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Experimental study on shoe based navigation system for the visually impaired

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ABSTRACT

World Health Organization statistics show that 37 million individuals in world are affected by blindness. People with partial as well as complete visual impairment are usually dependent on some other people, dogs or stick to travel outdoor. It leads to damaging their self-esteem. With current technological advancement, it is essential for providing people with visually impairment a tool that can help them travel independently in the surrounding. A shoe based navigation system is developed for the visually impaired where an individual can be assisted to travel around freely in the surrounding. It aids the person to avoid obstacles when travelling alone. As the navigation system is fitted in the individual's shoes, it helps the person to move freely. Moreover, an ultrasonic sensor and an infrared sensor are used to find the range of obstacle and reduce the prediction of number of false positives respectively. This data is in turn given to the ARM cortex M3 microcontroller which determines if an obstacle is present or not. A force sensitive resistor (FSR) is used to optimize the system efficiency. Cloud computing concept is also incorporated so that the data can be accessed anywhere.

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1. Introduction

Visually impaired find it very difficult to carry on their routine work without vision. This increases their dependency on external person or objects in order to lead their day to day life. An obstacle detection system is developed which gives an interaction with different parts such as tangible vibratory sensor, speech analyzer and an alarm which is used to alert the individual of any obstacle [1]. Electronic bracelets are developed to detect the obstacles of the visually impaired. These devices are used to detect obstacles using ultrasonic sensors within waist or chest level [2]. Some systems are developed for obstacle detection where several sensors and alarms are used [3]. In few other systems, alarms are used in forms of vibrations or pre-recorded messages to detect the obstacles. For such cases, optical sensors and ultrasonic sensors are used for implementation of such systems [4].

Optical sensors are costly and cannot be afforded for economic devices, as a result, infrared sensors are used for smart stick which are used to detect the obstacle [5]. Stereoscopic sonar sensor is used by system to develop a mobile ultrasonic navigation device which will detect obstacle and transmit a vibro-tactile feedback to the individual detecting the location of obstacle [6]. Another system is developed which gives the urban routes for walking to the user and also suggests the direction the user has to take. Ultrasonic sensors are inbuilt in a stick to find the obstacle and an alarm gets activated when obstacle is found [7]. Another system is developed where RFID tags and a Global Positioning system is inbuilt in a walking stick to help individuals travel indoor or outdoor separately [8].

Moreover, these sticks can be developed along with wireless remote-control system so that even when the stick is lost, it can be found [9]. A navigation system is been developed with GSM and GPS application so that the obstacle is detected, moreover the location of user will be sent through SMS to the user's caretaker [10]. Another navigation assisting stick is implemented where obstacles can be detected in different sides. Moreover, pits and manholes present in ground can also be detected [11]. Requirements and needs for navigation assistance of each person will vary based on various factors. This study has encouraged developing a navigation system based on individual needs so that each visually impaired will be engaged with minimum distraction while travel-

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ling [12]. Independent indoor mobility is an important requisite of a visually impaired to smoothly run his day to day life. This facility is proposed based on Deep Convolutional Neural Network (DCNN) model and obtained 100% performance accuracy precision [13]. Visually impaired have difficulty recognizing text and signs which caused difficulty in finding places, travelling and mingling with people. Object detection network and Optical character recognition (OCR) instrument are used to develop system to identify text while navigating [14].

From the above given study, it can be inferred that various tools have been developed for assisting visually impaired to navigate independently and safely indoor and outdoor. But most of the conventional tools have some limitations and not adaptable in cloud environment. This has motivated us to develop a navigation system which is more accurate, simple and can be used in a cloud environment.

2. Basic system design

In this paper, a shoe based obstacle detection system for people with disorder in visibility is developed as shown in Fig. 1. The main objective behind the system is to assist the individual when some obstacle is present in the path. The presence of the obstacle is intimated using a buzzer. Also the location of the individual can be broadcasted using cloud. As the system is fitted in shoes of the individual, its easy to use, compact and less clumsy as compared to a stick.

ARM cortex M3 LPC1768 is the microcontroller used for the system. Instruction set adapted by the system is thumb-2. Other components used by the system are:

- A flash memory of 512 KB
- 64 KB data memory
- A processor frequency of 100 Hz
- 13 General Purpose Input-Output (GPIO) registers
- 6 Pulse Width Modulation (PWM) pins
- 8 channel 12-bit analog to digital converter (ADC).

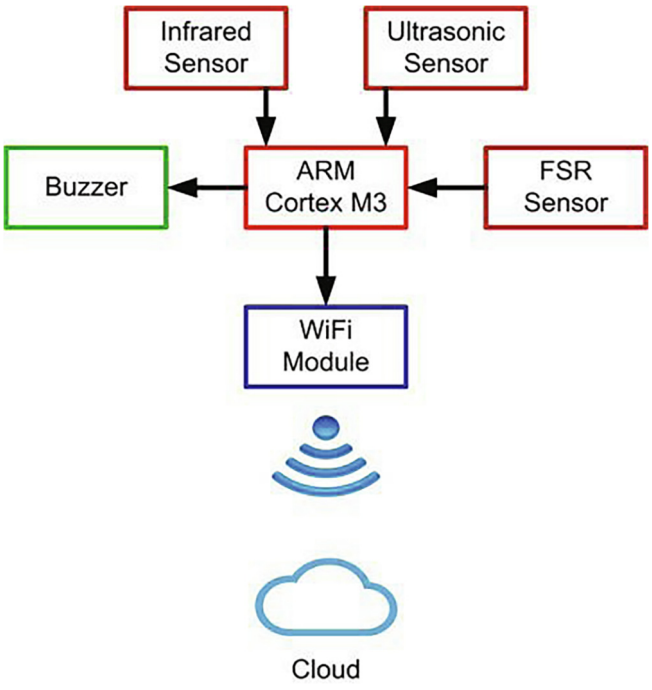

Fig. 1. Shoe Based Navigation System for Visually Impaired.

Distance is analysed by the using the ultrasonic sensor. Moreover, the system reduces the amount of false positive which are found using the infrared sensor. Force Sensitive Resistor (FSR) is used to monitor whether the system is working or not based on the force given on it. As soon as some pressure is built, ultrasonic sensor and infrared sensor are activated. In the same way, when no pressure is there, the system goes to a sleep mode. As a result, the efficiency can be increased. ESP8226 is the Wi-Fi module used in the system which is used for transmission of distance to cloud.

3. System components

3.1. Force sensitive resistor sensor

The system is developed by keeping the FSR sensor in the lower part of the shoes. This helps it to get activated when pressure is present on it which means that when a person wears the shoes. This operation is performed by the piezoelectric part present in the sensor. As a result the system will be activated only when the person wears the shoes and stands, thus resulting in more efficiency as compared to other systems where either the user has to manually switch on or off the system, or the system is continu-

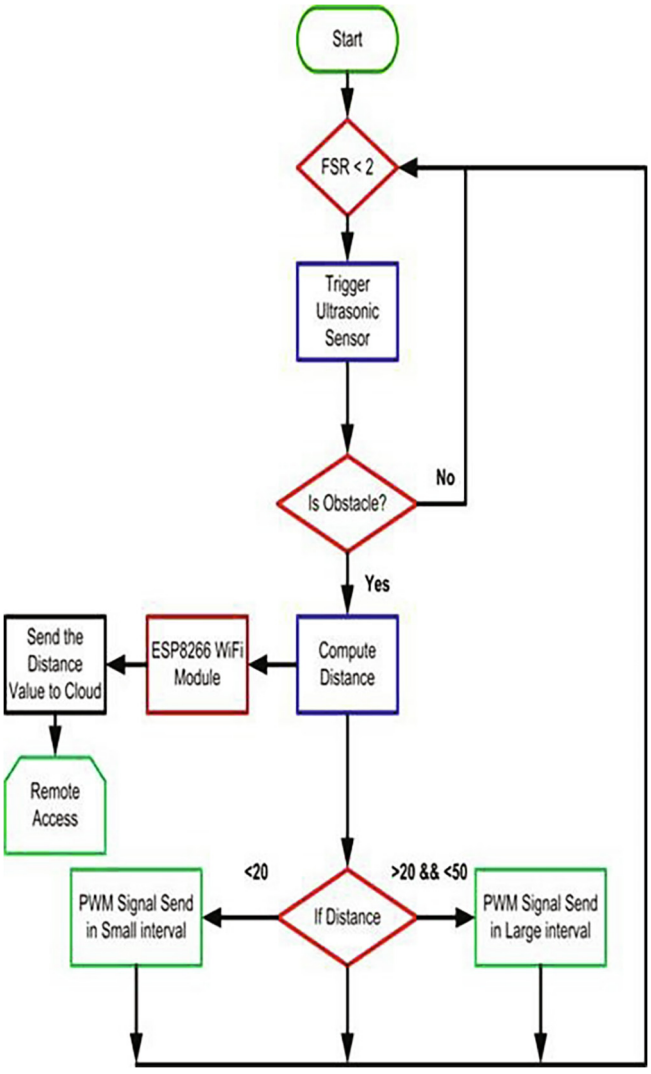

Fig. 2. Decision making flow chart.

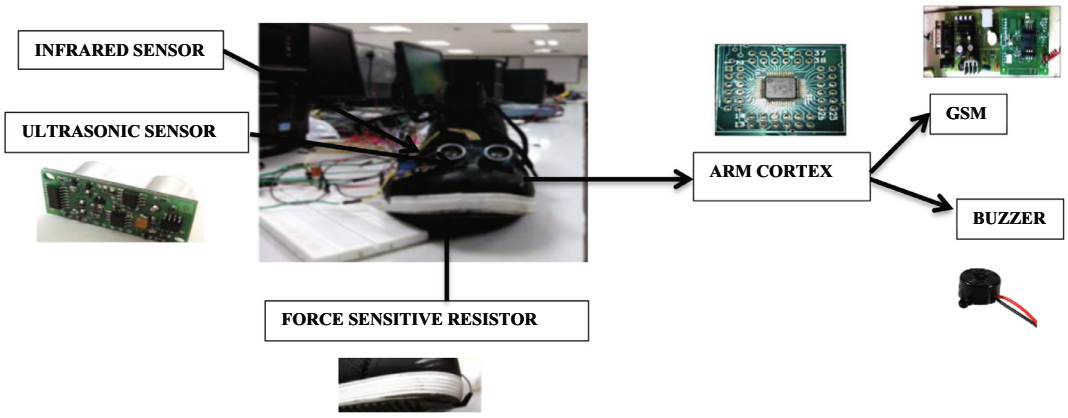

Fig. 3. Device Prototype front view and Prototype- FSR attached at the bottom of the shoe.

ously active. The Decision making flowchart and Device prototype are represented by (Figs. 2 and 3).

3.2. Obstacle detection and distance calculation

The system uses 2 sensors to detect the obstacles namely the infrared sensors and the ultrasonic sensor. Ultrasonic sensor calculates the distance of the obstacle and gives to the system. System uses Infrared sensor such that system can detect less false positives. Ultrasonic sensor works under the concept that the amount of time required to reach and come back from the obstacle is taken and the corresponding time difference and as a result the distance is calculated [15].

As soon as the distance is been fed to the system, it is checked with the distance limit which is given. If the obstacle is near, immediately buzzer is activated. Moreover, microcontroller receives the value of PWM function.

3.3. Wireless communication from the microcontroller to the cloud

The microcontroller is the central system which calculates and controls all the functions in the system. In this case, microcontroller used is connected to sensor to get the information and also with a Wi-Fi module so that the information can be sent to the cloud.

As soon as the distance is calculated and sent to the microcontroller, it is passed through Wi-Fi to the cloud. Access point here used is the phone. As a result, using the url any person can view the movement of the person using the shoes. It both safe for the user as well as the caretaker can keep a watch on the visually impaired without himself being near the user.

4. Results and discussion

The Shoe based navigation system developed is used for easy and independent travelling of visually impaired. Moreover, the location of the individual can be displayed from time to time to their care taker or guardian through cloud environment.

The system is basically in a sleep mode. Whenever any individual uses the system, based on the pressure caused in the shoes while wearing it, the system gets activated. The FSR present in the bottom of the shoes is responsible for this purpose. Once the individual starts wears the shoes, the ultrasonic sensor checks for any obstacle in path. If the obstacle is found, distance is calculated and sent to the micro controller.

Based on the distance calculated the following actions takes place:

If distance of obstacle is less than 20 feet; the obstacle is very near and PWM signals are activated in small intervals.
If distance of obstacle is between 20 and 50 feet; the obstacle is little far and PWM signals are activated in large intervals.
If the distance of obstacle is greater than 50 feet, it is not considered.

IR sensor is used to reduce the false positives. Consequently, the same information is sent from the microcontroller through GSM to the cloud environment. In our case, we have used Thingspeak cloud environment as it is economic and serves our purpose.

A unique Uniform Resource Locator (URL) will be shared to the caretaker or guardian which is unique to the device. This url can be used by the caretaker to access the Thingspeak web page. In the Thingspeak web page, the guardian can watch the chart of distance of the obstacles in intervals and warn the individual if he find something risky. This keeps the visually impaired individual secured when at the same time giving him him the sense of independence. Fig. 4 shows the distance which is computed by the system sent and displayed in Thingspeak cloud environment.

Fig. 4. Thingspeak web page.

5. Conclusion

People with visual impairment form a very large part in our society. Due to partial or complete loss of vision, it is not possible for them to perform day to day activities without depending on someone else. With the advancement in technology, it is vital to help them navigate safely indoor as well as outdoor. Moreover, a system is required which is less bulky, fits as a part of his daily accessories and equally efficient.

The Shoe based navigation system used in our paper has the ability to find if any obstacles or disturbances are found in the path. If the obstacle is found, the distance is calculated and buzzer is activated if the obstacle is nearer than the limits. Moreover, nearer the obstacle, buzzer will be made louder by giving a pulse of higher frequency. This will help the individual get alerted about the obstacle and will cause him to change the path.

Additional feature of the system is that Wi-Fi module is used to send the distance parameters of the user to his caretaker or guardian through cloud. As a result, the guardian can also warn him directly, Moreover, as the data are available in cloud, the caretaker can be anywhere in the world but easily monitor the user. The system is embedded in shoe so that it can be easily used as compared to white cane or some other external assisting device.

Using cloud environment, all the required details can be sensed using sensor, processed in the microcontroller and sent to the user. Thinkspeak is a very simple cloud platform where all the required charts can be easily accessible.

The visually impaired people find it very difficult to travel on their own due to their disability. This system is a small effort to help them travel on their own without depending on others. The developed system is found to be more efficient, economic, user friendly and easy to use as compared to other systems available in the market.

CRediT authorship contribution statement

Laxmi Raja: Conceptualization, Methodology, Software, Visualization, Investigation, Writing - review & editing. **R. Santhosh:** Data curation, Writing - original draft, Validation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] B. Mustapha, A. Zayegh, R.K. Begg, Wireless obstacle detection system for the elderly and visually impaired people, in: The Proc. of the IEEE International Conference on Smart Instrumentation, Measurement and Applications (ICSIMA) 26-27 November, 2013, Kuala Lumpur, Malaysia, 2013.
[2] Shripad Bhatlawande, Manjunatha Mahadevappa, Jayanta Mukhopadhyay, Way-finding Electronic Bracelet for Visually Impaired People, in: 2013 IEEE Point-of-Care Healthcare Technologies (PHT) Bangalore, India, 2013.
[3] B. Mustapha, A. Zayegh, R.K. Begg, Reliable Wireless Obstacle Detection System for Elderly and Visually Impaired People with Multiple Alarm Units, in: IEEE 2014 International Conference on Computer, Communication and Control Technology (I4CT), 2014.
[4] B. Mustapha, A. Zayegh, R.K. Begg, Multiple Sensors Based Obstacle Detection System, in: 2012 4th International Conference on Intelligent and Advanced Systems (ICIAS2012), 2012.
[5] Ayat A. Nada, Mahmoud A. Fakhr, Ahmed F. Seddik, Assistive Infrared Sensor Based Smart Stick for Blind People, in; Science and Information Conference 2015 July 28–30, 2015, London, UK, 2015.
[6] Mounir Bousbia-Salah, Abdelghani Redjati, Mohamed Fezari, Maamar Bettayeb, An Ultrasonic Navigation System for Blind People, in: 2007 IEEE International Conference on Signal Processing and Communications (ICSPC 2007), 24–27 November 2007, Dubai, United Arab Emirates, 2007.
[7] Ankit Agarwal, Deepak Kumar, Abhishek Bhardwaj, Ultrasonic Stick for Blind, Int. J. Eng. Comp. Sci., 4 (4) (2015) 11375–11378, ISSN: 2319-7242.
[8] S. Kher Chaitrali, A. Dabhade Yogita, K. Kadam Snehal, D. Dhamdhere Swati, V. Deshpande Aarti, An Intelligent Walking Stick for the Blind, Int. J. Eng. Res. General Sci. 3(1) 2015, ISSN 2091-2730.
[9] Abhishek Bhokare, Amruta Amberkar, Anvesh Gawde, Pratham Kale, Abhijeet Pasi, Ultrasonic Blind Walking Stick, Int. J. Recent Innov. Trends Computing Commun. 4 (1), ISSN: 2321-8169.
[10] V. Ramya, Laxmi Raja, Thangarajah Akilan, A navigation system for the visually impaired using embedded technology, ARPN J. Eng. Appl. Sci. 10 (12) (2015).
[11] D.E. Gbenga, A.I. Shani, A.L. Adekunle, Smart walking stick for visually impaired people using ultrasonic sensors and Arduino, IJET 9 (5) (2017) 3435–3447.
[12] D. Ahmetovic, J. Guerreiro, E. Ohn-Bar, K.M. Kitani, C. Asakawa, Impact of expertise on interaction preferences for navigation assistance of visually impaired individuals, in: Proceedings of the 16th Web For All 2019 Personalization-Personalizing the Web, 2019, pp. 1–9.
[13] Aftf, Mouna, Riadh Ayachi, Yahia Said, Edwige Pissaloux, Mohamed Atri, Indoor object classification for autonomous navigation assistance based on deep CNN model, in: 2019 IEEE International Symposium on Measurements & Networking (M&N), IEEE, 2019, pp. 1–4.
[14] K. Xiang, K. Wang, L. Fei, K. Yang, Store sign text recognition for wearable navigation assistance system, J. Phys.: Conf. Ser. 1229 (2019) 012070, https://doi.org/10.1088/1742-6596/1229/1/012070.
[15] G. Prasanthi, P. Tejaswitha, Sensor assisted stick for the blind people, Trans. Eng. Sci. 3(1) 2015, ISSN: 2347-1964 (Online) 2347-1875 (Print).