Ultrasonic Assistive Headset for Visually Impaired People

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***Abstract*—This paper presents a developed device to solve the problem of moving and navigating of visually impaired and blind people. This device, called Ultrasonic Assistive Headset, is light, simple and low-cost option compared with other assistive devices. Ultrasonic Assistive Headset will guide for them among obstacles by employing ultrasonic distance sensors, microcontroller, voice storage circuit and solar panels to be battery-free. In proposed method, ultrasonic waves arrive to the ultrasonic sensors on the spherical membrane of the headset after sending this waves from ultrasonic distance sensors reflection from obstacles. A microcontroller determines the location of the obstacles according to the sensor ID and the information of distance. The system produces an voice data defining the location, and then it speaks to blind person where the obstacles are. Ultrasonic Assistive Headset can be used easily by them both indoor and outdoor, so they can avoid obstacles quickly and accurately.**

Keywords—Assistive device; voice record; visually impaired people; microcontroller; ultrasonic sensor.

I. Introduction

Today, 285 million people are estimated to be visually impaired worldwide: 39 million are blind and 246 have low vision. About 90% of the World' s visually impaired live in low-income settings [1]. Therefore, assistive device must be simple and cheap. Ultrasonic Assistive Headset is very simple and low-cost option because it employs in-expensive components like ultrasonic transducers, a cheap microcontroller and solar cells as compared to expensive solutions like camera, computer systems.

Ultrasonic Assistive Headset provides ease of indoor/outdoor use. It can detect obstacles by direction, and can speak to blind person where it is. Obstacle detection in Ultrasonic Assistive Headset is environment-friendly, and it does not disturb anybody since it sends and receives ultrasonic waves, which is inaudible by humans. Because ultrasonic waves are not harmful for human health, blind or visually impaired people can use it safely. Ultrasound, which is similar in nature to audible sound, has far shorter wavelengths and is far more suitable to detect small flaws. These shorter wavelengths are what make ultrasound and ultrasonic transducers extremely useful for nondestructive testing and measurement of materials.

Ultrasonic Assistive Headset is also wearable like ordinary headsets. Because headsets are commonly used in society, it does not attract attention. This assistive device will provide convenience for blind and visually impaired people, and will increase the quality of their life.

The recent studies on blind people also show that head-level and fall accidents represent a non-negligible risk associated with walking without sight. These accidents happen at least once a month by most of the blind people and often required medical attention. So far, many outdoor or indoor navigation devices have been developed to assist blind people and to protect them against possible accidents. However, these devices have many disadvantages such as they are not as cheap and economical as every blind can afford to buy; they do not have enough protectable properties against possible accidents. Ultrasonic Assistive Headset resolves the disadvantages mentioned above.

The rest of the paper is organized as follows. Section 2 gives related works. General description and operating logic of proposed headset is introduced in Section 3. Section 4 concludes.

II. Related Works

Researchers have been developing assistive travel devices for blind and visually impaired people, designed to help users detect obstacles in their way.

Navbelt, developed under development at the University of Michigan, enabled a blind user to quickly and safely walk through obstacle cluttered and unknown environments. The total power consumption of this device was 18 W; the total weight of the portable system was 3.4 Kg [2].

Cardin et. al. (2005) developed an obstacle detection system for visually impaired people. The system detects the nearest obstacle via a stereoscopic sonar system and sends back vibro-tactile feedback to inform the user about its localization [3].

Zelek (2005) used sensory replacement and substitution techniques for wayfinding and developed a portable system consisting of a stereo camera and haptic glove for blind or visually impaired [4].

Dolsma (2006) investigated the signal properties of ultrasonic sensors and design a tool which uses this knowledge to detect objects in both the work area as the blind zone of ultrasonic sensors [5].

Ju et.al. (2009) demonstrated a novel assistive device which can help the visually impaired or blind people to gain more safe mobility, called as “EYECane” which is the white-cane with embedding a camera and a computer. It automatically detects obstacles and recommends some avoidable paths to the user through acoustic interface. For this, it is performed by three steps: Firstly, it extracts obstacles from image streaming using online background estimation, thereafter generates the occupancy grid map, which is given to neural network. Finally, the system notifies a user of paths recommended by machine learning. To assess the effectiveness of the proposed EYECane, it was tested with 5 users and the results show that it can support more safe navigation, and diminish the practice and efforts to be adept in using the white cane [6].

Pallejà et. al. (2010) developed a bio-inspired electronic white cane for blind people using the whiskers principle for short-range navigation and exploration. Whiskers are coarse hairs of an animal's face that tells the animal that it has touched something using the nerves of the skin. In this work the raw data acquired from a low-size terrestrial LIDAR and a tri-axial accelerometer is converted into tactile information using several electromagnetic devices configured as a tactile belt. The LIDAR and the accelerometer are attached to the user’s forearm and connected with a wire to the control unit placed on the belt. Early validation experiments carried out in the laboratory are promising in terms of usability and description of the environment [7].

Velázquez (2010) summarized wearable assistive devices for blind people have been presented to illustrate the most representative work done in this area. Several universal design concepts for acoustical/tactile based assistive devices have been developed. They provide guidelines to stimulate both hearing and touch in order to obtain the best performance from these senses. He concluded that some considerations must be taken into account such as; sensory overload; long learning/training time; acoustical feedback (useful only for reading applications); tactile feedback (a viable choice for mobility applications) [8].

Kammoun et.al. (2012) developed a device, which is called NAVIG, to answer all limitations through a participatory design framework with the blind and orientation and mobility instructors. The NAVIG device aims to complement conventional mobility aids (i.e. white cane and guide dog), while also adding unique features to localize specific objects in the environment, restore some visuomotor abilities, and assist navigation [9].

Lewald (2012) investigated whether blind people compensates for their visual loss by the increased use of auditory spatial information. The study demonstrated a substantial superiority of blind subjects in perception of auditory motion compared to sighted controls, whereas equally good performance in both groups of subjects was found for localization of stationary sound [10].

III. The Proposed Headset

An ultrasonic transducer itself is a device that is capable of generating and receiving ultrasonic vibrations. The active element is a piezoelectric or single crystal material which converts electrical energy to ultrasonic energy. It will also then receives back ultrasonic energy and converts it to electrical energy. The sound waves reflect from obstacles. So these piezoelectric transducers on the membranes sense the reflected ultrasonic waves, then produce electrical signal. This signal is binary coded and send to the microcontroller. The left membrane senses left obstacles while the right membrane senses the right obstacles.

Spread direction of ultrasonic waves is given in Fig. 1. The headset include two spherical membranes in both sides. Every membrane is covered by two ultrasonic sensors which are able to detect right and left obstacles. DYP-ME007 is used as the ultrasonic distance sensor. The minimum measurement distance is three centimeters and the maximum measurement distance is four meters. The angle between the ultrasonic distance sensors is 60-degree. Because the angle of view of the DYP-ME007 distance sensor is 30 degrees, angle between the ultrasonic distance sensors is designated as 60 degrees. Thus it is easily perceived obstacles between the two sensors.

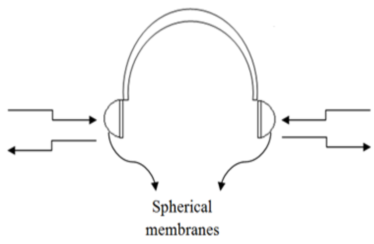


Fig.1. Ultrasonic assistive headset

Voice is an analog information. At first voice waves are converted into electrical signals using a microphone to convert voice into digital information. However, this signal is still analog. ADC is required to convert to digital. The ADC (Analog to Digital Converter) converting to digital analog signals applied to input. Finally, if generated numerical values store in a storage unit voice will be recorded. The playback of voice is achieved by repeating the process that is done in the opposite direction. Namely, saved numerical values are converted to analog with the aid of a DAC (Digital to Analog Converter). If after sufficiently amplified is transmitted to a speaker recorded voice will be listen.

There are electronic devices which are improved to store voice as digital and play back. Thanks to this elements, voice recording and playback of the recording is simplified. These elements contain static EPROM (Erasable Programmable Read-Only Memory), DAC and ADC converters, microphone pre-amplifier, variety voice filters. Thus, the user does not have to deal with such details. ISD series are used as the voice storage circuit. Providing high quality, easy to use, storing the multiple voice recording and addressing the recordings are the advantages of this IC (integrated circuit). This integrated which has 90-second voice recording space is ISD2590 model. ISD2590 voice storage circuit has 10 address pins between A0-A9. Voice recording samples are saved as commands in voice integrated. There are different voice recording samples for each address. Voice recording samples was recorded to the IC previously. Records contain the direction information of obstacles. There are 6 voice recording. They are right front, right side, right behind, left front, left side and left behind. The front and behind voice recordings can only be decided by an ultrasonic distance sensor. The side voice recordings can be decided by two ultrasonic distance sensors. Because side voice recordings are an expression of obstacles at the intersection of the two ultrasonic distance sensors.

The easiest way of multiple recording and addressing access applications with ISD series of voice storage circuit is using a microcontroller and the desired sound is to be elected to the microcontroller. 16F877 are used as microcontroller. Selected microcontroller are preferred due to input / output ports number. Fig. 2 shows the microcontroller system diagram of Ultrasonic Assistive Headset. There are four ultrasonic distance sensors. All the sensors have ID. All binary codes of ultrasonic distance sensors are buffered (Si). If the reflected waves from obstacles are shorter than determined distance 1 information will be sent microcontroller. Otherwise 0 information will be sent microcontroller. They are scanned outputs are transmitted to the microcontroller, and the microcontroller checks which of them are active. Because the binary codes are ID of sensors, the microcontroller can understand which sensor senses a reflected ultrasonic wave. So the direction of the obstacle is determined. Then the microcontroller gets suitable voice record from the ISD2590. And the record is played back to the blind person. The flow chart of the Ultrasonic Assistive Headset is given in Fig. 3.

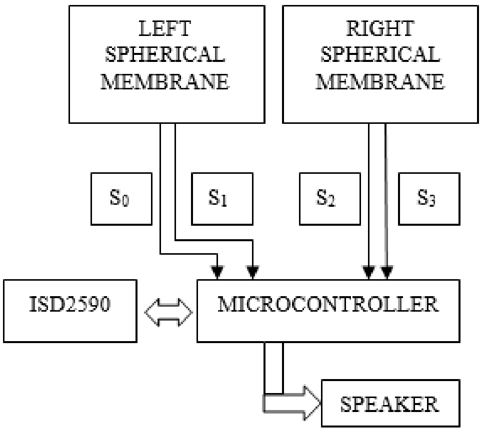


Fig. 2. *Microcontroller system of ultrasonic assistive headset*

Electrical needs required for voice storage circuit and microcontroller is provided by solar panels. The surface of the headset is surrounded by two solar panels. Solar panels which we used for the proposed headset have 0.6w maximum power. Working voltage of them is five volts voltage and working current of them is 90 ma. Low cost is the most important reason of using solar panels. So the headset does not need any battery to accomplish these operations.

PICBASIC programing language is used to program the microcontroller. The software has been tested using Proton IDE compiler. Tested program is installed with the Leap Pstart Development Programmer to microcontroller.

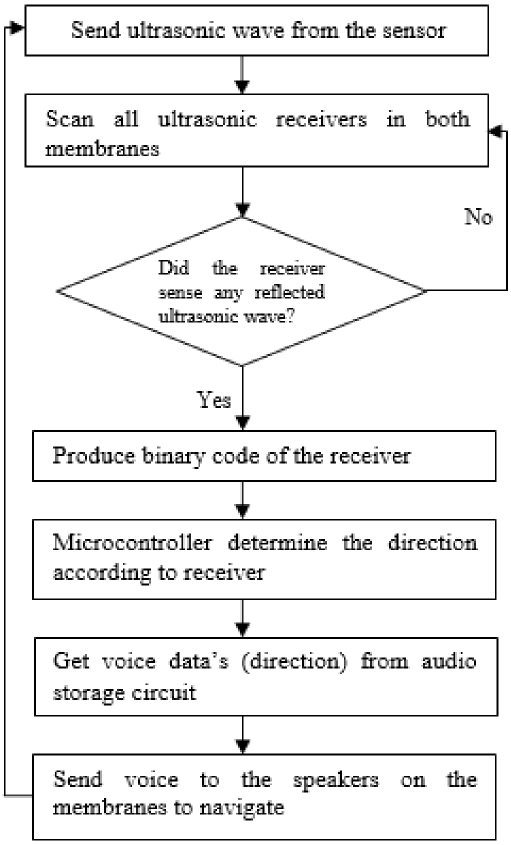


Fig. 3. Flow chart of the ultrasonic assistive headset

Circuit diagram for proposed headset has been simulated with the ISIS 7 Professional program. Because ISD2590 and DYP-ME007 are not in ISIS program they were added later. Circuit diagram which was drawn ISIS program is given in Fig. 4. Circuit diagram which carried out simulations is implemented in ARES program. So circuit diagram is adapted for printed circuit.

Ultrasonic Assistive Headset is given in Fig. 5. There are 3 different picture of the headset because the connections can be seen more clearly. A of Fig. 5 is given against view of the headset. Concealing cable connections and circuits on the headset will become a more aesthetic appearance. B of Fig. 5 is given circuits on the headset. Between circuits on the headset and the user's head will be surrounded by sponge. Thus, the headset will be created ease of use for the user and it will not bother user. C of Fig. 5 is given top view of the headset. The surface of the headset is surrounded by two solar panels. The solar panels are connected in parallel to each other.

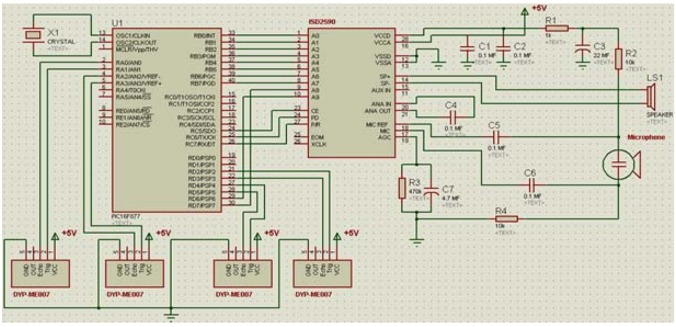
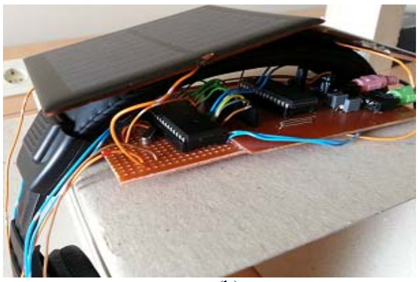
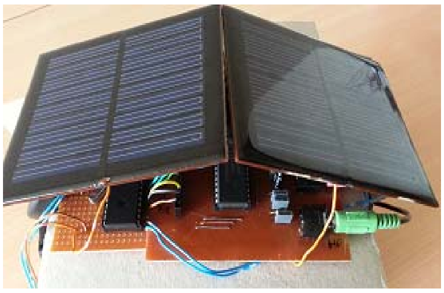


Fig. 4. Circuit diagram for the ultrasonic assistive headset

(a)



(b)



(c)

Fig. 5. Proposed headset: a) Against view of the headset, b) Circuits on the headset and c) Top view of the headset.

IV. Conclusion

We designed Ultrasonic Assistive Headset for blind or visually impaired people. Ultrasonic Assistive Headset is very simple and low-cost option because it employs in-expensive components like ultrasonic distance sensors, microcontroller circuit and solar cells as compared to expensive solutions like camera, computer systems. So this device is candidate to be used by blind or low-vision and low-income people. Some assistive navigation devices for blind people have been studied in the literature. Most of them employ complex systems, which are expensive for such kind of people.

Ultrasonic Assistive Headset is a navigational aid for the blind and visually impaired that quickly and accurately identifies the location of obstacles. It provides ease of indoor/outdoor use. But outdoor use is more efficient than indoor use. It is environment-friendly, and it does not disturb anybody because it is wearable like ordinary headsets. So it does not attract attention in society. This headset is easy to understand and so requires very little training, that does not interfere with the use of the user's hands, and that is relatively inexpensive to manufacture, durable, light weighted and battery-free.

Ultrasonic Assistive Headset can be used for different purposes like night navigation without light, seeing blind zones in transportation, military, mobile robot navigation etc. It can be combined with other technologies to implement different tasks.

References

[1] Available: http://www.who.int/mediacentre/factsheets/fs282/en/ (visited date 2015, July 28)

[2] Borenstein J., "The NavBelt - A Computerized Multi-Sensor Travel Aid for Active Guidance of the Blind", Proceedings of the CSUN's Fifth Annual Conference on Technology and Persons with Disabilities, Los Angeles, California, pp. 107-116, March 21-24, 1990.

[3] Cardin S., Thalmann D., Vexo F., "Wearable Obstacle Detection System for visually impaired People", Workshop on Haptic and Tactile Perception of Deformable Objects, pp. 50-55, 2005.

[4] Zelek J.S., "Seeing by touch (haptics) for wayfindings", International Congress Series, vol. 1282, pp. 1108-1112, 2005.

[5] Dolsma J.M., "Obstacle detection in blind zone of ultrasonic sensors", Traineeship report, Technische Universiteit Eindhoven, Eindhoven, 2006.

[6] Ju, J.S., Ko, E. and Kim, E.Y., "EYECane: Navigating with camera embedded white cane for visually impaired person", ASSETS'09, pp. 237-238, Pittsburgh, Pennsylvania, USA, DOI: 10.1145/1639642.1639693, October 25-28, 2009.

[7] Pallejà T., Tresanchez M., Teixidó M., Palacin J., "Bioinspired Electronic White Cane Implementation Based on a LIDAR, a Tri-Axial Accelerometer and a Tactile Belt", Sensors 2010, 10, 11322-11339; doi:10.3390/s101211322, 2010.

[8] Velázquez R., "Wearable Assistive Devices for the Blind", Chapter 17 in A. Lay-Ekuakille & S.C. Mukhopadhyay (Eds.), Wearable and Autonomous Biomedical Devices and Systems for Smart Environment: Issues and Characterization, LNEE 75, Springer, pp. 331-349, 2010.

[9] Kammoun S., Parseihian G., Gutierrez O., Brilhault A., Serpa A., Raynal M., Oriola B., Macé M.J-M, Auvray M., Denis M., Thorpe S.J., Truillet P., Katz B.F.G., Jouffrais C., "Navigation and space perception assistance for the visually impaired: The NAVIG Project", IRBM. vol. 33, no. 2, pp. 182–189, 2012.

[10] Lewald J., "Exceptional ability of blind humans to hear sound motion: Implications for the emergence of auditory space", Neuropsychologia, dx.doi.org/10.1016/j.neuropsychologia.2012.11.017,2012.