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RESEARCH ARTICLE

OBSTACLE DETECTION DEVICE FOR PHYSICALLY CHALLENGED PEOPLE

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ABSTRACT

In last few decades there has been a rapid increase in research work in the field of wearable devices for the physically challenged people. However the research work being carried out is still in the preliminary stage and the wearable devices are just coming into existence and beginning to display some future potential. Hence there are not many wearable devices available which can substantially benefit the physically challenged person in improving the lifestyle. In this study we have attempted to propose a design of a wearable travelling aid for a person who is blind as well as deaf. The wearable is an electronic device in which Infrared sensors (IR) are deployed to detect obstacles which are in close proximity to the user. Furthermore, on detecting the obstacle, the wearable device warns the user with the help of haptic sensor. The wearable device is hands-free and easy to operate and with the use of the IR sensor it is easy to detect the obstacle as it is a sharp detector and also covers the significant range of distance.

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INTRODUCTION

The survey conducted by World Health Organization (WHO) (http://www.who.int/mediacentre/factsheets/fs282/en/) reveals that approximately 285 million people are visually impaired worldwide: 39 million are blind and 246 million have low vision. Of these 39 million blind people across the globe, over 12 million are from India. Furthermore 82% of the visually impaired worldwide are aged 50 and above. The main reason behind the moderate and severe visual impairment globally is due to uncorrected refractive errors; cataracts remain the leading cause of blindness in middle and low economic countries. Studies suggest that approximately 80% of all visual impairment can be prevented or restored with the help of some minor or major medical aid. Among this visually impaired population, there are a large number of people who are suffering from deaf-blind condition. In another study in the year 2010, the Centre for Disability Research (CeDR) produced a report (https://www.sense.org.uk/content/how-many-people-who-are-deafblind-are-there) commissioned by Sense that estimated that there are approximately 358,000 people with sight and hearing loss in the UK. This estimate is in correspondence to a number of research projects undertaken in the last 20 years. A blind person fails in dealing with many of the daily activities as he is devoid of a substantial communication and interaction with their surroundings. A visually impaired person thus requires help from another sighted guide or dogs that are trained to give aid to the blind. Thus visually impaired needs to appoint a person who is willing to assist him or get a trained guide dog. Researchers found that both these methods proved significantly helpful in restoring the mobility and communication of the deprived person. The blind person can hear the instructions from the assistant or bark of his guide dog and follow accordingly to navigate from one place to another, but the deaf-blind person is dependent only upon the touch of his guide for communication. Since most of the visually impaired belongs to the underdeveloped or developing nations, it is difficult for the deprived person to bear the expenses of the maintenance of his guide. These methods are neither cost effective nor efficient, so scientists have been actively working in overcoming these drawbacks. Scientists are doing research on various electronic wearable devices which can help the visually impaired in the communication. The blind persons are deprived of their visual senses, so the navigation aids need to provide them a feedback either via auditory senses or tactile means. In case of the deaf-blind person, the feedback has to be in the form of tactile means for their better communication. The design of the device we have proposed consists of Infrared Sensors (IR sensor) for constantly observing the surrounding environment and sending tactile (vibration) feedback to the user regarding the position of the closest obstacle in range. This paper describes the

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architecture and discusses the potential benefits of the system we have designed. One of the main contributions is the use of Infrared sensor along with the haptic sensor (vibrators) in the architecture of our system to give the information and feedback respectively about the obstacles which is in the range of the user. The device is significantly useful for the person having a deaf-blind condition.

1.Related Work

Plenty of research work has been accomplished to improve mobility and provide individualism to visually impaired people, specifically to strengthen their ability to explore the surrounding environment. Various wearable devices have been designed based on new technologies such as laser, sonar or stereo camera vision for sensing the environment and using audio or tactile stimuli for the feedback to the user (Strothotte and Fritz, 1996). One such system can be exhibited by the C-5 Laser Cane (Benjamin and Ali, 1973). This device is based on optical triangulation which detects obstacles up to a range of 3.5m ahead. The device scans the environment in proximity to the user and provides information on one of the nearest obstacle at a time by means of acoustic feedback. The most advanced development was done using stereoscopic cameras coupled with a laser pointer and audio system has been developed at the University of Verona (Panuccio, 2002). The device raised the interest of the scientists since it consists of the translation of the 3D visual information into relevant stereoscopic audio stimuli. The sound generated on ear phones is in accordance to the position of the obstacle. As a Camera vision based system, it can recover more information than only distance to the obstacle. The problem with this device is there is a constant requirement of huge computation power and their sensitivities to light exposition.

The other recent project, CyARM (Ito *et al*., 2005), is also based on low cost wearable devices but it uses ultrasonic transducers to detect and analyze the distance of the nearest obstacle. This information is provided to the user through variation of tension of the fixation wire attached to the belt. Higher tension means the proximity of the obstacle. However the major drawback of this device is, it is still not hands free and needs the user to constantly move the device to sense the environment. Nowadays, some of the new commercial devices appear on the market, like the UltraCane (UltracaneTM, www.soundforesight.co.uk) which uses a built-in sonar system and sends feedback in the form of vibrations through the handle. The ultra cane improved the traditional white cane by giving information about the obstacles before direct contact. But it doesn't provide any new functionality to the traditional cane and still the localization is done by movement of the cane and it doesn't detect objects at head height. It is important for a usable electronic travel aid to let the user hand free in order to allow the use of traditional navigation tools. By letting the user hand free, the whole system has to be embedded in the clothes. Wearable constraint implies that all the system and computing power has to be implemented into small electronic system powered by battery. The system has to be low electrical consumer in order to be usable for several hours in a row. Small sized, low power consumer in energy and computation, Infrared sensor based system seems to fit perfectly our needs for the application. By using vibro-tactile feedback the device will be helpful for the deaf-blind person as well. The next part will describe the design of the system based on Infrared sensors and Haptic sensors.

System Architecture

Schematic Design

The system architecture is exhibited by the schematic design where the components of the device are attached to a jacket. This wear cloth is easy to carry and thus keep the users' hands free to perform other day to day activities. Following are the components being integrated: three Infrared sensors, a microcontroller, and three vibrators. The two sensors are fixed on the shoulders and one is fixed on the front side of the jacket to increase the field of sensing and side determination.

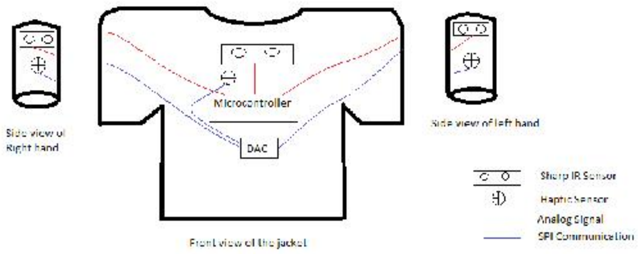

Figure 1. Schematic design of the System Architecture

Infrared Sensor

The Sharp IR sensor (http://education.rec.ri.cmu.edu/content/electronics/boe/ir_sensor/4.html) is used to detect the distance of the nearby object. The Sharp sensor has a special detector that not only determines light, but can also measure the distance of an object and returns an analog voltage that can be used to determine the closeness of the nearest object. These sensors are good for detection between 100cm-500cm (1-5 meters / 3-15 feet). The long range makes them a good alternative to a sonar sensor.

Figure 2. Sharp Infrared Sensor

The detector in the Sharp IR sensor is similar to the imaging sensor found in digital cameras. Since the detector and the IR LED have a fixed distance and orientation relative to each other, the distance of an object will affect the angle at which the light from the IR LED hits the receiver. By looking at where the light hits the detector, it is possible to calculate the angle of the light and from that angle derive the distance to the object (all of which is done by the sensor itself). Further, this sensor is inexpensive, has low power consumption, fit in small space and has a unique range that is suitable for this wearable device.

Microcontroller

The microcontroller gathers the information from the Sharp Infrared sensor in the form of analog signal. Since, the output of the IR sensor being used is analog in nature and these analog signals cannot be processed directly by the ATmega 16 microcontroller (http://education.rec.ri.cmu.edu/content/electronics/boe/ir_sensor/4.html). So, first this signal needs to be converted to digital value to be processed by the microcontroller. The conversion can be done with the help of ADC of the AVR ATmega16 microcontroller. After converting the analog signal to digital, the microcontroller will display the digital value in the 1×8 LED array. But the LED array can display only 8-bit at a time. So, the 1×8 LED array will first display the lower 8-bit and then the upper 2-bit of the 10-bit digital output with a delay of 500ms.

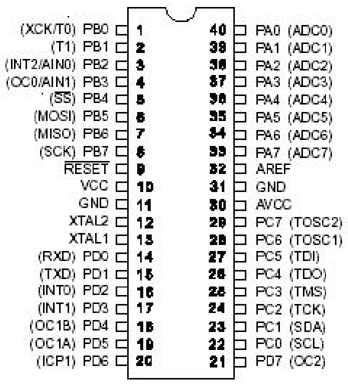

Figure 3. Schematic representation of ATmega16 microcontroller

Once the distance of the obstacle is being estimated, a corresponding feedback is send to the user. This distance is then converted into a voltage command for appropriate vibrating feedback and the direction is given by comparison of the signal from all the sensors. The vibrating feedback has been sent in such a way that closer the object, higher is the vibrating feedback. The system redirects the information to the haptic sensor via Serial Peripheral Interface (SPI) (https://learn.sparkfun.com/tutorials/serial-peripheral-interface-spi). A multi-channels Digital Analog Converter (DAC) recovers 2 integers (address and data) and sends the desired output voltage to the appropriate vibrator.

Haptic Sensor

The eccentric rotating mass (ERM) (https://blog.somaticlabs.io/how-devices-provide-haptic-feedback) motor is similar to a regular DC motor: it uses the magnetic field of a direct electrical current to move an object in a circle. Due to the uneven centripetal force produced by the rotation of the mass, the entire motor will move back and forth to produce a vibration from side to side (lateral vibration). Since the motor can be driven using a DC current, a simple switching circuit can turn the motor on or off as needed.

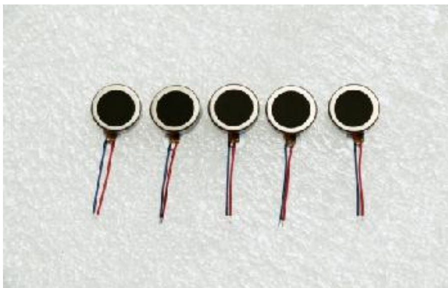

Figure 4. Eccentric rotating mass motor

As applications utilizing ERM motors require more precise feedback, the driver circuit for the motor may be modified to provide more precise control over the strength of vibration produced by the motor. Instead of a Pulse-width modulated (PWM) signal provided to a transistor, a higher or lower voltage within the specified range of the motor will more precisely change the speed of its rotation, thus changing the frequency and amplitude of the vibration that is produced.

Battery

The 9-volt battery was introduced for the early transistor radios. It has a rectangular prism shape with rounded edges and a polarized snap connector at the top. This type is commonly used in walkie-talkies, clocks and smoke detectors. The battery has both terminals in a snap connector on one end. The positive of the battery is the smaller circular (male) terminal, and the negative one is the larger hexagonal or octagonal (female) terminal. The connectors on the battery are the same as on the connector itself; the smaller one connects to the larger one and vice versa.

RESULTS AND CONCLUSION

The proposed design is the theoretical model and the practical implementation of the design is under way. With the help of the proposed design we can suggest that the wearable device can cover a wide range of the area surrounding the user. Further it which helps in detecting the obstacle more accurately. On detecting the obstacle, the wearable device will send the feedback to the user in form of vibrations. If the user feels the vibration on his right shoulder, it means the obstacle is present on the right side whereas if the vibration is felt on the left shoulder, the obstacle is on the left side if the user. The user will feel the vibrations on the chest when the obstacle is in the front of the user. As the sensors are placed on the shoulder height, it is easy to detect the object that are at shoulder height but the obstacle which are on the floor are difficult to detect as it might not be covered in the range of the sensor. Thus by keeping in mind about this scenario, the user can analyze the objects which are on the floor. Similarly, the user can detect the moving objects, as the feedback from such objects will change dynamically. By this the user can detect the speed and the distance of the object. The wearable device can turned out to be significantly helpful for those who are visually impaired and also deaf as the user will not need any further assistance since the feedback from the device are in the form of vibrations which can helpful in guiding the user in navigating from one place to another. The only difficulty which the user may face is while analyzing the objects which are small and are placed on the floor which cannot be detected by the sensors.

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UltracaneTM, www.soundforesight.co.uk

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