SMART NAVIGATION SYSTEM FOR VISUALLY CHALLENGED PEOPLE

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Abstract— Visually Impaired persons requires continuous assistance of other people for their mobility which makes them largely dependent on others for their social life. Traditional Guide tools were available such as white canes and guide dogs; both are limited and have many disadvantages. With the advancement in technology, Electronic Navigational aids were developed for the benefit of visually impaired, extensive research has been done on various types of navigational devices using different methods and technologies, such as GPS, Computer vision, ultrasonic[US] etc. GPS based Navigation devices are very costly and cannot be used in rural and sub-urban areas. The computer vision aids are bulky due to the usage of computers. This paper explains the obstacle avoiding technique using Ultrasonic sensor based spectacles, waist belt and shoes, which makes use of two, three and four US sensors respectively to detect ground, waist level and head height obstacles. The proposed system can also detect pits in the ground and also in downstairs, The obstacle present in the path of visually impaired is informed through pre-recorded audio messages.

Keywords— Electronic Navigational tools, Ultrasonic, Obstacles.

I. INTRODUCTION

Blind and visually impaired persons always depend upon others for their locomotion. Eyes are prime sense organ in perceiving the outside environment; dysfunction of such prime sense organ severely effects the knowledge perceiving capability of the outside environment. Travelling in such outside environment is a challenge because the blind cannot depend upon his own eyes [1].Traditional mobility aids include white canes and guide dogs, white canes is the most used, cheap, versatile guide tools used by the blind but, it can only detect nearby obstacles and it cannot detect head height obstacles [2]. Guide dogs was have the capability to inform about the head height obstacles, it can also detect cross walks, potential dangers, choosing right paths and many more however, guide dogs are costly, need to extensively trained and it cannot be used for more than 5 years [3].

Involvement of technology in the guide tools was started by building a navigation systems for blind and visually impaired. Different types of mobility aids using different technologies and methods were developed. Few of the key methods used was laser, GPS, computer vision infrared and SONAR.

Electronic canes using laser technology was developed. LaserCane[4], Telecat[5] and Minitact[6] are such laser canes. The laser based navigation devices cannot detect obstacles made of glass and also costs of these devices are very high.

GPS based Navigation devices were developed using GPS technology. These devices were able to detect obstacles but GPS based devices cannot detect obstacle which are very nearby [7] [8]. Hence, the visually impaired should depend upon other means for very near obstacles. The second important disadvantage is its cost factor. These devices are very costly and cannot be used in rural and sub-urban areas.

Vision based navigation systems are the systems which makes use of image processing technique. These systems makes use of cameras to capture the image, process it using algorithm and if obstacles are detected , the information about obstacles is informed to the individual by suitable audio or vibration. Some of the vision based navigation systems are vOICe [9], SVETA [10], NAVI [11]. In the vOICe, an image is being obtained by video camera and based on the characteristics of the image, sounds of different volumes are generated. In the SVETA, the matching of stereo is done on the converted images in order to calculate the dense disparities of the image. Sonification procedure is used to convert the disparities of image to its appropriate musical sound. In NAVI, an image is obtained, it is rescaled to the required length, separation of background and foreground is done, these images are converted into stereo sounds. Vision based navigation systems uses computer which makes the navigation system bulky.

Most of the commonly used electronic navigation aids are ultrasonic based aids [12]. NavBelt [13] is a waist belt which makes use of ultrasonic [US] sensors, computer and earphones for navigation but it was very bulky. NavBelt was updated to GuideCane [14]. GuideCane is an electronic cane which has wheels at the bottom, whenever an obstacle is detected, the GuideCane takes the other direction thereby avoiding the obstacle and guiding the visually impaired. The drawbacks are its small scanning area and failure in detection of waist and head height obstacles.

II. RELATED WORK

A sonar based waist belt which is used to avoid obstacle [15] was built using ultrasonic sensors,

microcontroller and DC motors. The information of obstacle detection is informed to the individual through vibrators. The drawbacks of system are its inability to detect immediate ground level obstacles and head height obstacles and the adverse effects caused by the output vibrations to the body.

A very simple, economical walk-in assistant for the blind [16] was proposed. In this system, a US sensor, a microcontroller and a alarm generator are connected to a spectacle. When an obstacle is detected, alarm is generated. The demerits of this system are, it cannot detect very near-by obstacles and near-by side obstacles.

A prototype rehabilitative shoe and spectacle [17] was developed. In this method, US sensors were connected to shoes and spectacles to detect ground obstacles and head height obstacles respectively. The US sensors in shoes also detect pits Such as stair cases. Obstacle detection is informed through vibration to the visually impaired, but this system does not provide warning to the impeding obstacle and guidance around obstacles.

A wireless warning device for upper body level [18] was developed. This system mainly focused on deaf-blind people. It contains spectacles with US sensor and vibrator with wrist band. The obstacles identified were informed through vibrations. Compared to other existing methods, this system was slow.

Ultrasonic spectacles and waist belt for visually impaired was developed. This system makes use of US sensors at spectacles and waist belt to detect head level and waist level obstacles respectively. The obstacle detection is informed to the blind through audio. The demerit of this system is that it cannot detect ground level obstacles.

III. PROPOSED METHOD

In this proposed method we use an embedded system which consists of HC-SR04 ultrasonic sensors, APR9600 audio recording and playback flash memory and a microcontroller. Two sensors are used at spectacles, three sensors are placed at waist belt with 12 cm distance from each other facing left, center and right direction. Two sensors are placed in each shoe, one facing the front and the other facing down. Fig. 1 shows the proposed system for visually impaired and blind navigation.

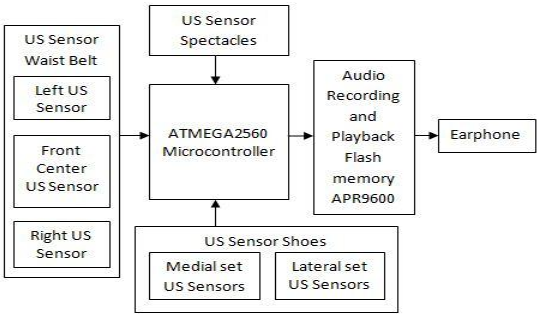

Fig. 1.Ultrasonic spectacles, shoes and waist belt system for visually impaired and blind person.

The US sensor spectacles detects the obstacles at head height, the US sensor waist belt detects the waist level obstacle and the US sensor shoes detects the obstacle at ground level and also pits in the ground as well as downward steps, with such an alignment of US sensors, we will be able to detect obstacles from head level to ground level and also pits in the ground along with the downward steps. These sensors collect data about the obstacles and pass it to microcontroller, the microcontroller processes the data and based on the data, the relevant speech is invoked, which was stored in flash memory.

The US sensor is a transducer, and is used in pair as transreceiver. The transmitter emits the US waves and if obstacles are present in the path, the US waves hits the obstacles and gets reflected back, the reflected wave is received by the receiver. The US sensor is a combination of one transmitter and receiver. The time interval between sending and receiving of the US signal is calculated, this time interval is used to calculate the distance between sensor and the obstacle.

The equation for the distance calculation between the sensor and the object is as follows:

$$D = (HPTW * SV)/2$$

Where,

D = Distance in cm.
HPTW = High time of pulse width.
SV = Sound velocity in cm/s.

The sensors which are placed in waist belt are in such a manner that the Ultrasonic pulses of sensors must not be overlapped one over the other. Sensors has a field of view (coverage) of about 60 degrees for 4 feet distance, as the distance from the sensor increases, the coverage angle decreases as shown in the fig. 2.

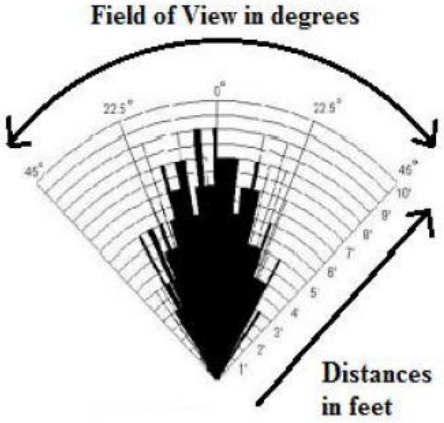

Fig. 2. Performance Test of HC-SR R04 showing the variation of the "angle of field of detection" with respect to "distance".

Each US sensor in waist belt covers 60 degrees, together three sensors covers the entire 180 degrees. Thereby the waist belt covers the entire front view of the waist level. The coverage of sensors is as shown in fig. 3.

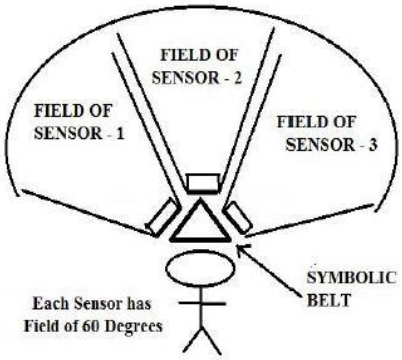

Fig. 3. Illustration of the Detection Field of the system

Each shoe are mounted with two US sensors placed at shoe toe. One at the lateral and the other at medial. The lateral set detects the ground obstacles and the medial set detects the pits in the ground as well as downwards steps.The US sensors mounted on the shoe is as shown in the Fig. 4.

The US spectacle is as shown in Fig. 5. The spectacle contains US sensors in each of its two lenses as shown in the below figure. Sensor communication with microcontroller is wireless via zigbee, The US spectacle detects the head height obstacles.

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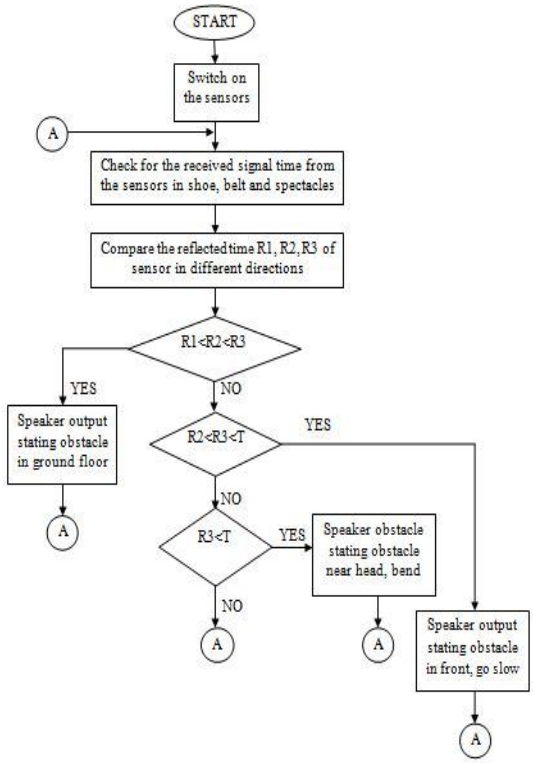
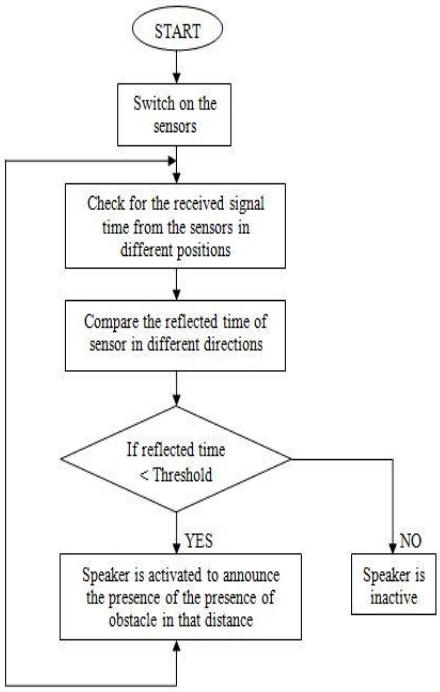
In our paper, we make use of audio recording and flash back memory APR9600. The flash memory has pre-recorded speech messages to convey the message of obstacle detection to the visually impaired. This flash memory is preferred over text to speech as pre-recorded speech can be in any language.

Main Flowchart:



Where,
R_1 is reflected time of the sensor in Shoe.
R_2 is reflected time of the sensor in Waist-Belt.
R_3 is reflected time of the sensor in Spectacles.
T is the threshold time.

Sub Flowchart:



CONCLUSIONS

The proposed system uses US sensor based spectacles, belt, and shoes to detect obstacles from head level to ground level and also to detect pits in ground as well as downwards steps, these three devices are light weight wearable devices ,which makes the system easy to carry. Also, the proposed system is low cost, which is a significant factor because 90 percent of the visually impaired in the world lead their life in low income [19]. This system improves the quality of visually impairer's life and reduces dependency on others for their social life. The walking speed of the new users of the system is less, after sufficient practice in short time, The visually impaired gains confidence and control over the system, the walking speed is increased.

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