DESIGN OF MICROCONTROLLER BASED VIRTUAL EYE FOR THE BLIND

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ABSTRACT
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. In this proposed work, a simple, cheap, friendly user, virtual eye will be designed and implemented to improve the mobility of both blind and visually impaired people in a specific area. The proposed 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 Raspberry pi speech synthesizer. The proposed 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, raspberry pi speech synthesizer, headphone.*

I. INTRODUCTION
Vision is a beautiful gift to human beings by GOD. Vision allows people to perceive and understand the surrounding world. However a World Health Organisation survey made in 2010, estimated 285.389 million people with visual impairment across the globe. These visually impaired people face the problems of orientation and mobility in an unknown environment. Many efforts have been made to improve their mobility by use of technology [1]. Total blindness is the complete lack of form and visual light perception and is clinically recorded as NLP, an abbreviation for "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 [2].

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 [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 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. RELATED WORK

Over the last decades, research has been conducted for new devices to design a good and reliable system for blind people to detect obstacles and warn them at danger places. There are some systems which has some deficiencies.

Shoval et. al in [5] developed a Navbelt, an obstacle avoidance wearable portable computer which is only for indoor navigation. Navbelt was equipped with two modes, in the first one the system information was translated to audio in different sounds. One sound for free for travel direction and other for blocked, it was difficult for the person to differentiate the sounds. Other problem was the system would not know the user momentary position.

D. Yuan et al. in [6] have discussed about the virtual white cane sensing device based on active triangulation, that can measure distances at a rate of 15 measurements/second. A blind person can use this device for sensing the environment, pointing it as if it was a flash light. Beside measuring distances, this device can detect surface discontinuities, such as the foot of a wall, a step, or a drop-off. This is obtained by analyzing the range data collected as the user swings the device around, tracking planar patches and finding discontinuities.

Benjamin et al. in [7] introduce a laser cane with three photo diodes and three laser diodes function as receiver making an optical triangulation. The laser cane detects the obstacle in three different directions. One is 45º to the ground for overhanging obstacles, the second one is parallel to the ground and third one is for sharp deepness. The laser cane has no system for determining location and position. J. Na proposed an interactive guide system for indoor positioning, which can't detect the obstacles and hurdles. The system is not suitable for the outdoor activities.

S. Innet and N. Ritnoom in [8] have introduced a stick for distance measurement using infrared sensors, which is a complex and time wasting process. The stick has different vibration modes for different range which is difficult for a blind to differentiate, it needs time for training. The stick informs the person clearly at dangerous stage which conveys less information and safety. The stick has no location and positioning features.

Evangelos Milios et al. in [9] have presented a device that allows three-dimensional (3-D) space perception by sonification of range information obtained via a point laser range sensor. The laser range sensor is worn by a blindfolded user, who scans space by pointing the laser beam in different directions. The resulting stream of range measurements is then converted to an auditory signal whose frequency or amplitude varies with the range.

J. Borenstein and Y. Koren in [10] have discussed the VFH method which uses a two-dimensional Cartesian histogram grid as a world model. This world model is updated continuously with range data sampled by on-board range sensors. In the first stage the histogram grid is reduced to a one- dimensional polar histogram that is constructed around the robot's momentary location. In the second stage, the algorithm selects the most suitable sector from among all polar histogram sectors with a low polar obstacle density, and the steering of the robot is aligned with that direction.

Sylvain Cardin et al. in [11] have presented an obstacle detection system for visually impaired people. User can be alerted of closed obstacles in range while traveling in their environment. The system we propose detects the nearest obstacle via a stereoscopic sonar system and sends back vibro-tactile feedback to inform the user about its localization.

Przemyslaw Baranski et al. in [12] have explained the concept and reports tests of a remote guidance system for the blind. The system comprises two parts – a remote operator's terminal and a blind person's mobile terminal. The mobile terminal is a small electronic device which consists of a digital camera, GPS receiver and a headset. The two terminals are wirelessly connected via GSM and the Internet. The link transmits video from the blind traveller, GPS data and provides duplex audio communication between the terminals.

Maroof H. Choudhury et al. in [13] have described a Pocket-PC based Electronic Travel Aid (ETA) that helps a blind individual navigate through indoor environments. The system detect surrounding obstacles using ultrasonic range sensors and the travel direction using an electronic compass. The acquired information is processed by a Pocket-PC to generate a virtual acoustic environment where nearby obstacles are recognizable to the user.

Rupali Kale and A. P. Phatale in [14] have presented this project aims to make the blind person fully independent in all aspects. The proposed system is based on Global Positioning System (GPS) and Obstacle detection and object avoidance technologies .

Sabarish.S in [15] have described the development of a navigation aid in order to assist blind and visually impaired people to navigate easily, safely and to detect any obstacles. The system is based on a microcontroller with synthetic speech output. In addition, it consists of two vibrators, two ultrasonic sensors mounted on the user's shoulders and another one integrated into the cane.

Bruce Moulton et al. in [16] investigated the suitability of a user centered client server approach for the development of a talking GPS system intended to fill a niche for outdoor way finding. The work resulted in a working prototype proof-of-concept system that uses a speech-recognition speech-synthesis interface.

V.Dhilip Kanna et al. in [17] have presented this project aims to make the blind person fully independent in all aspects. The proposed system is based on "Programmable Gate Arrays (PGA) and Detectors". This constitutes a virtual eye which communicates to the outside surrounding through a camera. The camera acts as a constant source of information to the system.

M Bujacz et al. in [18] have discussed the main idea of the system to transmit a video stream from a camera carried by a visually impaired user to a remote assistant that navigates the blind by short spoken instructions. The communication link is established over the GSM network within the High-Speed Downlink Packet Access (HSDPA) communication protocol.

Andreas Riener and Harald Hartl in [19] have proposed a wearable solution for boundary detection (using ultrasonic range finders) and notification (via tactile actuators) under conditions of poor visibility. The unique feature of "Personal Radar" used for obstacle scanning and notification solution is, that it is self-contained and fully self-governed.

Horace Josh et al. in [20] have presented an FPGA implementation of a real-time vision system that simulates this phenomenon. The system is low-cost, mobile and consists of a CMOS camera, FPGA development board, and a head-mounted display.

Bousbia Salah et al. in [21] have described the problem of distance measurement. The proposed system is based on the technique of using an accelerometer and double integrating ' its output with respect to time.

D. Dakopoulos and N. G. Bourbakis in [22] have presented a comparative survey among portable/wearable obstacle detection/avoidance systems (a subcategory of ETAs) in an effort to inform the research community and users about the capabilities of these systems and about the progress in assistive technology for visually impaired people.

Ranu Dixit and Navdeep Kaur in [23] have involved the synchronization of different sound signals and reading of each signal bit wise. These signals store in database, apply the HMM algorithm and distribute each sound signal in one information database.

G. Balakrishnan and G. Sainarayanan in [24] have presented a review on vision-aided systems and proposes an approach for visual rehabilitation using stereo vision technology.

WaiLun Khoo et al. in [25] have described how a wearable range-vibrotactile device is designed and tested in the real-world setting, as well as thorough evaluations in a virtual environment for complicated navigation tasks and neuroscience studies.

Chang Gul Kim and Byung Seop Song in [26] have designed a microprocessor and a PDA. All of the information about obstacle in front of user is checked by three ultrasound sensor pairs and delivered to the microprocessor which analyzes the information and generates the acoustic signal for alarm.

E. Milios et al. in [27] have presented a device that allows three-dimensional (3-D) space perception by sonification of range information obtained via a point laser range sensor.

J. Brabyn in [28] have presented an overview of both early and recent developments in artificial aids for blind orientation and mobility.

Orly Lahav et al. in [29] have developed a new virtual environment system for people who are blind to aid them in their anticipatory exploration and cognitive mapping of unknown environments.

Simon Meers and Koren Ward in [30] have presented a novel human-computer interface that enables the computer display to be perceived with- out any use of the eyes. Our system works by tracking the user's head position and orientation to obtain their 'gaze' point on a virtual screen, and by indicating to the user what object is present at the gaze location via haptic feedback to the fingers and synthetic speech or Braille text.

Brabyn in [31] have discussed a reading service for the blind in which an on-call remotely located sighted reader could read to and interact with blind clients as if they were in the same room, using telecommunication and virtual presence technologies. The method combines the advantages of automated reading machines with those of a sighted reader (i.e., intelligent scanning, information extraction and interpretation, ability to deal with handwriting, etc.).

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, Raspberry pi, Headphone, Power supply.

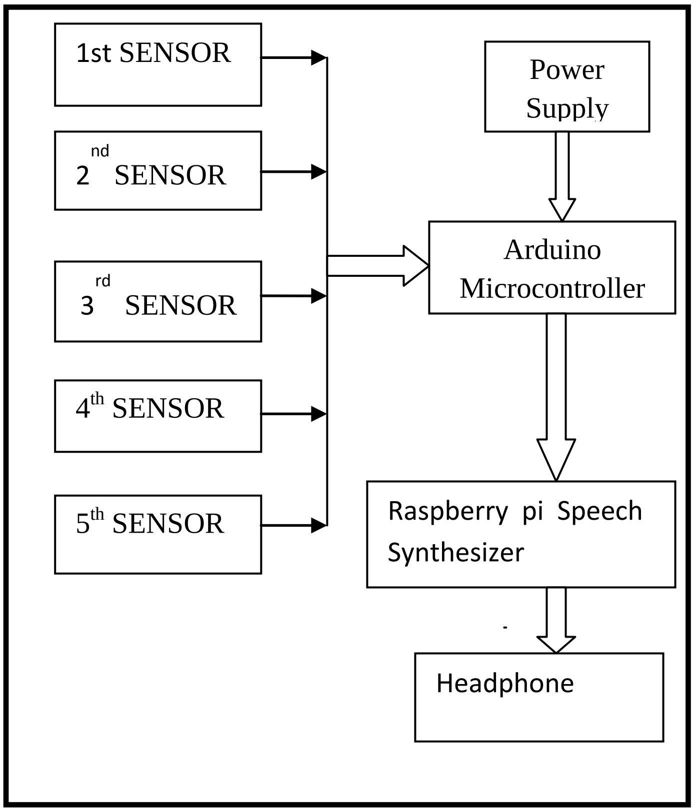

Fig. 1 Block Diagram of the Virtual Eye

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.

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.

c) Raspberry pi Speech Synthesizer

The text generated by distance measurement module was stored in a folder. The speech maker spells the text from this folder and outputs the same form of a voiced signal. Blind person can hear this output through microphone.

A system used for this purpose is known as Raspberrypi speech synthesizer and it can be implemented in software and hardware both. The quality of speech synthesizer is judged by its similarity with human voice and its clarity to be understood. Festival text-to-speech software installed in Rpi allows people with visual impairments or reading disability to listen to written works. Festival is a software multi-lingual speech synthesis workbench that runs on multiple-platforms offering a full text to speech system with various APIs, as well as an environment for development and research of speech synthesis techniques. It is written in C++ with a Scheme-like command interpreter for general customization and extension.

d) Headphone

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

e) 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.

IV. WORKING OPERATION

Our project is an innovative idea of intelligent system which has basically Obstacle detection feature and will provide safety and support to visually impaired Persons. The ultrasonic sensors in the system will sense surrounding and will detect the obstacles and give feedback to raspberry pi speech synthesizer change the path way.

1) The power supply activates the circuit.

2) The sensor transmitter transmits the frequency, which reflects from the obstacle. Sensor receiver receives the reflected frequency and gives it to microcontroller.

3) The Arduino microcontroller processes it and gives signal to Raspberry pi speech synthesizer.

4) Raspberry pi speech synthesizer gives sound and start to inform the person that the obstacle is detected through headphone.

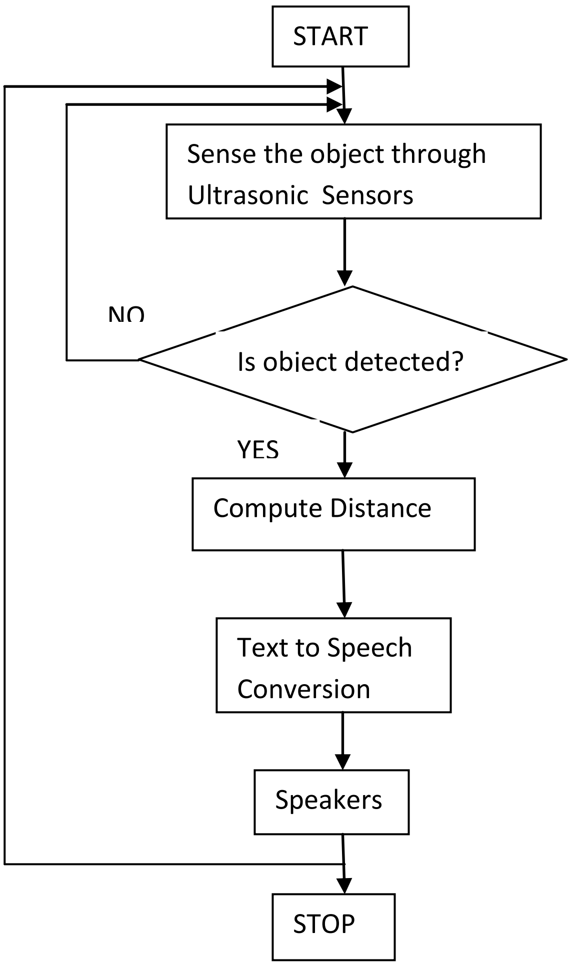

Fig. 2 Flow Chart of the Virtual Eye

V. 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.

VI. SCOPE OF THE WORK

1) Radar can be used for measuring large range target objects.
2) Shape detection test for objects can be considered that move at different rotational speeds across several distances.
3) The other scope may include a new concept of optimum and safe path detection based on neural networks for a blind person.
4) To show good accuracy an image processing technique can be considered.

VII. CONCLUSION

This project proposed the design and architecture of a new concept of Microcontroller based Virtual Eye for the blind people. 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 will be 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, and in front of the blind person regardless of its height or depth. With the proposed architecture, if constructed with at most accuracy, the blind will be able to move from one place to another without others help.

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