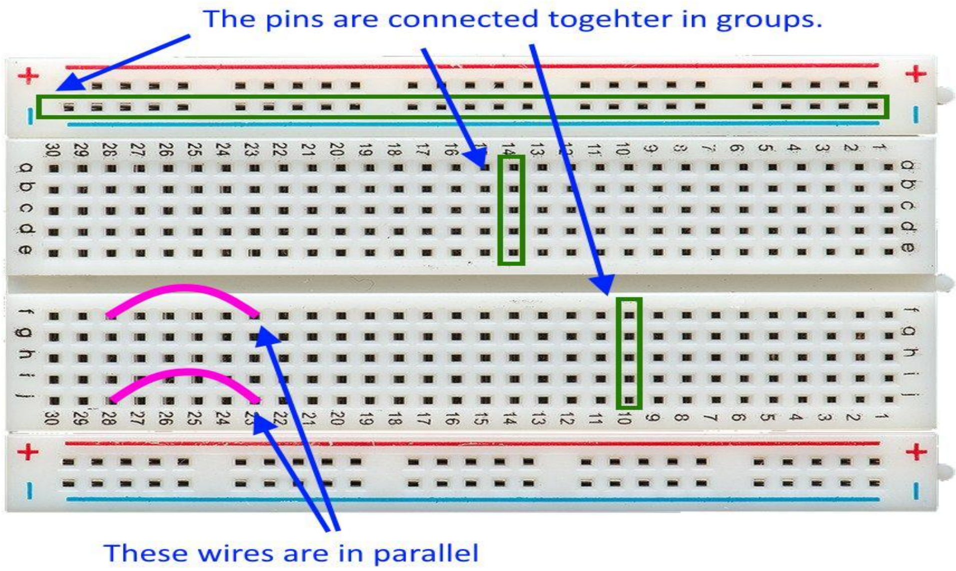
A breadboard, or protoboard, is a construction base for prototyping of electronics. Originally the word referred to a literal bread board, a polished piece of wood used when slicing bread.[1] In the 1970s the solderless breadboard (a.k.a. plugboard, a terminal array board) became available and nowadays the term "breadboard" is commonly used to refer to these.

Because the solderless breadboard does not require soldering, it is reusable. This makes it easy to use for creating temporary prototypes and experimenting with circuit design. For this reason, solderless breadboards are also popular with students and in technological education. Older breadboard types did not have this property. A stripboard (Veroboard) and similar prototyping printed circuit boards, which are used to build semi-permanent soldered prototypes or one-offs, cannot easily be reused. A variety of electronic systems may be prototyped by using breadboards, from small analog and digital circuits to complete central processing units (CPUs).

Compared to more permanent circuit connection methods, modern breadboards have high parasitic capacitance, relatively high resistance, and less reliable connections, which are subject to jostle and physical degradation. Signaling is limited to about 10 MHz, and not everything works properly even well below that frequency.

A common use in the system on a chip (SoC) era is to obtain an microcontroller (MCU) on a pre-assembled printed circuit board (PCB) which exposes an array of input/output (IO) pins in a header suitable to plug into a breadboard, and then to prototype a circuit which exploits one or more of the MCU's peripherals, such as general-purpose input/output (GPIO), UART/USART serial transceivers, analog-to-digital converter (ADC), digital-to-analog converter (DAC), pulse-width modulation (PWM; used in motor control), Serial Peripheral Interface (SPI), or I²C.

Firmware is then developed for the MCU to test, debug, and interact with the circuit prototype. High frequency operation is then largely confined to the SoC's PCB. In the case of high speed interconnects such as SPI and I²C, these can be debugged at a lower speed and later rewired using a different circuit assembly methodology to exploit full-speed operation. A single small SoC often provides most of these electrical interface options in a form factor barely larger than a large postage stamp, available in the American hobby market (and elsewhere) for a few dollars, allowing fairly sophisticated breadboard projects to be created at modest expense.



9V BATTERY

The nine-volt battery, or 9-volt battery, is a common size of battery that was introduced for the early transistor radios. It has a rectangular prism shape with rounded edges and a polarized snap connector at the top. This type is commonly used in smoke detectors, gas detectors, clocks, walkie-talkies, electric guitars and effects units.

The nine-volt battery format is commonly available in primary carbon-zinc and alkaline chemistry, in primary lithium iron disulfide, and in rechargeable form in nickel-cadmium, nickel-metal hydride and lithium-ion. Mercury-oxide batteries of this format, once common, have not been manufactured in many years due to their mercury content. Designations for this format include *NEDA 1604* and *IEC 6F22* (for zinc-carbon) or *MN1604 6LR61* (for alkaline). The size, regardless of chemistry, is commonly designated PP3—a designation originally reserved solely for carbon-zinc, or in some countries, *E* or *E-block*.

Most nine-volt alkaline batteries are constructed of six individual 1.5 V LR61 cells enclosed in a wrapper.[2] These cells are slightly smaller than LR8D425 AAAA cells and can be used in their place for some devices, even though they are 3.5 mm shorter. Carbon-zinc types are made with six flat cells in a stack, enclosed in a moisture-resistant wrapper to prevent drying. Primary lithium types are made with three cells in series.

9-volt batteries accounted for 4% of alkaline primary battery sales in the United States in 2007, and 2% of primary battery sales and 2% of secondary battery (rechargeable) sales in Switzerland in 2008.

RESULTS AND DISCUSSION

Ultrasonic sensors, LED and buzzer are tested individually as well as integrated. As ultrasonic sensors work on principle of echo, studying of its reflection on different obstacle is very important. The measurement cycle starts with Arduino Uno R3 transmitting the 10µs high level pulse to the sensor trigger pin to start ranging , then the sensor will send out ultrasonic signal with 40 kHz and 450µs and then wait to capture the rising edge output by echo port (T3) from 150µs: 25ms, depending on measured distance as shown in Figure. In case of no obstacle (no signal reflected) it waits 38ms before it restarts transmission.

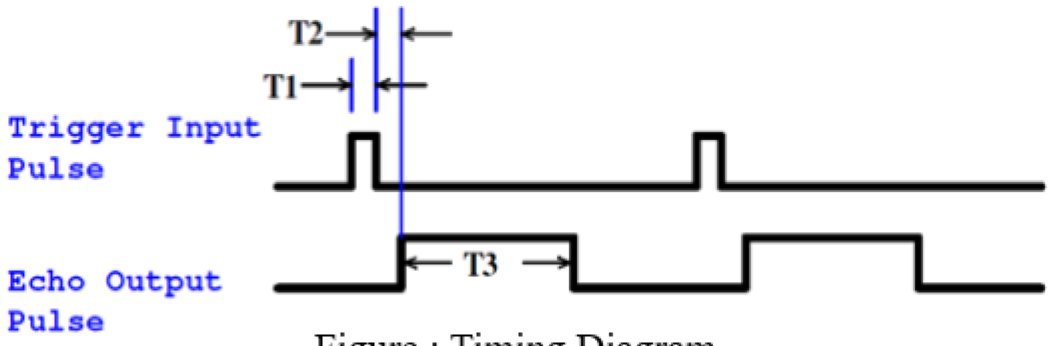


Figure : Timing Diagram

Ultrasonic distance sensor uses time of flight (TOF) to detect obstacle - the output is a digital pulse which length is the time it takes for the sound to reach the target and return.

Several experiments were done on obstacles at different distance and the average TOF results are shown in Figure.

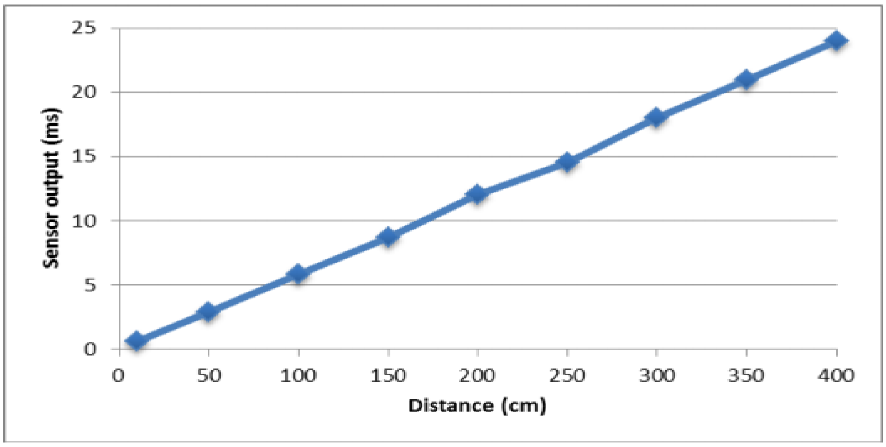


Figure : Time of flight vs measured distance of ultrasonic sensor

TABLE II. RESULT OF ULTRASONIC SENSOR COMPARISON

Distance (cm)	Analog value calculated (mV)	Analog value measured (mv)	error
5	25	24	1 mv
10	50	48.8	1.8 mv
20	100	97.6	2.4 mv
30	150	146.4	3.6 mv
40	200	195.3	4.7 mv
50	250	244.15	5.85 mv
75	375	366	9 mv
100	500	489	11 mv
150	750	732	16 mv
200	1000	976.6	23.4 mv
250	1250	1220.7	29.3 mv
300	1500	1464.9	35.1 mv
350	1750	1709	41 mv
400	2000	1953.2	46.8 mv

We tested how the ultrasonic sensors performance in lab compared to simulated calculation. TABLE II and Fig. 12 are present comparison of the ultrasonic sensor analog voltage value between the calculation value and measurement value. Thereafter the error is calculated in small range 5:50 cm error is 1– 6 mv, medium range 75:200 cm error is 9 – 23 mv and far range 250:400 cm error is 30 – 47 mv.

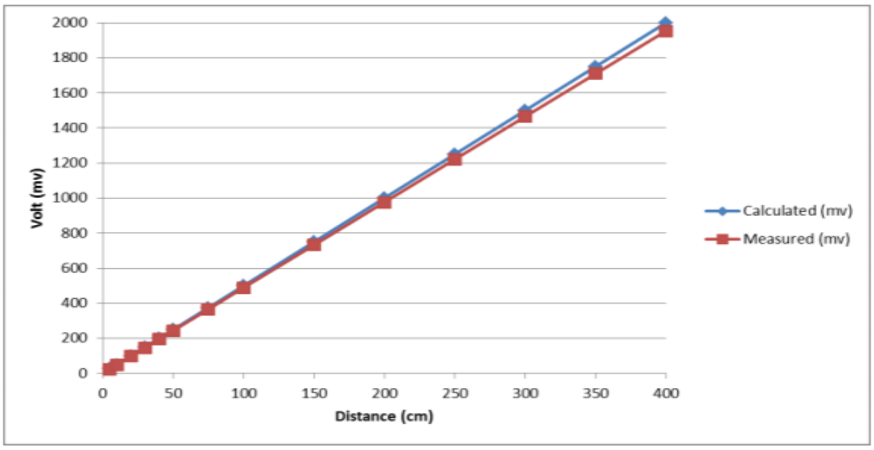


Figure 12. Difference between calculated and measured value

The proposed system should be compared with available and up to date technology. Several parameters should be considered to evaluate the performance of the proposed guidance system such as the range of detection, time response and power consumption.

- The first parameter is the range of detection. A tool which can find obstacles throughout 0-2m can be considered as a low range device, 2-4m as medium range, while higher than 4m is considered as high range.
- The second parameter is the response time, and a system sensing and responding 0–100ms is regarded as fast, 100–200ms medium and higher than 200ms as slow.
- The third important parameter is the power consumption of the system and how long it will stay working without the need to recharge. The following ratings are considered: consumption of an electrical power of 0 0.5W is regarded as low power, 0.5–1W as medium consumption, and higher than 1W as high consumption.
- The device is portable if it is light in weight and the user can easily wear for extended period of time otherwise it is considered non-portable.

We compared our performance with last 5 years literature with 3 devices. Vibration and Voice Operated Navigation System for Visually Impaired Person consists of three ultrasonic sensors, PIC microcontroller16F877A using the feedback through vibration and voice alerts the user if any obstacle is around and within 70cm, A Smart Infrared Microcontroller-Based Blind Guidance System consists of three infrared sensor, microcontroller 16F877A using feedback through vibration and tune speakers warn the user if any obstacles is around within 2 m, Ultrasonic Spectacles and Waist-belt for Visually Impaired and Blind Person consists of five ultrasonic sensors, APR9600 audio recording and playback flash memory, earphone with AT89S52 microcontroller. The comparison is shown in TABLE III.

TABLE III. COMPARISON OF OTHER DEVICES

Devices	Detection Range	Time Response	Power Consumption	Detection		Portable
				Stairs	Water	
Proposed System (Smart Helmet)	High	Fast	Low	Yes	No	Yes
Vibration and Voice Operated Navigation System for Visually Impaired Person	Low	Medium	Low	No	No	Yes
A Smart Infrared Microcontroller-Based Blind Guidance System	Medium	Fast	Low	No	No	Yes
Ultrasonic Spectacles and Waist-belt for Visually Impaired and Blind Person	High	Fast	Low	No	No	Yes
Smart Blind Stick	High	Fast	Low	Yes	Yes	Yes

CONCLUSION

The Smart Helmet acts as a basic platform for the coming generation of more aiding devices to help the visually impaired to be safer. It is effective and afford. It leads to good results in detecting the obstacles lying ahead of the user in a range of four meters, detecting stairs and water pits.

This system offers a low-cost, reliable, portable, low-power consumption and robust solution for navigation with obvious short response time. Though the system is hard-wired with sensors and other components, it's light in weight. Further aspects of this system can be improved via wireless connectivity between the system components, thus, increasing the range of the ultrasonic sensor and implementing a technology for determining the speed of approaching obstacles. While developing such an empowering solution, visually impaired and blind people in all developing countries were on top of our priorities.

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