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Microcontroller based Navigation System for Visually Impaired People

Chaitali Kishor Lakde[1], Dr. Prakash S. Prasad[2]

P.G. Student, Department of Computer Technology, Priyadarshini College of Engineering, Nagpur, India[1]

Associate Professor and Head of Dept. of Computer Technology, Priyadarshini College of Engineering, Nagpur, India[2]

Abstract: Navigation assistance for visually impaired (NAVI) refers to systems that are capable to assist or guide people with vision loss, ranging from partially sighted to totally blind, by means of sound commands. Many researchers are working to assist visually impaired people in different ways like voice based assistance, ultrasonic based assistance, camera based assistance and in some advance way researchers are trying to give transplantation of real eyes with robotic eyes which can capable enough to plot the real image over patient retina using some biomedical technologies. In other way creating a fusion of sensing technology and voice based guidance system some of the products were developed which could give better result than individual technology by the use of microcontroller. There are some limitation in system like obstacle detection which could not see the object but detection the object and camera based system can't work properly in different light level so the proposed system is a fusion of color sensing sensor and the obstacle sensor along with the voice based assistance system. The main idea of the proposed system to make person aware of path he is walking and also the obstacle in the path.

Keywords: Navigation system; visually impaired; obstacle detection; mobility; microcontroller.

I. INTRODUCTION

Blindness is the condition of lacking visual observation due to neurological and physiological factors. For blind pedestrian secure mobility is one of the biggest challenges faced in their daily life. According to the World Health Organization (WHO) in 2012, out of 7 billion global population there were over 285 million visually impaired people and 39 million were totally blind out of which 19 million are children (below 15 years) and this number is growing at an alarming rate.[1] So, some navigation system is required to assist or guide this people. Many researches are being conducted to build navigation system for blind people. Most of these technologies have boundaries as its challenge involves accuracy, interoperability, usability, coverage which is not easy to overcome with current technology for both indoor and outdoor navigation. [2]

The proposed system mainly focuses on two components; sensing of the immediate surrounding environment against obstacle for the visually impaired person and warning about the obstacle by means of vibration along with voice feedback system.

II. LITERATURE REVIEW

Traditionally white cane is the most popular, simplest tool for detecting obstacles due to its low cost, portability. It enables user to effectively scan the area in front and detect obstacles on the ground like holes, steps, walls, uneven surfaces, downstairs etc .but it can only be used to detect obstacles up to knee-level. Its detection range is limited up to 1-2 feet only. Certain obstacles (e.g. protruding window panes, raised platforms, a moving vehicle, horizontal bars) cannot be detected till they are dangerously close to the person. Even dog guides are very capable to guide these persons but they are unable to detect potentially hazardous obstacles at head level. Guide dog service stage is on average 6 years and requires regular dog up-keeping expenditure and lifestyle changes. [3]

Several solutions have been proposed in the recent years to increase the mobility and safety of visually impaired persons.

A system "Roshni" determines the user's position in the building, navigation via audio messages by pressing keys on the mobile unit. It uses sonar technology to identify the position of user by mounting ultrasonic modules on ceiling at regular intervals.

This system is portable, easy to operate and is not affected by environmental changes. But this system is limited only for indoor navigation because it requires detailed interior map of the building. [4]

Another real-time technology developed to alert visually impaired user by the presence of static / dynamic obstacles in a few meters surrounding, which works without depending on any Smartphone, uses camera for background motion detection.

This system is robust to complex camera and background motion and does not required any prior knowledge about the obstacle size, shape or position. This camera based image processing system can be a better option but it requires lot processing power and hence system becomes bulky, costly and it must be transportable. [5]

Navigation system generally comprised either an indoor or outdoor positioning system or both, for detecting the position of consumer. Most of the outdoor navigation systems employ GPS for positioning. Unfortunately, GPS can only be used outside of buildings because the employed radio signals cannot penetrate solid walls.

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Outdoor navigation systems generally rely upon GPS; indoor systems rely upon different techniques for localizing the consumer, as GPS signals cannot be received indoors. Currently, indoor navigation systems always employ radio signal for positioning, which may suffer from the problem of signal impairments, such as multipath propagation and Radio Frequency interference.
A navigation system for blind pedestrian using RFID passive tags provides location markers. A mobile receiver provides navigation guidelines based on the code saved in each tag. This system overcomes the GPS navigation limits in indoor environment and does not need any power supply for location markers. On the counter side, the tags assignment cost could be high and generally tags are not easy to adjust for an outdoor, insensitive environment. [6]
GPS based technique is "Drishti" which can switch the system from an indoor to an outdoor environment and vice versa with a simple vocal command. To provide complete navigation system, authors extend indoor version of Drishti to the outdoor versions for blind pedestrians by adding only two ultrasonic transceivers that are smaller than a credit card and are tagged to the user's shoulder. System provides a real-time communication between user and the mobile client via the headphone in which user can ask for the path, obstacle prompts, and even his/her current location in familiar or unfamiliar surrounding also. Unfortunately, this system has two limitations. As only two beacons attached to the user's shoulder, so it becomes impossible to obtain the height data of the user. Used algorithm calculates the location of user in two dimensions assuming the average height of a person, which gives larger error if the user sits or lies down. Another limitation is that because of signals reflection or blocking by walls and furniture, there are some "dead spots" due to the bad faulty date reads. [7]

"Blind audio Guidance system" is based on embedded system, uses ultrasonic sensor for distance measurement, IR sensor for object detection and AVR sound system for audio instructions. The main functions of this system are environment recognition and path detection. Ultrasonic sensors receive visual information and this visual information is transformed into auditory information. To represent the information about the position of obstacles audio components of intensity, frequency, binaural phase difference are used. This signal transformation system reduces the training time required to use a white cane. However, only issue of this system is the difficulty to know one's location globally. [8]

The NavBelt is developed based on navigation and obstacle prevention technologies that are originally designed for mobile robots. This system consists of eight ultrasonic sensors worn on a user's waist like a belt, a portable computer on his/her backpack, and a stereophonic headphone. [9]
Vibration and voice operated navigation system developed using ultrasonic sensors to detect obstacles. Since visually impaired people are more sensitive in hearing and possesses strong perception than ordinary people. So this system gives alert through vibration and voice feedback. System works in indoor as well as outdoor navigation and focus on continuously sensing surround obstacles and alerting through vibration and voice feedback. Depending upon the distance between obstacle and user different intensity levels are provided to vibration motor to alert user's mobility. [2]

A navigation system designed for blind people using RGB-D sensor with range expansion. System uses a consumer RGB-D camera for range and visual information, which support range based floor segmentation. Cheaper RGB sensor supports in object detection and color sensing. User interface is given through audio instructions and sound map information.[10]

Ultrasonic navigation system enhances the independent mobility of visually impaired people. It consists of a portable device based on microcontroller with synthetic speech output and obstacle detection system using ultrasounds and vibrators. This device uses the principle of reflection of high frequency ultrasonic beam to detect obstacles in the path. [11]

A wearable jacket-type scheme is proposed in [12]. Sonar sensors and vibrators are attached on a jacket, and are used to let a consumer know the direction from which an obstacle is coming.

One more jacket-type scheme using an RGB-D camera with tactile devices [13] is proposed for real-time navigation with obstacle avoidance. The RGB-D camera generates depth data registered with RGB images, and traverse ability maps are provided to indicate free and occupied (obstacle) spaces. Instructions such as "Go straight" and "Turn right" are given to a consumer via four micro vibration motors on a jacket.

A talking assistance type location finding system proposed for both indoor and outdoor navigation. System consists of walking stick having GSM module to send message to authorized person at the time of tragedy, sonar sensors and RF transmitter and receiver. For indoor localization RFID and for outdoor localization GPS system is used. Thus, this GPS system used in walking cane reduces the cost of installing many RFID tags in outdoor to identify the place. [14]

Motivations of proposed system:

- White cane requires the user to actively scan the small area ahead of him/her.
- Secondly, **c**amera based system using image processing can be better option but it requires lot processing power and hence system will become bulky and it must be portable
- A single system which can guide blind pedestrians by both voice feedback and vibration alert.
- A system helps user to identify the surface on which he/she is walking.
- To design and implement an affordable user-enabled system for convenient indoor navigation at affordable prices.

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III. PROPOSED SYSTEM

Proposed system is mainly aiming at novel approach towards designing and developing a shoes and portable audio playing device in order to assist blind person to move on different surface and in different path. By the means of creating fusion between visual sensing technologies, object finding technology and the voice guidance technology. This system consists of

- Design and developing a shoe having multiple depth, obstacle detection and RGB sensor.
- Design a control board to detect multiple level of obstacle and the ground object.
- Develop sound recording and playing module for voice assistance.

Fig. shows the proposed system architecture which state following units.

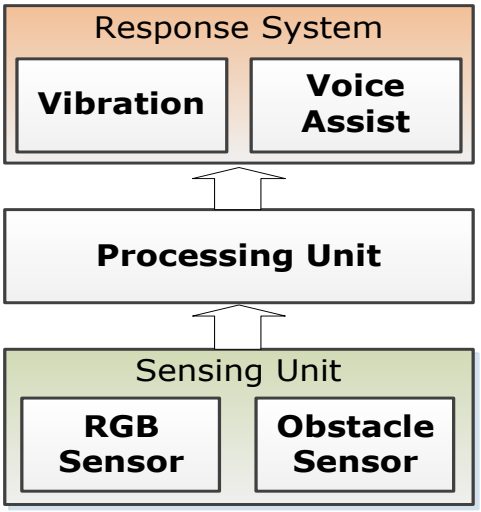

Fig:1. System architecture

A. Sensing Unit

OBSTACLE SENSOR:

The basic concept of IR(infrared) obstacle detection is to transmit the IR signal(radiation) in a direction and a signal is received at the IR receiver(photodiode) when the IR radiation bounces back from a surface of the object. Sensing unit IR based system can be used to detect the obstacle in particular direction even the distance of the object.

Proposed system consists of number of IR sensors to alert visually impaired person from obstacles in path. These IR sensors are connected on shoes at its front, left and right side to accurately detect the position of obstacle.

There are different obstacle sensors available in market like sonar sensor, ultrasonic sensor and IR sensor. But proposed system uses IR sensor as IR sensors are highly directional and cheaper compared to others. So it can easily differentiate the direction of obstacle.

RGB SENSOR:

RGB sensor is used to detect obstacles depending upon its red, green and blue color level intensities of detected obstacle. RGB sensor is used to detect the red, green, blue color level from reflected light at the boundary of obstacle. This sensor will be connected on shoes at front facing toward ground. The output of RGB sensor in the form of 3 different values of color intensities is given to microcontroller.

PROCESSING UNIT:

Processing unit consist of ardino microcontroller, power supply and voice to sound conversion IC. Processing unit collect all the information from sensing unit and accordingly send signals to response unit to alert blind user.

Depending upon this red, green and blue intensity values microcontroller decides whether the detected object is grass or road or indoor tiles.

A program has been developed that control the microcontroller to work in different situations required for the navigation system. The system utilizes a switch for turning on or off the system.

Processing unit consist of arduno microcontroller takes decisions depending on the pattern matching. It collects sensed input data from RGB sensor (in the form of red, green and blue intensity values) and IR sensor.

RESPONSE SYSTEM:

Since visually impaired people are more efficient in hearing and possesses strong sensitivity than ordinary people, therefore the proposed system focused on alerting the user through vibration and voice response.

VIBRATION ASSISTANCE:

For visually impaired users having less hearing capacity, vibration alert is a perfect indicator. It is used to alert the user depending on present surrounding. When object detects microcontroller gives alert through vibration assist unit which is a wearable device at hand of user as hand is sensitive body part. Depending upon the distance of obstacle, intensity of vibration varies. It vibrates at its highest intensity if the distance of obstacle is less. Its vibration intensity minimizes along with the increasing obstacle distance up to certain range.

VOICE ASSIST:

Voice assistance unit consist of a voice to sound conversion IC and a headphone. APR 9301 is a single chip voice recorder and playback device for 20 to 30 seconds voice recording and play back. This IC has data storage capacity and requires no software and provides high quality voice recording and play back up to 30 seconds. It has 100 year message retention capacity.

This IC stores some navigation assistance messages through recording mode and depending upon response of microcontroller it gives vocal guidance through ear phone. Ear phone is directly connected to voice recording IC. Through which user will receive navigation supporting messages in the audio form. If RGB sensor detects green color then microcontroller gives command to IC to alert through headphone as “you are walking on grass”. Accordingly it will produce guidance for road and indoor

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tiles. If obstacle detects at right side of user then through headphone guidance messages will produce as "obstacle right" and so on.

TABLE I: VOICE FEEDBACK AT DIFFERENT SITUATIONS

DIRECTION OF OBSTACLE RESPECT TO THE POSITION OF USER	ANNOUNCEMENT IN THE HEADPHONE
RIGHT FRONT	RIGHT OBSTACLE
LEFT	LEFT SIDE OBSTACLE
RIGHT	RIGHT SIDE OBSTACLE

TABLE II. VOICE FEEDBACK AT DIFFERENT TERRAINS

If event occurs	Different Announcement in the headphone depending on RGB sensor	Announcement in the headphone
Left front IR sensor detects obstacle	green	He is moving on grass or carpet
Left front IR sensor detects obstacle	black	He is walking on road
Left front IR sensor detects obstacle	white	He is on zebra crossing or indoor stile

IR sensor can detect the obstacle but it cannot detect color and type of obstacle. RGB sensor can detect color only, but it cannot detect range and distance up to obstacle. So, proposed system consist of fusion of both IR and RGB sensors. Proposed system is based on visual and range information. Instead of using several sensors, it uses a consumer RGB sensor, and takes advantages of both range and visual information.

IV. RESEARCH METHODOLOGY

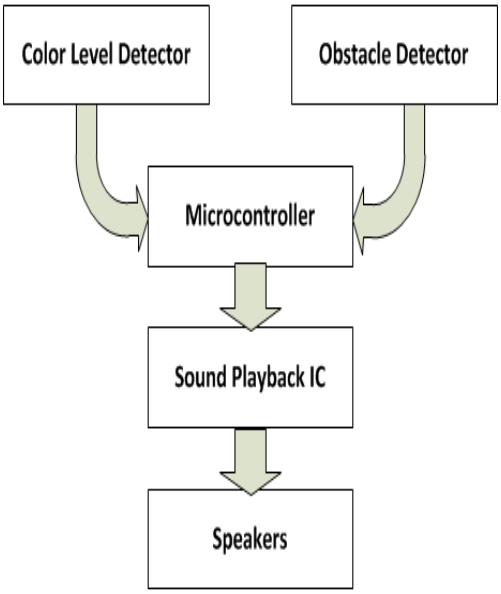

Fig:2. flow chart

Flow chart and its explanation

In the proposed system, IR sensor as an obstacle detector and RGB sensor as a color level detector both working as input device. This sensed input data is collected by microprocessor and according to developed algorithm (in embedded C) it gives comments to vibration assist and voice assist to alert blind pedestrian. Test to sound conversion IC has maximum 32 different messages storage capacity. IC in its record mode records different possible alert messages while developing and according to immediate environment it plays appropriate message to guide user through speakers.

RGB sensor makes it possible to assist user about flour on which he/she is walking. This will be definitely useful for visually impaired person. If user listens green then he/she is assume as walking on grass he/she will feels save to move. But if user listens that he/she is on road then user will be more alert and conscious at his/her every step. Most of other navigation system for blind fails to detect

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obstacle at head levels as protruding window panes, a moving vehicle, raised platforms, and horizontal bars etc.
"Navigation System for Visually Impaired Person" Proposed system solves this problem by adding one more IR sensor at cap of user which will be useful for detecting head level obstacles easily. As visually impaired persons are more efficient in sensing vibrations which will useful in giving warning signals. Proposed system has capacity to alert user at different terrain like grass, road, zebra crossing etc by giving specific message though headphones as soon as it senses any obstacle by left front shoe.

V. REQUIREMENT ANALYSIS

- **Hardware**
  - AVR 8/16 development board
  - RGB sensors
  - IR sensors
  - Headphone
  - Voice Recording IC
  - Power supply
  - Vibrator
  - Wearable devices
- **Development Tools**
  - Embedded 'C'

VI. CONCLUSION

In this proposed system more attention is paid to sensor fusion which has been attained by the use of microcontroller, seamless switch between indoor and outdoor navigation, route announcement, minimizing the amount of infrastructure argument that is required for localizing the user.

So, the overall aim is to construct and design a portable, simple, less costly device that will help visually impaired people to move in unfamiliar environment also. Proposed system is designed considering usefulness of all ages, user friendliness and does not need pre training and knowledge of advanced technologies.

The primary objective of this system is to design a cost effective and easier to handle even for a visually impaired illiterate person. This system is efficient than previous ones and is more adaptive as well as more accurate.

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BIOGRAPHIES

Chaitali Kishor Lakde received undergraduate degree in electronics engineering in 2013. She has presented a paper in national conference and published a paper in international journal. She is currently student of M.E. in wireless communication and computing branch at Priyadarshini college of Engineering, Nagpur.

Dr. Prakash S. Prasad obtained Ph.D. degree in Computer Science & Engineering. He has published more than 16 papers in National and International Conferences. He is Member of IEEE, ISTE and IACSIT. He has completed his bachelor 's degree in 1997 and Masters Degree in 2007. He is currently working as Associate Professor at Priyadarshini college of Engineering and Head of The Department of Computer Technology. He is having 16 Years of Teaching experience and his interests include network security, Operating System and System Software.