ABSTRACT

This paper is focussed to develop an electronic navigation system for visually impaired, that makes use of sensors for obstacle detection. People who are visually impaired struggle every day in performing actions that can be as simple as moving from one point to another without falling down or knocking against obstacles. An Electronic Travel Aid (ETA) is a form of assistive technology having the purpose of enhancing mobility for the blind and visually impaired (VI) pedestrian.

Assistive devices designed to aid visually impaired people need to deal with two different issues: at first they need to capture contextual information (distance of an obstacle, position of the sensors, environment around the user), followed by their need to communicate to the user with those observed information.

Sensors are deployed for obstacle detection. The real time signal reflected from the obstacles is collected by the sensor and Arduino Board processes the signal. Based on the processed data, appropriate decision is taken by the microcontroller in it.

Accordingly a relevant message is invoked from the flash memory. Further this can be extended to communicate or deliver the decision to the subject via earphones.

Keywords: Visually Impaired (VI), Infrared (IR), Light Dependent Resistor (LDR)

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I. INTRODUCTION

According to the World Health Organization (WHO), there are 285 million visually impaired people in the world, 39 million of which are blind and 246 million have a low vision. Nowadays, technologies dominate and make people's tasks easy in different domains. With 7.8 million blind people in India, the country accounts for 20 % of the 39 million blind population across the globe, of which 62 % are on account of cataract, nearly 20 % have refractive error, 5.8 % glaucoma and one percent corneal blindness**.** On the other hand, when India needs 2.5 lakh donated eyes per year, the country's 109 eye banks (five in Delhi) manage to collect a maximum of just 25,000 eyes, of which 30% can't be used. Ageing populations and lifestyle changes lead to chronic blinding conditions such as diabetic retinopathy which rises exponentially. Without effective major intervention, the number of blind people worldwide has been projected to increase to 76 million by 2020 if the current trend continues. People who are visually impaired still struggle every day in performing actions that can be as simple as moving from one point to another without falling down, or knocking against obstacles. Guide dogs are very capable guides for the blind, but they require extensive training, and they are only useful for about five years . Furthermore, many blind and visually impaired people are elderly and find it difficult to care appropriately for another living being. A number of misperceptions relating to eligibility criteria emerged from the survey, in particular the belief that you need to be totally blind to qualify for a guide dog. This belief was the most common reason for non-owners not applying for a guide dog (40%, rising to 44% of men and those of working age), and the reason why the highest proportion (17%) of current owners had initially been put off applying. Other misperceptions about eligibility included age limits (7% of non-owners, 2% of those current owners), non-eligibility of those with multiple disabilities (6% of non-owners, 1% of current owners) and cost of ownership, including buying the dog and on-going veterinary bills.

The motion of a blind traveller in an unfamiliar environment is somewhat similar to that of a mobile robot. Both have the physical ability to perform the motion, but they depend on a sensory system to detect obstacles in the surroundings, and relay the information to the control system (human brain or motion control computer). An Electronic Travel Aid (ETA) is a form of assistive technology having the purpose of enhancing mobility for the blind pedestrian . Perhaps the most widely known device is the Laser-Cane or any other electronic cane , which might be a regular long cane with a built-in laser ranging system or a Geographic Information System (GIS). Despite decades of effort, technology has not yet rewarded us with an electronic device that can completely complement or replace the long cane. There are many problems with currently available assistive devices. Firstly, the rangefinder technology is unreliable in its detection of step-downs or stepups, such as curbs. Secondly, blind users find the tactile vibrations being used to encode the spatial information to be esoteric and difficult to interpret. In order to navigate, one must be able to detect "where" things are, in other words, the spatial positions of objects and other features in the physical world around us. This paper proposes an idea of identifying materials using sensors.

II.SURVEY

1. Microsoft's Joe Belfiore prototype of a new wearable called 'ALICE BAND'

   Microsoft is testing a prototype that function detecting the presence of surrounding objects, via customized sensors. These sensors process and transmit information in the form of audio signals to an earpiece that users wear. For instance, if a user wearing Microsoft's Alice Band comes across a tree, the wearable will inform the user that it is a tree that he/she is currently looking at.

For the wearable to work, specialised sensors need to be installed on objects/points which 'bounce off' real-world information to the sensors within Microsoft's wearable that convert these details into audio signals for users.

Microsoft's Alice Band, once officially launched, should help people with visual impairments perform vital tasks such as navigating staircases, elevators and even escalators.

2. Arunachal boy develops goggles for blind, using parking sensor technology

The Goggles for Blind (G4B) can be worn by the visually impaired, and using technology similar to parking sensors in cars, they can be alerted about nearby objects, without using a stick.

Moving around for the visually impaired could become a lot easier if an innovative technology developed by Anang Tadar, a class 11 student from Arunchal Pradesh, is mass produced.

The technology, which is based on echo location—similar to what bats use for navigation—was adjudged the most innovative at the regional level science festival, which concluded in Guwahati recently.

Named Goggle for Blind (G4B), the pair of glasses can be worn by the visually impaired, and using technology similar to parking sensors in cars, they can be alerted about nearby objects, without using a stick.

3.Revolutionary Technology for the Legally Blind.

eSight 3 is an engineering breakthrough that allows the legally blink to actually see.

How Does eSight Let The Legally Blind See?

eSight houses a high-speed, high-definition camera that captures everything the user is looking at. eSight's algorithms enhance the video feed and display it on two, OLED screens in front of the user's eyes. Full color video images are clearly seen by the eSight user with unprecedented visual clarity and virtually no lag. With eSight's patented Bioptic Tilt capability, users can adjust the device to the precise position that, for them, presents the best view of the video while maximizing side peripheral vision. This ensures a user's balance and prevents nausea – common problems with other immersive technologies eSight allows those who are legally blind to see in virtually the same manner the sighted can.

4.RNIB Smart glass

What are RNIB Smart glasses?

RNIB Smart glasses help wearers to identify shapes, determine distance, and are able to detect objects up to three metres away.

Our smart glasses have:

- a transparent display - lenses appear clear to others and allow eyes to be seen.

- two cameras at the front of the glasses which mimic the location of your eyes to determine distance (stereoscopic vision).
- the ability to be adjusted to suit different eye conditions.
- night vision - smart glasses work both during day and night!

Their development

RNIB Smart glasses are the brainchild of Dr Stephen Hicks of Oxford University, and have been in development with RNIB for over three years. Earlier this year we won the Google Impact Challenge, receiving a much needed funding boost and recognition for the project.

The project's main aim is to develop a commercially viable product that is affordable, practical and intuitive.

Awards and recognition

The RNIB Smart glasses project has a huge potential to change the lives of many visually impaired people, allowing greater independence in everyday situations. It has been recently recognised for this social impact by the Nominet Trust 100.

5.Google Glass Applications for Blind and Visually Impaired Users

Brandyn White and Andrew Miller are computer science Ph.D. students and the principals of Dapper Vision, which provides *"computer vision consulting and development with a focus on web-scale, mobile, and* *cloud applications."* They are also spearheading, via Dapper Vision, the OpenGlass Project, which is using emerging Google Glass technology to develop applications that can help blind and visually impaired users identify objects and environments via crowd-sourcing technologies and feedback. About Google Glass: the Basics

Google Glass *(pictured at left)* is a wearable computer with an optical head-mounted display that is being developed by Google in the Project Glass research and development project. Google's mission is to produce a mass-market pervasive computer [i.e., computing that can appear everywhere and anywhere]. Google Glass displays information in a smartphone-like hands-free format that can interact with the Internet via natural language voice commands.

Here is more information about the Google Glass research and development project from Engadget's comprehensive – and excellent – overview:

…it's not a pair of "Google Glasses," but a single Google Glass headset. Glass has a very simple, clean design that, in some regards, is beautiful and elegant; in others, crude and clumsy. We'll start with the elegant bits, most compelling being the plastic-backed titanium band that sweeps around and forms the frame.

From here, two nose grippers (also titanium) arc down, each one terminating with a clear silicone pad. These pads are replaceable and tacky enough to keep the whole assembly from immediately sliding down your nose.

All the circuitry for the device lies in two plastic housings, one that rests behind your ear (containing the battery and bone conductive speaker) and a second that's up front (with the processor, camera and display assembly). The side of the forward portion is also touch-sensitive, forming a … slender trackpad.

Glass can function with a WiFi or Bluetooth data connection – it is a fully independent device. This means you can leave your phone behind and walk around anywhere with WiFi without losing connection.

The display in Glass is an interesting one. When wearing the headset, you can look straight through the transparent part and barely even see it. It only minimally refracts the light that's beaming toward your eye. But, if you look at it from above, you can clearly see the reflective surface embedded inside at a 45-degree angle, forming the display your eyes see.

The panel itself is off to the right, built into the headset and beaming light into the clear piece from the side, which then hits that sliver of material and reflects into your eye. It's an interesting arrangement and the net result is, indeed, a glowing image that appears to be floating in space. Google says it's "the equivalent of a 25-inch high definition screen from eight feet away."

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The full Engadet review (with photos) describes how to activate Glass; use touch controls and voice commands; and take photos and videos.

About the OpenGlass Project

The OpenGlass Project is using Google Glass technology to develop applications that can help blind and visually impaired users identify objects and environments via established crowd-sourcing technologies.

The following videos demonstrate user trials of two OpenGlass applications in development that can inform blind and visually impaired users about critical features and/or objects in their environments:

- The first application, called *Question-Answer*, allows blind and visually impaired users to use Google Glass to take a picture with a question attached, which is sent to "the cloud" for answers from sighted respondents via Twitter or Amazon's Mechanical Turk platform. The answer is read aloud to the user through the bone conduction speaker that is part of the Google Glass headset.
- The second application, called *Memento*, automatically recites notes when the blind or visually impaired user faces, or looks at, a recognizable scene. To use Memento, sighted users must first record descriptions or commentary about environmental features or a room setup. When a blind or visually impaired person using Google Glass approaches the same spot, Google Glass will recognize the feature or scene and read back the pre-recorded commentary.

The Future of the Open Glass Project

According to Dapper Vision, the OpenGlass applications will remain in limited testing until Google releases Google Glass to the general public. Until then, Dapper Vision is developing a method to reward Question-Answer contributors with BitCoins [i.e., digital currency]. Dapper Vision is also releasing weekly videos to document their progress on the ongoing OpenGlass project.

III. ELEMENTS OF ASSISTANCE SYSTEM

Assistance devices designed to aid visually impaired people need to deal with two different issues: at first they need to capture contextual information (distance of an obstacle, position of the sensors, environment around the user), second they need to communicate to the user with those observed information. The contextual information captured from this assistance system are distance of the obstacle from the user using ultrasonic sensors and differentiation of the materials using IR transmitter along with Light Dependent Resistor (LDR).

A basic building block of assistance system to measure the distance of the obstacle from the user is shown in the Fig.1 The elements involved are Sensors, Arduino Board, Arduino Software, Flash Memory and Audio output. The ultrasonic sensor produces ultrasonic signal and transmit it to the surroundings to sense the obstacle. If the obstacle is detected, the obstacle reflects back the signal fall on it. The processing of distance calculation is done through arduino software using arduino board. Then, this distance information is given to the user through ear phones with the help of audio recording and

play back flash memory. Block Diagram for differentiation of materials using Infrared (IR) transmitter and LDR is shown in the Fig. 2 Here,

an IR transmitter sends the IR signal and it is reflected back when it falls on any object. This signal is captured by LDR. Based on the result, which is depending on the variation in the light intensity with respect to the analog voltage, the material can be differentiated using arduino software.

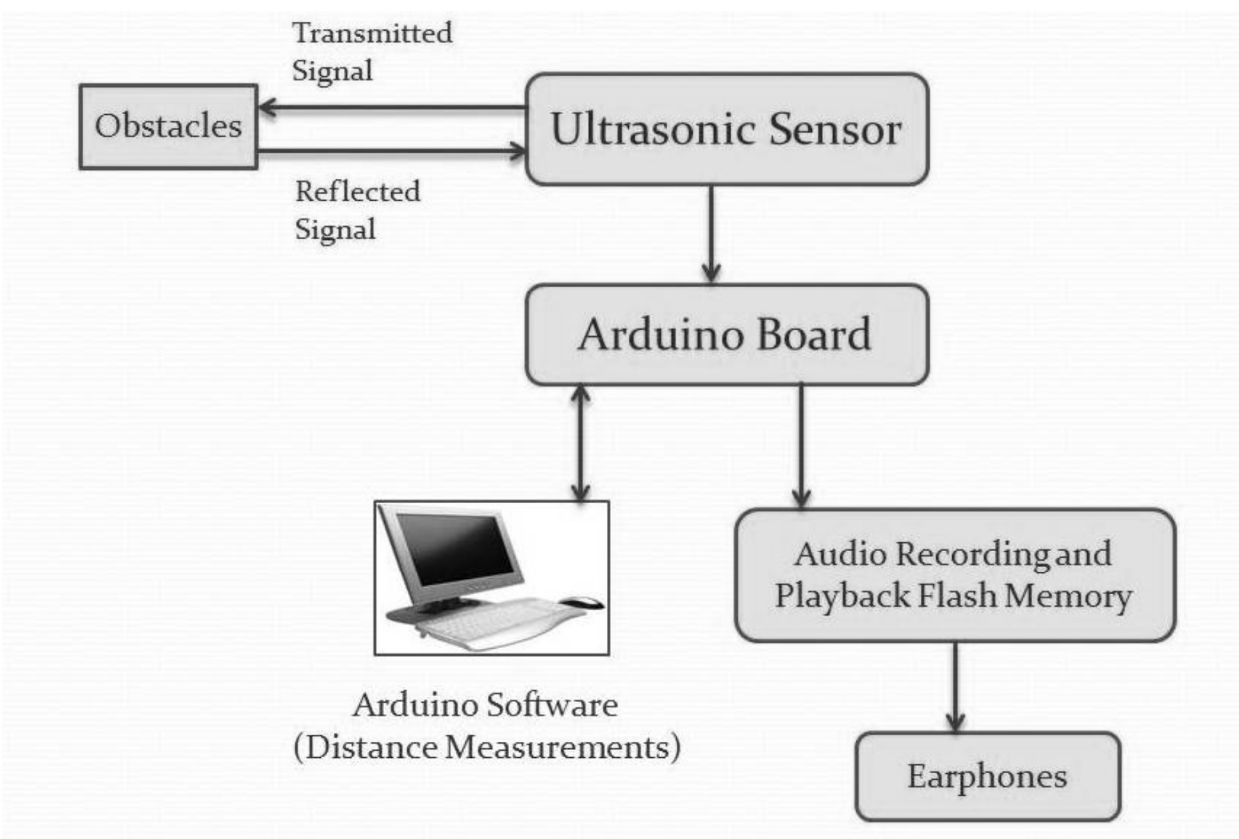

Fig. 1 Block Diagram for measuring distance between the obstacle and Sensor

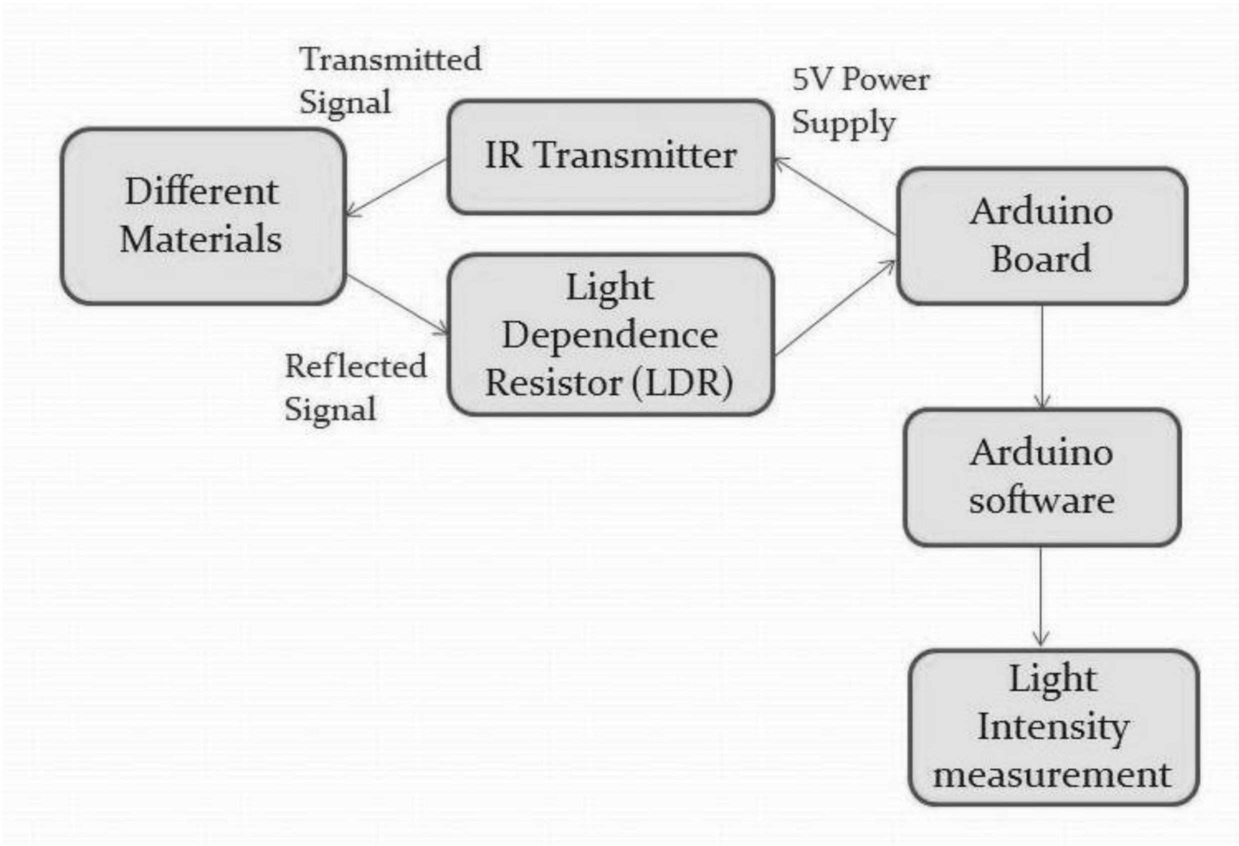

Fig. 2 Block Diagram for Material Differentiation

A. Ultrasonic Sensors

Ultrasonic sensors are designed for contactless and wearfree detection of a variety of targets by means of sonic waves. It is not important, whether; the target is transparent or coloured, metallic or non-metallic, firm, liquid or powdery. Environmental conditions such as spray, dust or rain seldom affect their function. An ultrasonic sensor transmits ultrasonic waves from its sensor head and receives the ultrasonic waves reflected from an object. By measuring the length of time from the transmission to reception of the sonic wave, it detects the position of the object as shown in Fig. 3.

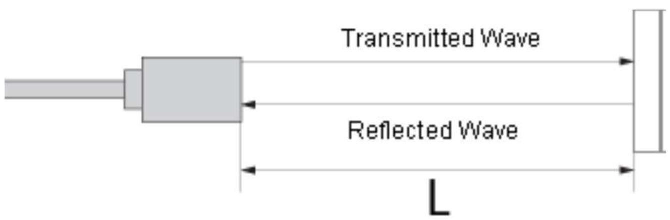

Fig. 3 Ultrasonic Sensor Principle

The ultrasonic sensors used in this work are PING sensor and HC-SR04 ultrasonic sensor.

1)Ping Ultrasonic Sensor: The PING sensor has a male3-pin header used to supply power (5 VDC), ground, and signal as shown in the Fig. 4. The Ultrasonic sensor detects objects by emitting a short ultrasonic burst and then "listening" for the echo. Under the control of a host microcontroller (trigger pulse), this sensor emits a short 40 kHz (ultrasonic) burst. This burst travels through the air at about 1130 feet per second, hits an object and then bounces back to the sensor. This sensor provides an output pulse to the host that will terminate when the echo is detected and hence the width of this pulse corresponds to the distance to the target as shown in the Fig.5.

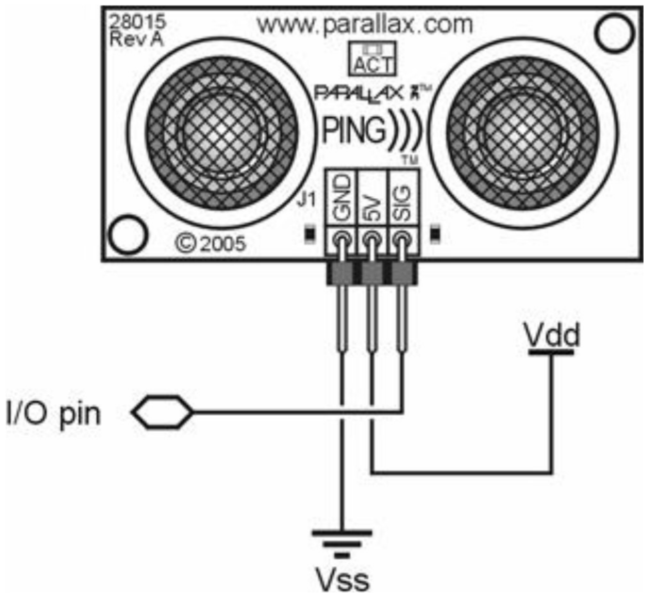

Fig. 4 PING Ultrasonic Sensor

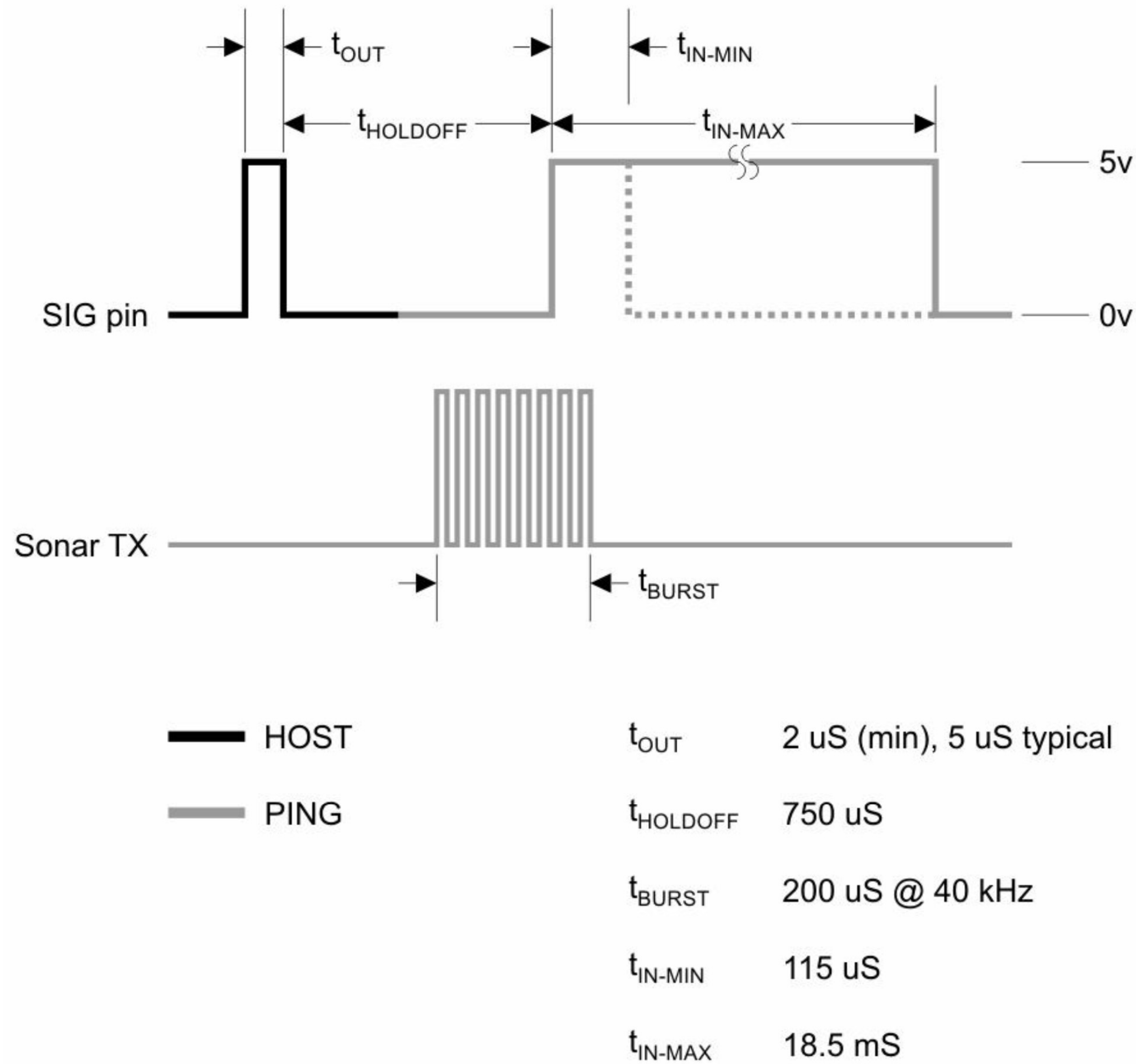

Fig. 5 Operation of PING Ultrasonic Sensor

2) HC-SR04 Ultrasonic Sensor: The HC-SR04 Ultrasonic Sensor has a 4-pin header used to supply power (5 VDC), ground, trigger and echo signal as shown in the Fig. 6. Ultrasonic ranging module HC-SR04 provides 2cm - 400cm non-contact measurement function and the ranging accuracy can reach up to 3mm. This module includes ultrasonic transmitters, receiver and control circuit. The signal processing involved using HC-SR04 are listed below,

i. Using input output (IO) trigger for at least 10µs high
level signal.

ii. The Module automatically sends eight 40 kHz and detects whether there is a pulse signal back.

iii. If the signal is back through high level, time of high output IO duration is the time from sending ultrasonic to returning.

Fig. 6 HC – SR04 Ultrasonic Sensor

B. Arduino

Arduino is a tool for making computers that can sense and control more of the physical world than the desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Arduino projects can be stand-alone, or they can communicate with software running in the computer (e.g. Flash, Processing, MaxMSP.) The boards can be assembled personally or purchased and open-source IDE can be downloaded for free. The Arduino programming language is an implementation of wiring a similar physical computing platform, which is based on the processing multimedia programming environment. The advantages of using Arduino than other microcontrollers are, inexpensive, simple programming environment and Open source and extensible software as well as hardware. The microcontroller used in Arduino is Atmega 328.

C. Light Dependent Resistor (LDR)

Light dependent resistors are the resistors whose resistance varies with the intensity of light incident on it. The resistance is typically very high when no light is incident and it begins to reduce as light is incident on it. LDR or a photo sensor finds its application in many robotics/embedded system applications such as line following robot, light seeking robot, garage door opener when cars light incident on it, solar tracker etc. It is known by many names such as LDR, photo resistor, photo conductor etc. The resistor has a component which is sensitive to light. One of the semiconductor materials used in constructing a LDR is cadmium sulphide (CdS). Since an electrical current would involve movement of electrons, it drifts as per the potential difference applied at two ends. A LDR or photo resistor is made up of a semi conductor material which has a high resistance, offering only less number of free electrons for conduction. As light (of sufficient frequency) is incident upon this semiconductor material, photons are absorbed by the lattice of the semiconductor. A part of this energy gets transferred to the electrons in the lattice which would then have sufficient energy to break free from the lattice and participate in conduction. Hence, the resistance of the photo resistor reduces with varying intensity of incident light.

IV. OBSTACLE DETECTION AND DISTANCE CALCULATION

A. Obstacle Detection

Ultrasonic sensors are used for obstacle detection and calculation of its adaptive distance from the visually impaired person as in Fig. 1.

Ultrasonic sensors are used in pair as transceivers. One device which emits sound waves is called as transmitter and other who receives echo is known as receiver. These sensors work on a principle similar to radar or sonar which detects the object with the help of echoes from sound waves. An algorithm is implemented in C-language on AT89S52 microcontroller. The time interval between sending the signal and receiving the echo is calculated to determine the distance of an object. As these sensors use sound waves rather than light for object detection, this can be comfortably used in ambient outdoor applications also.

B. Distance Measurement

The known relationship between distance, time and speed is used here (distance is the product of speed and time). Distance calculated is twice the actual distance because it includes returning time also. Hence, only half of the distance is considered. Using equation 1 the distance is calculated.

D= [(EPWHT) * (SV)/2] ------ (1)

Where,

D = Distance in cm

EPWHT = Echo pulse width high time

SV = Sound velocity in cm/s

However, the basic principle of sound is that, the sound velocity in atmosphere changes with respect to different temperatures. When the temperature is 0°C, the sound velocity in the atmosphere reaches 331.45 m/s. For every 1°C temperature rise the sound velocity increases by 0.607 m/s. The sound velocity at different temperatures can be calculated with the following formula.

$C = 331.45\ m/s + (0.607\ m/s * T°C)$ ------ (2)

Where,

C-Sound velocity,

T-Current temperature

V. MATERIAL DIFFERENTIATION

IR transmitters are used for the transmission of light. Thus, a pulse of light is transmitted and reflected back by the material. The emitted light is reflected from the target and its intensity is measured at the detector. However, it is often not possible to make reliable distance estimates based on the value of a single light intensity that is reflected back, because the return depends on the geometry and properties of the reflecting target. Likewise, the properties of the target cannot be deduced only from the intensity returns without knowing its distance and angular location [3]. Depending on the characteristic of the material, a part of light may be absorbed by the material and some are reflected back. The reflected light is captured by the Light Dependent Resistor (LDR). LDR is used to measure the intensity of the light that is reflected back. Thus with the property of difference in light absorptivity by different materials, this can be used to differentiate between different materials. In arduino board, the value of the reflected signal voltage is calculated and the corresponding light intensity is found using the following equation (3).

$$\text{Light Intensity} = \frac{500}{\frac{10.72}{5 - \text{Volt}} * \text{Volt}} \quad \text{----- (3)}$$

VI . EXPERIMENTAL RESULTS AND DISCUSSION

The distance of various materials from the ultrasonic sensors ping and HC-SR04 is calculated using the equations

(1) for distance measurement and equation

(2) for calculating

speed of sound in air with respect to temperature. The test environment in our work is, the average temperature at Chennai is 28.6 °C, thus the speed of sound is 348.66 m/s, average walking speed of blind people is 0.3 m/s and coverage angle of ultrasonic sensor is 60° (±30°). The serial monitor displaying the distance of the obstacle from the sensor in the Arduino Software is shown in the Fig. 7. The material differentiation is done by measuring intensity levels of the reflected light from 15 different materials using equation 3. The Fig. 8 shows the plot of intensity values for nearly 30 samples from different kind of materials and the average value of the voltage and intensity levels in lux for 30 samples are tabulated in the Table 1. The plot in Fig. 9 clearly indicates the range of average value of light intensity for some material that are experimented before.

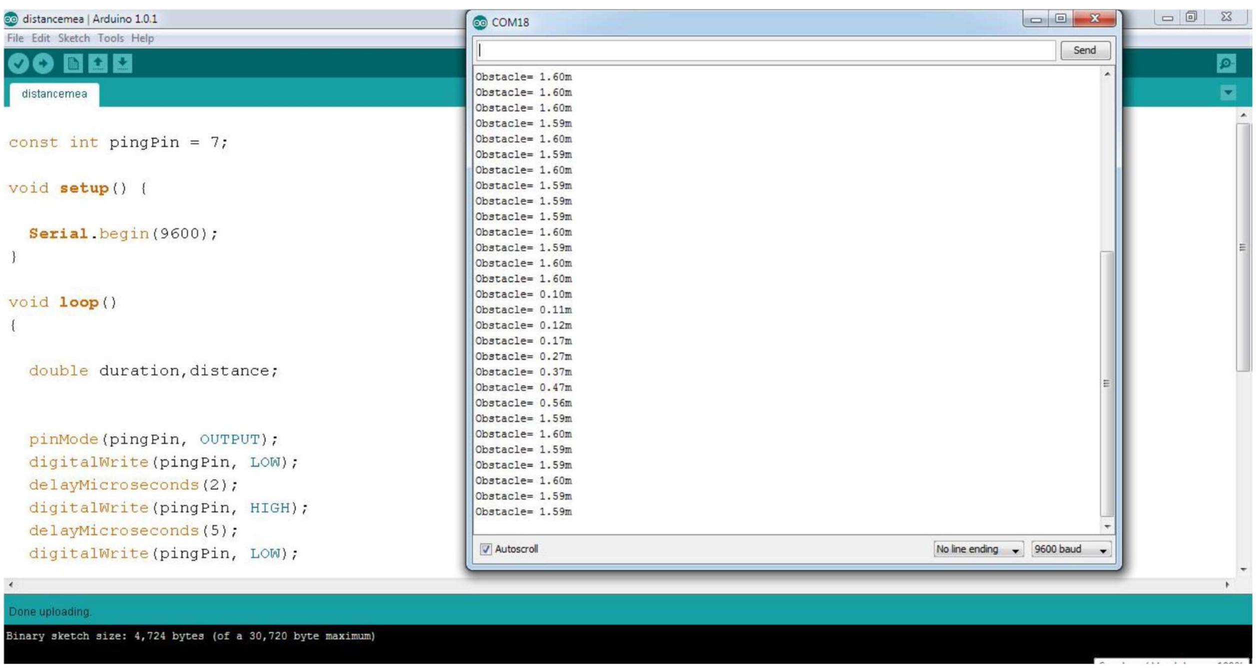

Fig. 7 Snapshot of Serial Monitor for distance measurement by Arduino board using Arduino software

TABLE 1
AVERAGE VALUE OF LI FOR DIFFERENT MATERIALS

Materials	**Voltage(V)**	**Light Intensity (LI) (lux)**
Test Environment	1.27	136.94
White Cardboard	1.15	156.16
Transparent Plastic	2.15	61.65
Paper	1.74	87.10
Stone	1.78	84.26
Cloth	3.35	23.04
Tiles	4.12	10.02

With the help of Fig. 8 and Fig. 9 the materials can be grouped with three reference light intensity values as given in Table 2. In real time scenario, the major obstacles faced by visually impaired like wall, cardboard, stone, mirror and cloth are recorded here. It is also seen, that the lowest light intensity is for tiles and highest for White cardboard.

TABLE 2
CATEGORISING MATERIALS

Light Intensity <50lux	**Light Intensity >50lux**	**Light Intensity >100lux**
Tiles Cloth	Transparent Plastic Stone Paper	Test Environment White Cardboard

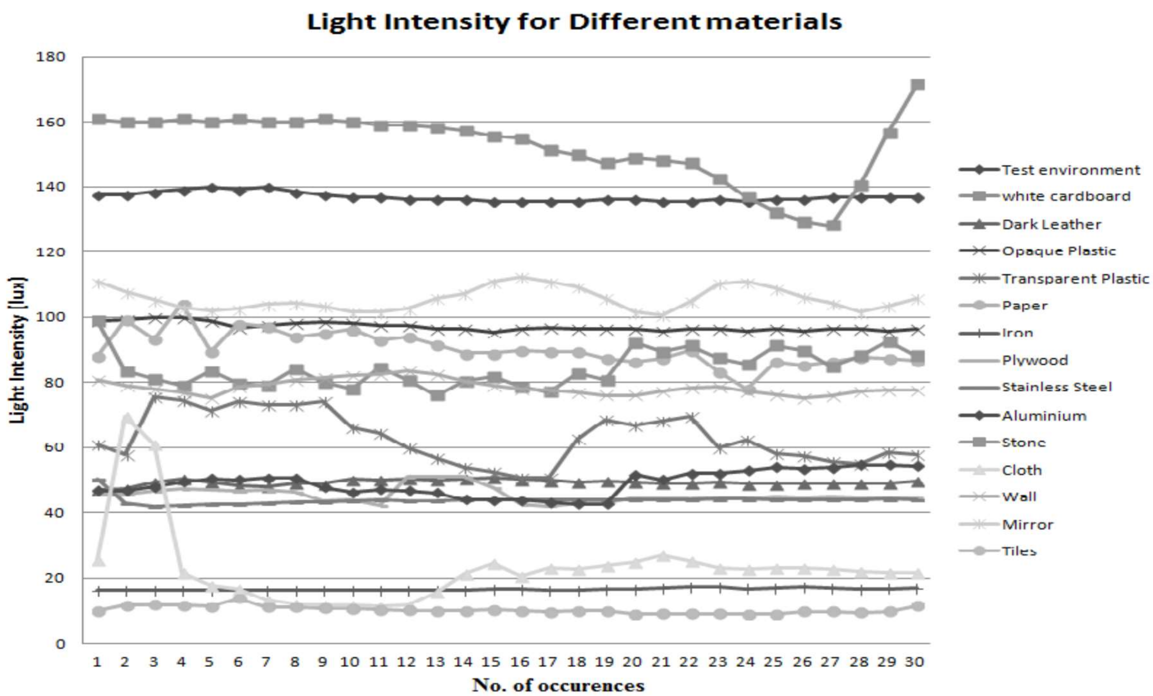

Fig. 8 Light Intensity for different materials

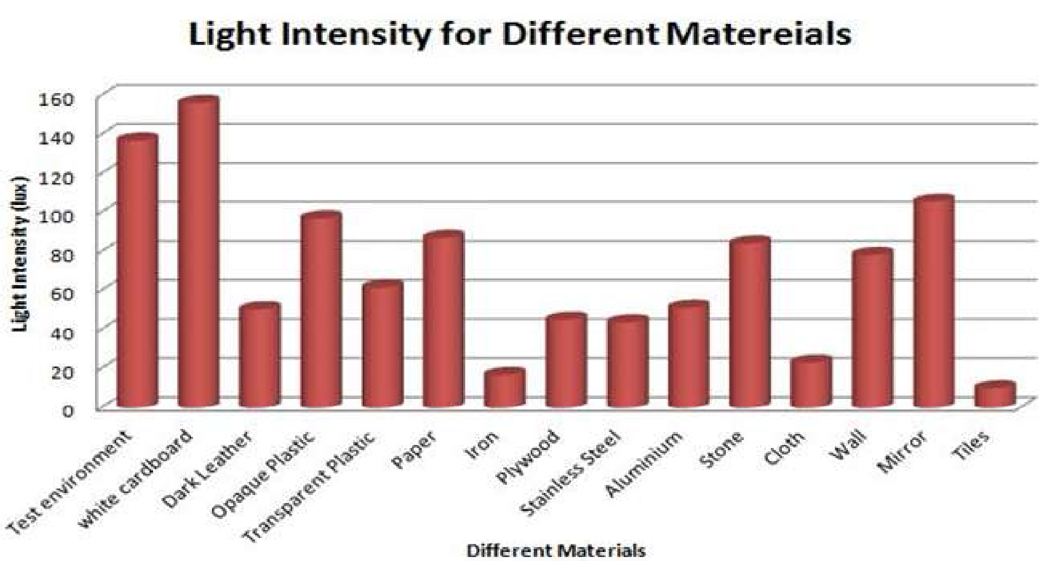

Fig. 9 Average of Light intensity for different materials

VII. CONCLUSION

The main objective of this project is to assist blind or visually impaired people to safely move among obstacles and other hazards faced by them in daily life. To investigate the performance of the whole strategy, several trials have been conducted on the multi-sensor structure for different materials. The assistance device in this work will tell the user about the distance of the obstacle from the user and different types of

materials are distinguished based on light intensity phenomenon for indoor environment. In the distant future it can be extended to a system to suit outdoor environments. Also, the audio output to the user can be given using ear phones.

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