Smart Walker for Visually Impaired People

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Abstract— Visual impairment is characterized by the decrease in functional abilities inducing an increase in dependencies. Many systems have been developed to help visually impaired people to gain their self-sufficiency during their activities of daily living. A new design concept is proposed which extends navigational assistance to visually impaired people for their independent movement. In this article, a new design concept is proposed to help visually impaired people. The system is made possible by the use of different sensors. Infrared sensors and ultrasonic sensor are able to detect obstacles in front of the walker and provides directional information about obstacle to the controller. In response system will trigger an audible notification to alert the visually impaired if there is an obstacle ahead. Accelerometer sensor made aware the visually impaired of potential fall by buzzer sound indication. Since many walkers available in the market are complex and requires training to use, proposed smart walker provides reliability with future expansion.

Key words: Visual Impairment (VI), Navigational Assistance, Sensors

I. Introduction

Several reports had said that more number of people from all over the world suffering from visual impairment. Visually impairment is worsening since decrease in visual abilities makes person dependable on others. Referring to this, assistance is required by humans or technological mediations. The framework of this mediation is to address the needs of visually impaired persons in terms of mobility. The consequences of this assistance measured in terms of improvement in the life of visually impaired people.

The objective of this article is to make visually impaired people independent on others in the unknown environment.

To fulfill this requirements walker is designed with the use of sensors as shown in "Figure 1". Sensors analyze environmental data and provide steering information to the visually impaired person by the use of audible notifications for movement in the correct direction and by means to avoid obstacles. The sensors, infrared and ultrasonic are used to detect obstacles. Infrared sensors are mounted on walker at some height from ground to detect lower height obstacles. Ultrasonic sensor is mounted on the motor and motor is fixed on the chassis of the walker to detect obstacle at higher height [1]. The motor covers semicircle region around the walker. Accelerometer sensor is used to detect the potential fall. It uses the phenomenon of the acceleration to detect the potential fall. Controller gets directional data from all sensors and converts it into audible notifications and sends this information to visually impaired person via audible notification module.

The objective of this research is to develop a technological mediation to help visually impaired person for improving the mobility in unknown environment.

Although there are several walkers present in the world, this proposed smart walker introduces new hardware guidance that support visually impaired person in any complex environment.

II. Related Work

According to the need of visually impaired people many products are developed to assist them in unknown environment. Such as Walking Aid [2] the walker is suitable for stability and good balance purpose. It has 4 legs design with more beneficiaries in weight. It can handle more weight of person. The revised version of walking aid is provided with electric motor [3] to move further. Since motor creating vibrations the walker gets unstable due to this, this design is unsuccessful. Wearable Obstacle Avoidance Electronic Travel Aids for Blind: A Survey [4] presents a comparative survey among portable/wearable obstacle detection/ avoidance systems 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. A Smart Tactile for Visually Impaired people [5] proposes a new, cost efficient and simple system, which consists of two main elements: batons, and tagged paths to make traveling alone possible. Furthermore, the proposed system is available for IOS and Android mobile devices, and consists of two software applications, "InGuide" and "OutGuide", for indoor and outdoor environments respectively. Both of the applications use voice command interpreter algorithms to guide tactile users. A Navigation Aid for Blind People with Walking Disabilities [6] presents a smart walker that does not only provide walking assistance but also enables blind users with mobility impairment to avoid obstacles. By leveraging existing robotics technologies, our system detects both positive and negative obstacles such as curbs, staircases and holes in the ground and transmits obstacle proximity information through haptic feedback.

III. Proposed System

The proposed system approach meets the requirements of visually impaired persons. The aim of proposed system is to restore self-reliance in visually impaired people. Several sensors and electronic modules are mounted on the chassis of a smart walker.

The hardware architecture of the proposed smart walker is shown in "Figure 2".

The smart walker design integrates different modules onto one single system. Each module has different function such as

- Detection of obstacles
- Fall detection

– Notification alerts

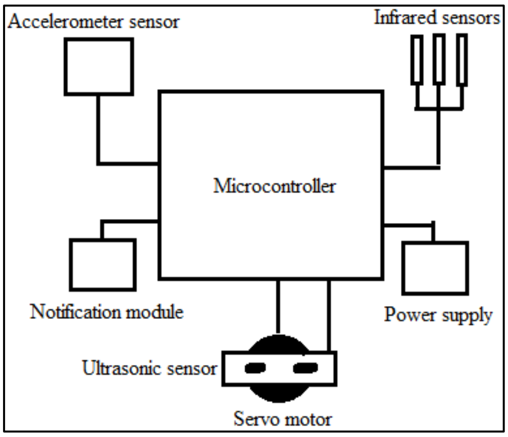

Fig. 2: Block diagram for smart walker

A. *Obstacle Detection*

Since the visually impaired person is at higher risk to run through obstacles despite his perception of the environment. In these cases, obstacle detection is very important. Low-height obstacles such as stairs are detected using infrared sensors. They are provided with emission and reception circuits for detecting the obstacles. These sensors detect reflected light from any type of surface which made them suitable for design of smart walker. The smart walker is furnished with three infrared sensors fixed on front side of the walker at proper distance above the ground [1]. Lower height obstacles are notified to system using interruption by infrared sensor.

Higher obstacles are detected using an ultrasonic sensor. The ultrasonic sensor constantly measures the distance between the walker and the obstacles. The use of this sensor is well suited for stationary and moving objects. It has a larger spectrum than the infrared sensor and wider area coverage. Despite the relatively large region left and right sides are not included nearby the walker. To solve this difficulty, the ultrasonic sensor is mounted on with servo motor. It is shown in “Figure 3”.

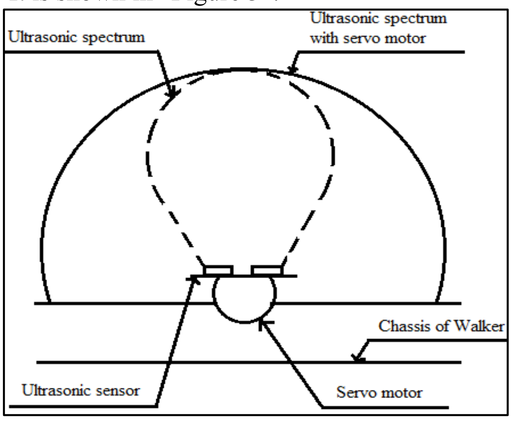

Fig. 3: Ultrasonic sensor obstacle detection scheme

The motor provides a surface area of a semicircle. The motor shaft moves from left to right. If an obstacle is present the servo motor stops and the visually impaired person is immediately notified to the position of the obstacle so that he can move in another direction.

B. *Fall Detection*

Despite of the obstacles detection provided by the sensors, there is still a risk of getting fall. The walker legs may reach an unstable ground leading to potential fall. Lower obstacle sensors are helpless during this situation. To overcome this difficulty, an accelerometer sensor is mounted on top edge of walker [1]. Before the conversion routine is taking place, the accelerometer must be calibrated. A common reference point is selected P(x, y, z) to start the reading of acceleration data. Angular values are processed and compared to threshold value P(x, y, z) for fall detection.

“Figure 4” illustrates the fall detection scheme. Angles A and B are the front and side angles measured in the XOZ and YOZ planes respectively. These angles are obtained using acceleration data provided by the sensor. It provides linear acceleration based on a fixed reference point. Angular interpretation of the linear acceleration required for comparison. Angular deviation can be easily derived from linear acceleration according to equation (1)

$$\text{Angle} = 7(\arcsin(0.1020\ Av)*180) / 22 \quad (1)$$

Where ‘Av’ is the acceleration collected from each axis (X, Y, Z). Angular data provided by the accelerometer alert about the potential fall.

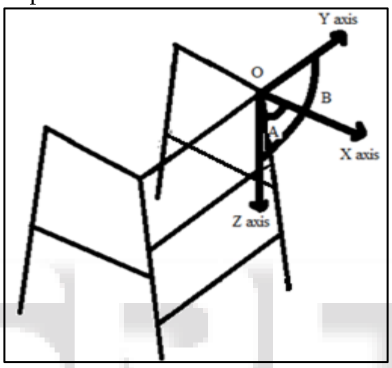

Fig. 4: Fall Detection Phenomenon

C. *Alerts and notification*

The visual impaired person is notified about obstacles as well as potential fall using audible messages. These messages are sent to the notification module via controller. These messages are audible signals suitable for visually impaired person. This module does not use prerecorded messages. It converts serial data into audio which makes it compatible with any type of controllers. Proper attention is kept to the repetition of the message to avoid flooding. Messages notify the orientation of the obstacle. These Messages are

– Lower obstacle present
– Higher obstacle present - at front or (on the left or right)

IV. WORKING ALGORITHM

A. *Potential fall phenomenon*

The acceleration value for each axis is defined first.

This default value is the reference value for analyzing potential fall. When person is moving in environment, acceleration for each axis is calibrated. It gives linear acceleration. We are interested in angular acceleration. It is calculated from linear acceleration by using equation (1) as defined above. This *Angle* value is compared with default acceleration value. If change occurs then then there is possibility of potential fall. If such condition occurs then person have to stop moving further. If no change occurs in value then same procedure is followed till such condition occurs. “Figure 5” illustrate proper algorithm for potential fall detection.

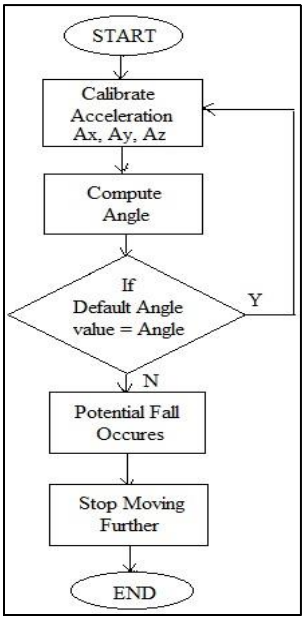

Fig. 5: Potential fall phenomenon

B. Obstacle Detection Phenomenon

In complex environment Infrared sensor is used for lower obstacle detection and Ultrasonic sensor is for higher obstacle detection purpose. Both sensors continuously started sensing for obstacle. IR sensor notifies to change direction if obstacle is present. The ultrasonic sensor is placed on servo motor to cover 180 degree rotational speed around the walker. If an obstacle is present the person is notified with the proper direction of the obstacle so that he/she can move to next direction. "Figure 6" will present the algorithm for obstacle detection.

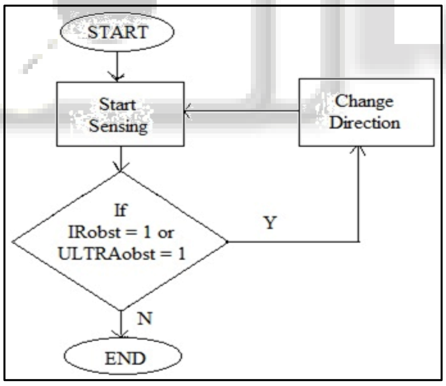

Fig.6 Obstacle detection phenomenon

V. CONCLUSION

The proposed smart walker will enable visually impaired people to navigate safely in unknown and complex environment. The walker will extend its reliability and effectiveness to provide more accurate guidance and real time functionalities to fulfill the requirements of an assisted living system for visually impaired people.

ACKNOWLEDGMENT

We thank to Head of Department, Electronics branch, Walchand Institute of Technology, Dr. S.R.Gengaje and PG Coordinator Prof. A.S.Gundale for providing help in our project work.

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