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Design and Development of Virtual Eye for the Blind

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Abstract: Vision is a beautiful gift to human beings by GOD. Vision allows people to perceive and understand the surrounding world. Till date blind people struggle a lot to live their miserable life. In the presented work, a simple, cheap, friendly user, virtual eye is designed and implemented to improve the mobility of both blind and visually impaired people in a specific area. The presented work includes a wearable equipment consists of head hat, mini hand stick and foot shoes to help the blind person to navigate alone safely and to avoid any obstacles that may be encountered, whether fixed or mobile, to prevent any possible accident. The main component of this system is the ultrasonic sensor which is used to scan a predetermined area around blind by emitting-reflecting waves. The reflected signals received from the barrier objects are used as inputs to Arduino microcontroller. The microcontroller carry out the issued commands and then communicate the status of a given appliance or device back to the earphones using SD Card Technology. The system is cheap, fast, and easy to use and an innovative affordable solution to blind and visually impaired people in third world countries.

Keywords: Ultrasonic Sensors, Arduino Microcontroller, SD Card, Headphone.

I. INTRODUCTION

Blindness is a state of lacking the visual perception due to physiological or neurological factors. The partial blindness represents the lack of integration in the growth of the optic nerve or visual centre of the eye, and total blindness is the full absence of the visual light perception[1]. Imagine walking into an unfamiliar place. One has to ask for guidance in order to reach to the destination. But what if the person is visually impaired!! Person has to completely depend on other people to reach destination. Generally we observe that white cane is the best friend of visually impaired person. But many a times this cane is not useful. In an unfamiliar surrounding visually impaired person might get confused. So this restricts their mobility. This makes them dependent on others. Regardless of the tool used, the factor that most determines a person's mobility is the use of essential personal skills[2]

Total blindness is the complete lack of form and visual light perception and is clinically recorded as NLP, an abbreviation as "no light perception". Blindness is frequently used to describe severe visual impairment with residual vision. Those described as having only light perception have no more sight than the ability to tell light from dark and the general direction of a light source[3].

Many people suffer from serious visual impairments preventing them from travelling independently. Accordingly, they need to use a wide range of tools and techniques to help them in their mobility. One of these techniques is orientation and mobility specialist who helps the visually impaired and blind people and trains them to move on their own independently and safely depending on their other remaining senses. Another method is the guide dogs which are trained specially to help the blind people on their movement by navigating around the obstacles to alert the person to change his/her way. However, this method has some limitations such as difficulty to understand the complex direction by these dogs, and they are only suitable for about five years. The cost of these trained dogs is very expensive, also it is difficult for many of blind and visually impaired persons to provide the necessary care for another living being [1][3]. There is an international symbol tool of blind and visually impaired people just like the white cane with a red tip which is used to enhance the blind movement. The walking cane is a simple and purely mechanical device dedicated to detect static obstacles on the ground, uneven surfaces, holes and steps via simple tactile-force feedback. This device is light, portable, but range limited to its own size and it is not usable for dynamic obstacles detection neither than obstacles not located on the floor [4]. Recently, many techniques have been developed to enhance the mobility of blind people that rely on signal processing and sensor technology. These called electronic travel aid (ETA) devices help the blind to move freely in an environment regardless of its dynamic changes. According to the literature, ETAs are mainly classified into two major aspects: sonar input (laser signal, infrared signals, or ultrasonic signals) and camera input systems (consists mainly of a mini CCD camera).The way these devices operate just like the radar system that uses ultrasonic fascicle or laser to identify height, the direction, and speed of fixed and moving objects. The distance between the person and the obstacles is measured by the time of the wave travel. However, all existing systems inform the blind of the presence of an object at a specific distance in front of or near to him. These details permit the user to change his or her way. Information about the object characteristics can create additional knowledge to enhance space manifestation and memory of the blind. To overcome the above-mentioned limitations, this work offers a simple, efficient, configurable virtual for the blind. The originality of the proposed system is that it

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utilizes an embedded vision system of five simple ultrasonic sensors and brings together all reflective signals in order to codify an obstacle through Arduino microcontroller. Furthermore, the user of the system does not need to carry a cane or other marked tool. He/she can just wear a hat, a hand mini stick (size of a pen) and foot shoes just like others. It is very suitable for real-time applications.

II. LITERATURE REVIEW AND DISCUSSION

Over the years of human nature development and behavior pattern development shows that he sees, realizes, he understood. In case of blind person, it is painful that he can not see but he tries to ask and get realization of locality and put it into memories when he moves around by sensing the noises and some pick point he understood the situation/locality. If by mistake he removes the kept memorized tag from his mind he can not realize the locality and he got confused and has to ask his fellow or other moving persons for assistance. Similar case is about direction finding for moving towards desired destiny. It clearly shows that any persons/whether impaired or not person keep memorizing the locality information and sense tags in to memory and recover it when they wants to moves around. Literature analysis shows that there are mainly four technologies and combinations are used to work in context with similar objective for blind personals. They are mainly as below:

(1)GPS

(2) RFID information grid

(3)Mobile platform devices /sensors and Client server architectural systems and devices.

Let us discuss about above one by one.

GPS: Global positioning system uses longitude and latitude calculations for find out the position of object. Since it uses geospatial satellites signals, to calculate the positional difference from satellite; the accuracy is quite in the range of 100m to 300m.For the person who is walking on the road can receive these signals, but for indoor it is very hard to receive the same. Also the accuracy required is not achievable; hence it is a void solution for blind person to use for navigating device[5-16].

RFID information grid: RFID is radio frequency identification device. It holds unique information such as number or symbol or text etc. It is passive device which is energized by interrogators emf field. To form a information grid the RfID tags are arranged in such a way that it could describe the longitudinal and latitudinal position. The searching device enquires about the positional information and sends it to server by sms. The server holds database with relational description of local position for reference send by sms. It search in database for same and broadcast it on FM which could be heard by the enquirer's device. The big issue To Design RFID Based Cognition Device for Assistance to Blind and Visually Challenged Personal for Indoor Use in system is that the sms sending and delivering time. Again the air calls traffic congestions. The personal device may work properly but server failure detection case cannot be solved. Hence addressed solution is more of problems than the solution. The two three device on different location should work in tune with single fetched query make more dependable which is not viable. The same about remaining technological solutions more or less they are combinations of two or more type of technical mix hybrid device. The RfID grid system with an RFID reader integrated into the user's shoe and walking cane with Bluetooth connection to the user's cell phone[17-30].

Mobile Platform Devices: Mobility is one of the main problems encountered by the blind in their life. Overtime, blind and visually impaired people have used some methods and devices such as the long white cane and guide dog, to aid in mobility and to increase safe and independent travel .Due to the development of modern technologies, many different types of devices are now known as electronic travel aids. Among these aids are sonic pathfinder, Mowat –Sensor and Guide cane which are called clear path indicators or obstacle detectors since the blind can only know whether there is an obstacle in the path ahead. These devices are used to search for obstacle in front of the blind person, and they operate in a manner similar to a flashlight, which has very narrow directivity. Sonic-sensor since it has wide directivity enabling it to search for several obstacles at the same time.

Portability, low cost, and above all simplicity of controls are most important factors which govern the practicality and user acceptance of such devices. The electronic travel aid (ETA) is a kind of portable device. Hence it should be a small sized and lightweight device to be proper for portability. The blind is not able to see the display panel, control buttons, or labels. Hence the device should be easy to control. No complex, control buttons, switches and display panel should be present .Moreover, the ETA device should be low –price to used by more blind persons[31-42].

III. PROPOSED DESIGN

In order to overcome the difficulties in the existing method and to provide the cost effective and user friendly system for blind navigation, the following design is proposed. Fig.1 shows that this project mainly consist on five parts namely Ultrasonic sensors, Microcontroller, SD Card, Headphone, Power supply.

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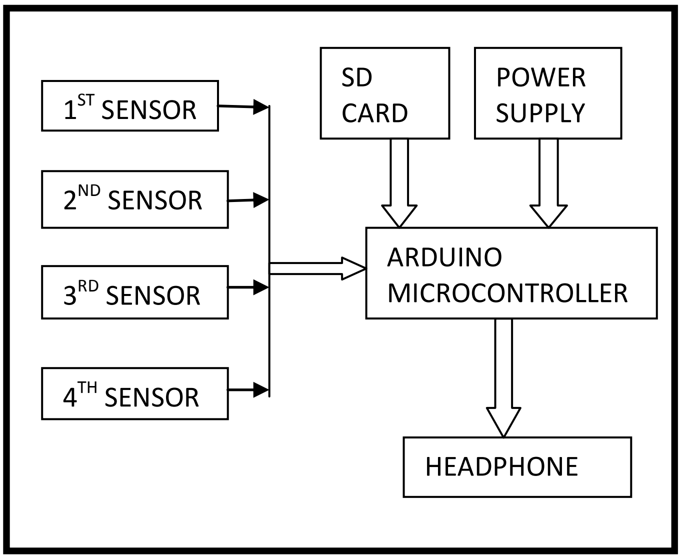

Fig.1 Block Diagram of the Virtual Eye

IV HARDWARE DESCRIPTION

A. Ultrasonic Sensors

In order to provide the obstacle avoidance, Ultrasonic sensor is used. Ultrasonic ranging provides 2cm- 400cm non-contact measurement function, the ranging accuracy can reach to 3mm.it includes ultrasonic transmitters, receiver and control circuit. Ultrasonic use I/O trigger for at least 10us high level signals. Sensor automatically sends eight 40 KHz and detect whether there is a pulse signal back. IF the signal back, through high level, time of high output I/O duration is the time from sending ultrasonic to returning.

Fig.2 Ultrasonic Sensors

The ultrasonic sensor determines the distance to a reflective surface by emitting high-frequency sound waves and measuring the time it takes for the echo to be picked up by the detector. The ultrasonic sensor can determine the distance to an object between 3cmand 3m away; closer than 3cm will result in the sound waves echoing back to the sensor before the detector is ready to receive. The ultrasonic sensor actually consists of two parts: an emitter, which produces a 40 kHz sound wave; and a detector, which detects 40kHz sound waves and sends an electrical signal back to the microcontroller. In order to determine the distance to an object, it is necessary to implement a timing loop in your microcontroller code to measure the length of time required for the sound wave generated by the emitter to traverse the distance to the object.

B. Arduino Microcontroller

Arduino is a single-board microcontroller, intended to make the application of interactive objects or environments more accessible. The hardware consists of an open-source hardware board designed around an 8-bit Atmel AVR microcontroller, or a 32-bit Atmel ARM. Current models feature a USB interface, 6 analog input pins, as well as 14 digital I/O pins which allows the user to attach various extension boards. It has 16 MHz crystal oscillator, a USB connection, a power jack, an 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 the Atmega 8U2 programmed as a USB-to-serial converter.

Fig.3 Arduino Uno Microcontroller

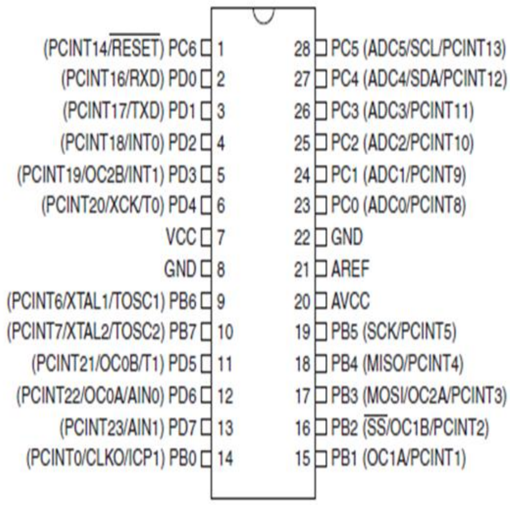

Fig.4 Pin Diagram of Arduino Uno Microcontroller (ATMEGA 238)

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C. SD Card

The Secure Digital (SD) Card is a non-volatile memory card format developed by the SD Card Association for use in portable devices. It is based on flash memory technology and widely used in digital cameras, cell phones, e-book readers, tablet computers, notebook computers, media players, GPS receivers, and video game consoles. Ever since its adoption in the year 2000, the format has proven very popular and is considered the de-facto industry standard.

Table.1 SD Card Size

Card type	Dimensions
SD, SDHC, SDXC, SDIO	32 x 24 x 2.1 mm
miniSD, miniSDHC, mini SDIO	21.5 x 20 x 1.4 mm
microSD, microSDHC, micro SDXC	15 x 11 x 1.0 mm

Table.2 Card Parameters

Card type	Year adopted	Size limit	Writing speed	FAT type
SD	2000	4GB	0.9 - 20MB/s	FAT16
SDHC	2006	32GB	2 - 40MB/s	FAT32
SDXC	2009	2TB	max 300MB/s	exFAT

MINISD CARD

The miniSD form was introduced at March 2003 CeBIT by SanDisk Corporation which announced and demonstrated it.The SDA adopted the miniSD card in 2003 as a small form factor extension to the SD card standard. While the new cards were designed especially for mobile phones, they are usually packaged with a miniSD adapter that provides compatibility with a standard SD memory card slot. Like other types of flash memory card, an SD card of any SD family is a block-addressable storage device, in which the host device can read or write fixed-size blocks by specifying their block number.

Per the SD card specification, an SD card is formatted with MBR and the following file system:

- For SDSC cards:
- Capacity of less than 32,680 logical sectors (smaller than 16 MB): FAT12 with partition type 01h and BPB 3.0 or EBPB 4.1
- Capacity of 32,680 to 65,535 logical sectors (between 16 MB and 32 MB): FAT16 with partition type 04h and BPB 3.0 or EBPB 4.1
- Capacity of at least 65,536 logical sectors (larger than 32 MB): FAT16B with partition type 06h and EBPB 4.1

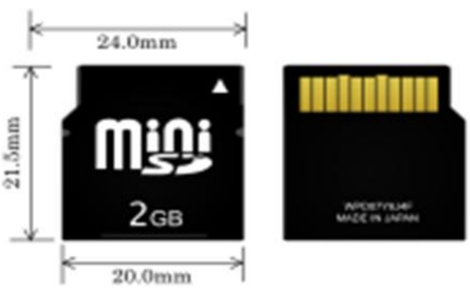

Fig.5 Mini SD Card

D. Serial Peripheral Interface (SPI)

Serial Peripheral Interface (SPI) is an interface bus commonly used to send data between microcontrollers and small peripherals such as shift registers, sensors, and SD cards. It uses separate clock and data lines, along with a select line to choose the device you wish to talk to.

E. Headphone

The headphone is used in this project for guiding the visually impaired persons to navigate independently by amplifying the predefined voice signals.

F. Power Supply

Since all electronic circuit work only with low dc voltage. We need a power supply unit to provide the appropriate voltage supply. This unit consists of battery, rectifier, filter and regulation.

V HARDWARE IMPLEMENTATION

A. Working

To implement, the ultrasonic sensors, Arduino microcontroller and SD card are used. Based on signals, decision is made in Arduino to manage and give timely signals. The input string is from the ultrasonic sensors which generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object. Ultrasonic sensor can measure distances in centimeters and inches. It can measure from 0 to 2.5 meters, with a precision of 3 cm. The input string is received by the Arduino microcontroller. The microcontroller will carry out the issued commands and then communicate the status of a given appliance or device back to the earphones using SD Card Technology. SD Cards are a small and cheap method of storing data, and an Arduino can communicate relatively easily with one using its SPI interface.

The Hardware platform developed consists of the following modules.

B. Ultrasonic Sensors Module

The Prototype Hardware consists of four ultrasonic sensors. It includes a wearable equipment consists of head hat, mini hand stick and foot shoes to help the blind person to navigate alone safely and to avoid any obstacles that may be encountered, whether fixed or mobile, to prevent any possible accident.

i) First sensor is placed on a mini hand stick to scan a front area upto a distance of 400cm. It also let the blind people know about the object when it comes closer at 100cm and more closer at 50cm.
ii) Second sensor is placed on a hat to scan a back area upto a distance of 400cm.
iii) Third sensor is placed on a left shoe to scan the left area upto a distance of 400cm.
iv) Fourth sensor is placed on a right shoe to scan the left area upto a distance of 400cm.

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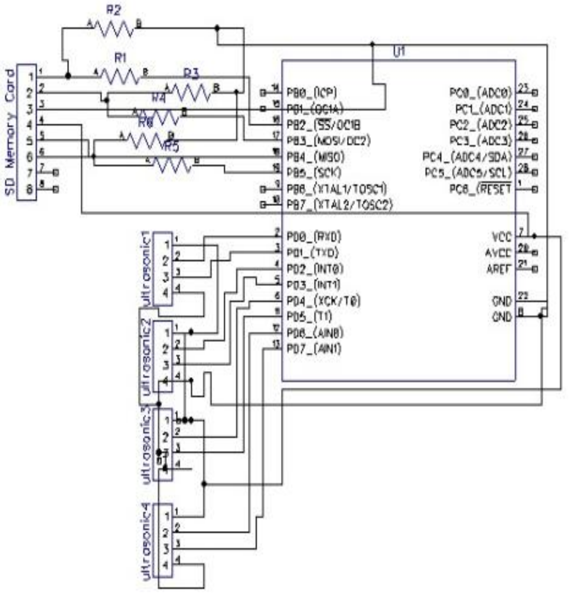

Fig.6 Circuit Diagram of the Prototype Hardware

C. Arduino Uno Module

Arduino microcontroller based control module receives instruction and command from a remote guidance system using ultrasonic sensors. The Arduino microcontroller processes it carry out the issued commands and then communicate the status of a given appliance or device back to the earphones using SD Card module. It provide the necessary interface between the sensor signals and audio system.

Now you are going to learn the basics of writing to and reading from an SD Card. SD Cards are a small and cheap method of storing data, and an Arduino can communicate relatively easily with one using its SPI interface. You will learn enough to be able to create a new file, append to an existing file, timestamp a file, and write data to that file. This will allow you to use an SD Card and an Arduino as a data-logging device to store whatever data you wish.

D. SD Card Access with the ARDUINO

The present application note deals with the implementation of the SPI-based access mode to read data from / write data to a SDSC (standard SD) card using an Arduino microcontroller. Figure 7 shows the SD card pinout and Table 3 the pin connections for both SD and SPI modes.

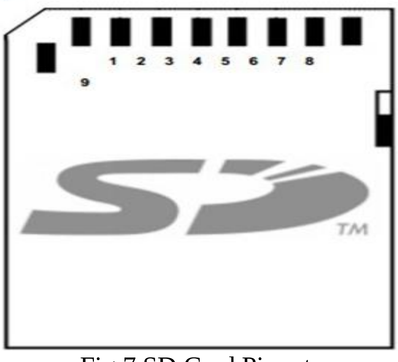

Fig.7 SD Card Pinout

Table.3 SD Card Pinout Description

Pin	SD card pinout - SD Mode			SD card pinout - SPI Mode		
	Name	Type	Description	Name	Type	Description
1	CD/DAT3	I/O/C	Card detection / Connection data line 3	CS	I	Chip selection in low status
2	CMD	C	Command/ Response line	DI	I	Data input
3	$V_{ss}1$	S	GND	$V_{ss}1$	S	GND
4	V_{dd}	S	Power supply	V_{dd}	S	Power supply
5	CLK	I	Clock	SCLK	I	Clock
6	$V_{ss}2$	S	GND	$V_{ss}2$	S	GND
7	DAT0	I/O/C	Connector data line 0	D0	O/C	Data output

The FATFS Library

The FatFs Generic FAT File System Module is a fully free FAT implementation in the form of a library and application interface module, destined to small embedded systems.

The FatFs is written in compliance with ANSI C and completely separated from the disk I/O layer, therefore it is independent of hardware architecture. It can be incorporated into low cost microcontrollers, from 8-bit to 32-bit and various architecture types. The diagram in Figure 4.1 shows how application interfaces the several data storage types using the FATFS library.

The main features of this library are as follows :

- Windows compatible FAT file system, which is platform independent and easy to port
- Supports FAT12, FAT16 and FAT32 with 2 partitioning rules: FDISK and Supe-floppy

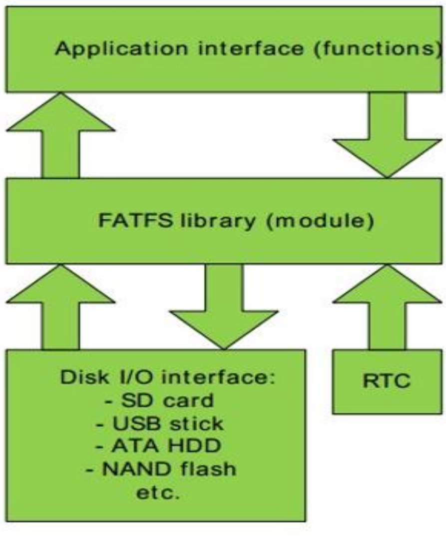

Fig.8 FATFS library interface diagram

VI SOFTWARE IMPLEMENTATION

A. Arduino WAV Playback Direct from SD Card

The best/simplest way to format the data for playback is to Check into the format of WAV files, they can be saved into a format that can read directly using an Arduino with an SD card. There is a small header at the beginning of the file, but then it is basically raw data. The data can be saved in an 8-bit format (0-255), which can be read into the

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Arduino, and written directly to the registers with no modification.

B. *Build a Library*

The easiest method was to use iTunes to convert the wav files, but any PCM file in the correct format will work:
Click Edit > Preferences > Import Settings
Then change the dropdown to WAV Encoder and Setting: Custom > 16.000kHz, 8-bit, Mono
Now you can just right click any file in iTunes, and select Create WAV Version
Then just copy the file(s) to an SD card attached to an Arduino, and check out the library below, with included example sketch.

C. *How it works:*

Since we are reading WAV files directly from SD, we can save as many as the SD card will allow, with general disregard for file size. The library uses timers and interrupts to create a signal that runs at 16000 cycles/second. The signal is controlled by the variables we read in from a file. The file is read into a small buffer, and playback is started. While interrupts control the playback, the second buffer starts filling up with data, using the spare cpu cycles between interrupts, and resumes playback once the first buffer is 'emptied'.
Then the first buffer starts loading data again, while the second is 'emptied' and so on. This allows a continuous stream of data to be available for playback.
Testing seems to indicate a minimum requirement for about 400 bytes of total memory for a steady stream and/or reasonable sound quality. (soundBuff = 200)

D. *How to load data:*

In order to load the needed data onto an SD card, the wave file must be in the correct format, or converted using iTunes and the instructions above. Basically, this can be done using any computer with an SD slot, using any method that outputs wav files in the correct format.

VII COMPLETE ASSEMBLY OF THE CIRCUIT

Complete assembly of the microcontroller based virtual eye for the blind is shown in Fig. . This board consists of regulated power supply, Arduino uno microcontroller, SD Card module, Ultrasonic sensors, speakers, resistances, etc are mounted with electrical connections.

Fig.9 Complete Assembly of the Microcontroller based Virtual Eye for the Blind

VIII FLOW CHART

The developed controller for virtual eye has been carried out by following steps as depicted in the flow chart shown in Fig.10

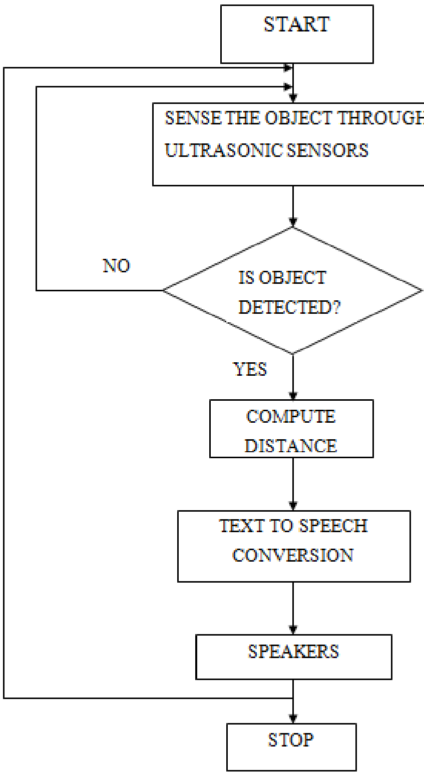

Fig.10 Flow Chart of the Virtual eye

IX RESULTS AND DISCUSSIONS

The presented system is designed and configured for practical use. The system is able to handle seven states that may face the blind people. The system will respond to each state according to a specific program which is coded and installed in the Arduino microcontroller.
Case 1: When object is in the left direction of the blind, then the speaker will give the audio, "obstacle in left".
Case 2: When object is in the right direction of the blind, then the speaker will give the audio, "obstacle in right".
Case 3: When object is in the front direction of the blind, then the speaker will give the audio, "obstacle in front".
Case 4: When object is in the back direction of the blind, then the speaker will give the audio, "obstacle in back".
Case 5: When object is in the left and right direction of the blind, then the speaker will give the audio, "obstacle in left and right".
Case 6: When object is in the right and front direction of the blind, then the speaker will give the audio, "obstacle in right and front".
Case 7: When object is in the front and back direction of the blind, then the speaker will give the audio, "obstacle in front and back".
Case 8: When object is in the back and left direction of the blind, then the speaker will give the audio, "obstacle in back and left".
Case 9: When object is in the left and front direction of the blind, then the speaker will give the audio, "obstacle in left and front".

Case 10: When object is in the back and right direction of the blind, then the speaker will give the audio, "obstacle in back and right".
Case 11: When object is in the left, right and front direction of the blind, then the speaker will give the audio, "obstacle in left, right and front".
Case 12: When object is in the right, back and front direction of the blind, then the speaker will give the audio, "obstacle in right, back and front".
Case 13: When object is in the front, back and left direction of the blind, then the speaker will give the audio, "obstacle in front, back and left".
Case 14: When object is in the back, left and right direction of the blind, then the speaker will give the audio, "obstacle in back, left and right".
The ultrasonic sensor at front also let the blind people know about the object when it comes closer at 100cm and more closer at 50cm.

Table.4 Comparison of different devices

System	Power consumption	Range	Portability	Invasiveness	Response time	Ease of usage
The current suggested system	Low	Medium	Yes	Noninvasive	Fast	Friendly (no need for training)
NavBelt	Medium	Low	No	Noninvasive	Medium	Not friendly (needs training)
The white cane	High	Medium	No	Invasive	Medium	Not friendly (needs training)
NAVI	High	High	No	Noninvasive	Slow	Not friendly (needs training)

The portability is an important parameter of the system. The system which can be worn and used by the subject for prolonged time is considered as a portable system; otherwise it is regarded as non portable. The easiness of the system usage is considered as another parameter. An easy to use device is actually easy to get to and an easy to function. Finally the noninvasive utilization of the system is considered as a property of the system. Table.4 compares the aforementioned parametric specifications for different systems.

X CONCLUSION

A simple, cheap, configurable, easy to handle electronic guidance system is proposed to provide constructive assistant and support for blind and visually impaired persons. The system is designed, implemented, tested, and verified. The real-time results of the system are encouraging; it revealed an accuracy of 93% in detecting distances. The results indicate that the system is efficient and unique in its capability in specifying the source and distance of the objects that may encounter the blind. It is able to scan areas left, right, back and in front of the blind person regardless of its height or depth. Therefore, it was favoured by those who participated in the test. The ultrasonic sensor has been fully utilized in order to advance the mobility of the blind and visual impaired people in safe and independent way. This system does not require a huge device to be hold for a long distance, and it also does not require any special training. This system also resolves limitations that are related to the most of the movement problems that may influence the blind people in their environment.

XI ADVANTAGES

1) Low design time.
2) Low production cost.
3) This system is applicable for both the indoor and outdoor environment.
4) Setting the destination is very easy.
5) It is dynamic system.
6) Less space.
7) Low power consumption.

XII FUTURE SCOPE

Future work will be focused on enhancing the performance of the system and reducing the load on the user by adding the camera to guide the blind exactly. Images acquired by using web camera and NI-smart cameras helps in identification of objects as well as scans the entire instances for the presence of number of objects in the path of the blind person. It can also detect the material and shape of the object. Matching percentage has to be nearly all the time correct as there no chance for correction for a blind person if it is to be trusted and reliable one. The principles of mono pulse radar can be utilized for determining long range target objects. The other scope may include a new concept of optimum and safe path detection based on neural networks for a blind person.

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