Indoor Navigation for Blind People using Raspberry Pi

Nilesh Raut[1], Shubham Jangam[2], Labham Palve[3], Piyush Ukarande[4], Veena Pawar[5]

[1] *Steudent, Department of Computer Engg., JSPM Jaywantrao Sawant College of Engg., Pune, India*
[2] *Steudent, Department of Computer Engg., JSPM Jaywantrao Sawant College of Engg., Pune, India*
[3] *Steudent, Department of Computer Engg., JSPM Jaywantrao Sawant College of Engg., Pune, India*
[4] *Steudent, Department of Computer Engg., JSPM Jaywantrao Sawant College of Engg., Pune, India*
[5] *Project Guide, Department of Computer Engg., JSPM Jaywantrao Sawant College of Engg., Pune, India*

ABSTRACT

Indoor navigation systems must deal with the absence of GPS signals since they are only available in outdoor environments. Therefore, indoor systems have to rely upon other techniques for positioning users. Recently various indoor navigation systems have been designed and developed to help blind people. In this paper, an overview of some existing indoor navigation systems for blind people is presented and they are compared from different perspectives. The evaluated techniques are ultrasonic systems, RGB-D camera-based solutions, computer vision aided navigation systems, and smartphone-based applications. This paper reviews various types of navigation systems developed for vision-less people for indoor navigation.

Keyword: *- Indoor navigation, Way finding, Visually impaired navigation, Sensor fusion, Image Processing, Wearable Device.*

---

1. INTRODUCTION

Blind people have high difficulty in doing their daily routines. Due to low vision or blindness, they suffer from an inferiority complex and also it affects their economic conditions because of less efficiency in doing the work and the cost of the treatment. The major difficulty faced by blind people while navigating or traveling in the unknown surrounding

.The main objective while navigation is to find out the obstacle-free path for secure navigation. Traditionally with the help of the animal guidance especially with the help of the dog, the navigation is carried out. The main problem regarding with the help of the dog guidance is that only the obstacles below the knee level get identified. Also, there is no complete guarantee to reach a destination location with the help of the sensing ability of the dog. The invention of the white cane made a significant impact in the field of blind navigation because of its low cost and easy use. The white cane gives the ability to navigate blind person on their own in an unknown environment. The main drawback of the white cane that it is unable to find out the obstacles present above the waist size of the person so that it is not also completely secure. Now a day's variety of approaches proposed in the field of computer science for designing of the wearable assistance device for navigation of blind people. The collision avoidance and 3D object recognition with the help of the visual image processing with the help of the image processing methodology and robotic techniques are carried out in real-time to travel the plausible path.

2. LITERATURE REVIEW

2.1 Multiple Distance Sensors Based Smart Stick for Visually Impaired People

[1] Amit Kumar proposed this system. In this system a novel low-cost yet durable and accurate smart stick to assist visually impaired people while they walk in indoor/outdoor unstructured environments. There is a large group of people who have difficulties in their daily routine work due to losing their eyesight. Walking with confidence is one of them which may have different challenges in different environments/countries. We have considered the Indian context where outdoor environments are often clustered and noisy. Keeping these challenges in mind, a new smart stick is developed which is capable of detecting obstacles of any height in front or slightly sideways of the person. The stick gives a fair idea about the distance and the location of obstacles through vibration in hand and audio in the ear of the person. The wireless connection has been set up using Bluetooth between the earphone and the stick. Different frequencies of the generated vibration and different tracks of the audio alert the person about the distance of the obstacle. Real-time experiments have been conducted in different environments by different people to observe the accuracy of the stick and results are quite encouraging.

2.2 Navigational Assistance System For Visually Impaired

[2] In this system, an electronic aid to visually impaired people is designed which helps them to voyage to the destination like normal people. The aiding system is built into a walking stick that shall be carried by a visually impaired person. The aiding system acts like a reproduction vision. Sensors with most accurate outputs are used in this work. The intelligent algorithm is used in the software so that it is more user-friendly. A suitable walking stick is designed with all the stuff built-in. The canopy people will able to budge from one place to another lacking other help. If such a system is developed, it will act as a basic stand for the invention of more such devices for the canopy people in the potential which will be cost-effective. And as far as the localization is anxious it will be able to provide accurate information on the position of the canopy if in case they lost with help from the GPS. It will be a real boon for the blind. The developed prototype gives good results in detecting obstacles paced at distance in front of the user. These works report the designing of the multi-sensor blind stick. This will be useful for visually impaired peoples. The canopy stick consists of tricky features which detect obverse and top part of the obstacles, water stagnated/manholes on the ground. Due to these features it is the best tool for blind and visually impaired people for on foot on the road. It is unforced, cost-effective, configurable and simple to handle smart supervision systems. The system is planned implemented, tested and verified. The results indicate that the structure is expert and inimitable in its impending in specifying the source and space of the obstacles.

2.3 The Assistance System using RGB-D Sensor with Range Expansion

[3] Navigation assistance for visually impaired (NAVI) refers to systems that can assist or guide people with vision loss, ranging from partially sighted to blind, using sound commands. In this paper, a new system for NAVI is presented based on visual and range information. Instead of using several sensors, we choose one device, a consumer RGB-D camera, and take advantage of both range and visual information. In particular, the main contribution is the combination of depth information with image intensities, resulting in the robust expansion of the range-based floor segmentation. On one hand, depth information, which is reliable but limited to a short-range, is enhanced with the long-range visual information. On the other hand, the difficult and prone-to-error image processing is eased and improved with depth information. The proposed system detects and classifies the main structural elements of the scene providing the user with obstacle-free paths to navigate safely across unknown scenarios. The proposed system has been tested on a wide variety of scenarios and data sets, giving successful results and showing that the system is robust and works in challenging indoor environments

2.4 Smart Phone Application to Assist Visually Impaired People

[4] Laviniu Tepelea, Loan Gavrilut & Alexandru Gacsadi proposed the assistance system. In the system to assist people with visual impairments, the smartphone proves to be very useful, but it requires sensory modules external to the phone to detect obstacles and find a safe way. The Android application we have made, offers not only a travel guide, but also other daily assistive functions such as reading a poster or article, making phone calls, finding the date, time, and battery level. The special interface created for the blind has proved its efficiency, and the communication of the relevant information verbally transmitted through the TTS to the earphones to one ear leads to

a correct understanding of the message and leaves the user the opportunity to receive other useful information from the environment. External platforms communicate data from sensors to the phone via Bluetooth and Wi-Fi where sensorial data fusion is made, and at the appropriate time, the relevant information is communicated to the user, warning of the existence of an obstacle at a certain level. The accelerator sensor can detect when the person with visual impairment is falling, and a phone call to a favorite number is made, for example, the emergency service, and the light sensor detects the need to move from outdoor guidance to indoor guidance and vice versa. Experimental tests made with the assistive system have proven its usefulness, but they have also revealed that further testing is needed to find the optimum obstacle detection distance, both inside buildings and in the outdoor environment. In the future, more powerful and cheaper smartphones will be made, which will lead to more effective assistance. Finally, this aiding system for visually impaired, based on a smartphone, but also using other small external sensory modules, proves to be a viable, portable, low-cost, small-scale solution. More important, it does not require many hours of training.

2.5 Novel Indoor Navigation System

[5] Kabalan Chaccour & Georges Badr proposed this system, In this system a novel design for an indoor navigation system for visually impaired and blind people. The proposed approach has a simple architecture that allows the subject to be fully independent in his home or work. The system provides navigation assistance and obstacle avoidance functionalities in indoor premises algorithms. Unlike other systems in the related work, the subject needs only to hold his smartphone during his displacement and doesn't require any particular skills to be operated. The complexity of the system resides in the computer vision processing algorithm seamlessly to the user. Future development is planned for the system expansion to add more functionality. On the application level, we are working to automatically run the application when motion is sensed from the subject (chair rise, walking, etc.). It can also revert to its sleep mode in static conditions to minimize the battery consumption. Battery level can also be communicated loudly through voice messages to avoid critical situations. The application may also offer gait analysis for elderly and visually impaired subjects and may prevent the subject from a potential fall. On the remote processing system level, enhanced image processing algorithms may be implemented to detect specific objects in the environment. The time between voice messages must be adequately chosen to avoid flooding the ears and disturbance. These issues will be addressed in future research activities.

2.6 Smart Guiding Glasses

[6] This system presents a smart guiding device for visually impaired users, which can help them move safely and efficiently in a complicated indoor environment. The depth image and the multi-sensor fusion based algorithms solve the problems of small and transparent obstacle avoiding. Three main auditory cues for the blind users were developed and tested in different scenarios, and results show that the beep sound-based guiding instructions are the most efficient and well-adapted. For weak sighted users, visual enhancement based on the AR technique was adopted to integrate the traversable direction into the binocular images and it helps the users to walk more quickly and safely. The computation is fast enough for the detection and display of obstacles. Experimental results show that the proposed smart guiding glasses can improve the traveling experience of the visually impaired people. The sensors used in this system are simple and at low cost, making it possible to be widely used in the consumer market.

3. COMPARISON OF THE REVIEWED SYSTEMS

System	Collision Avoidance & Object Detection (Yes/No)	Guiding Feedback Method & Device & Sensors Used	Feature
1. Multiple Distance Sensors Based Smart Stick for Visually Impaired People	1.Yes 2.Yes	1.Audio 2.Microcontroller, Ultra Sonic sensor, Bluetooth module, Vibration motor	[1] Accurate coordination and communication among sensors, motor, controller, Bluetooth modules and other components to build a smart stick for the blind people.
2.Navigational Assistance System For Visually Impaired	1.Yes 2.Yes	1.Audio 2.IR Sensor(30cm), Water Sensor, Pit Sensor, GPS,	[2] It focuses on barrier recognition, pit detection, water recognition and finding a location to weaken navigational difficulties for visually impaired people.
3.The assistance system using RGB-D Sensor with range expansion	1.Yes 2.Yes	1.Audio 2.Wearable Device, RGB-D Sensor	[3]Floor Segmentation with 99% accuracy
4.Smart Phone Application to Assist Visually Impaired People	1.Yes 2.Yes	1. Audio 2. Camera, Light Sensor, GPS Sensor, GSM Module, Arduino, Raspberry Pi.	[4] Small in size, Low weight, Easy to use
5.Novel indoor navigation system	1.Yes 2.Yes	1. Audio 2. PIC Controller, Beep Vibrating Motor, Ultrasonic Sensor	[5] More efficient to collision detection
6.Smart Guiding Glasses	1.Yes 2.Yes	1.Audio 2.Wearable Device, ultrasonic sensors, RGB-D camera	[6]Small and Transparent collision detection

Table -1: Comparison of the Reviewed Systems

4. PROPOSED SYSTEM

The Proposed system consists of following components.
1. The mobile phone holder with the smart phone.
2. The Raspberry-pi module.
3. The power bank.
4. Ultrasonic sensors.

The smart phone is used for the real time video feed capturing. For the real time video capturing the IP-Webcam android application is used. The ultrasonic sensors are used for the distance calculations. For the processing of the distance raspberry-pi module is used it sends the sensed information to the main processing unit which is the high processing laptop. For giving the 5V power supply to the raspberry pi the power bank is used.

4.1 System Architecture

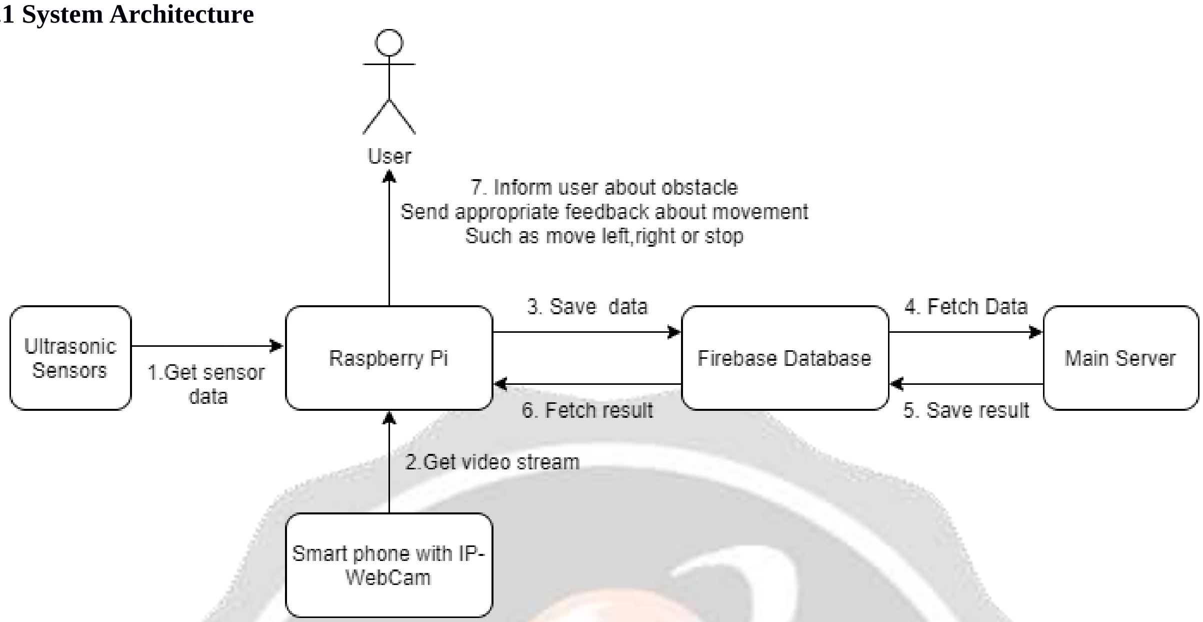

Fig -1: System Architecture

By using the IP-Webcam the real time video feed is hosted on the server. This real time video feed is accessed by the raspberry-pi by fetching each and every image from the url. Then this fetched image is sent to the real time firebase storage by using the firebase admin sdks. This real time data is fetched by the main processing unit and then computation is done over the each and every frame and generated result is again uploaded on the real time firebase database. From firebase the generated output is fetched again and from that the corresponding message is given to the user.

4.1 System Working Flow

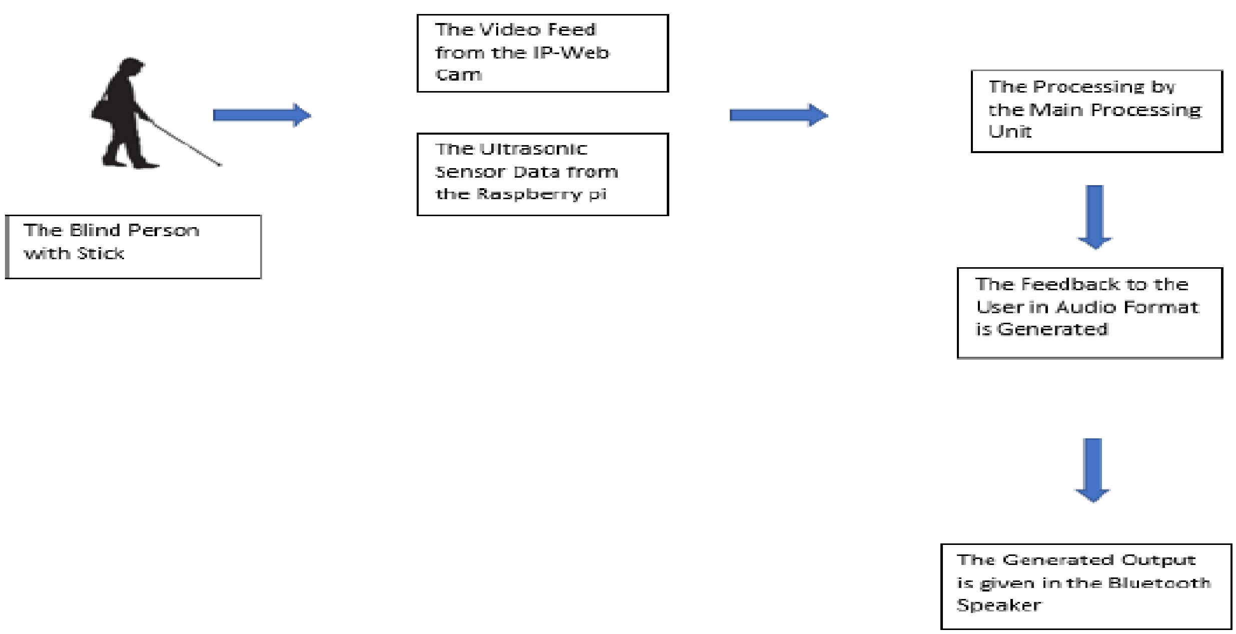

Fig -2: System Working Flow

Steps:

1. Initialization of Main server and Raspberry Pi. Raspberry pi connects to the main server.
2. Main server gets input as the Real time video feed and ultrasonic sensor data sheet
3. Frozen graph loaded in the program from inception v2 architecture
4. Label Mapper is loaded.
5. Session gets created.
6. Different tensors initialized.
7. Get real time video feed frame by frame. Define region of interest (ROI) over each frame.
8. The session is fired with the frame as the input tensor and this gives output as tuple of value of output tensors. The Values of the tuple get interpolate over the current frame.
9. Depending on which side of the frame is the object detected an appropriate feedback about movement is given to the user in the form of audio format.

5. CONCLUSIONS

We have examined various designing approaches for building assistance system for blind people. The survey focuses on the study of various kinds of sensors and computer vision-based image processing techniques used for indoor navigation. Each sensor and techniques have advantages as well as a drawback. However, amongst the analyzed sensors RGB-D sensor has the least amount of drawbacks and because of its active and passive sensing capabilities, the image processing techniques can be implemented with high performance. Because of these advantages, it is widely used in designing of the assistance system. The complex information is easy to analyze in an audio-based feedback method so that audio-based guidance is widely used for giving feedback about surrounding visual information. OpenCV library widely uses for image processing techniques.

The proposed system consists of main two processing units one is main server and second is the raspberry-pi which give assistance to the main server for giving ultrasonic sensor data sheet to the main server. On the basis of two inputs real time video stream and distance the safe navigation of blind person is carried out, also the information about the unknown environment is given to the user after each constant interval of time which provides ability to the blind person to sense the unknown environment.

6. FUTURE WORK

Various API's can be integrated with the system to boost its functionalities. The functionality of floor segmentation can be added to the original project model so as to be able to do independent decision about movement on its own. Visual odometry can be added to the given project for mapping of the unknown environment.

7. REFERENCES

[1] Sharang Sharma, Manind Gupta, Amit Kumar, Meenakshi Tripathi, Manoj Singh Gaur, “Multiple Distance Sensors Based Smart Stick for Visually Impaired People.”, 2017.

[2] M.Micheal Priyanka, M.Michael Dharsana, “Navigational Aiding System For Visually Impaired", Third International Conference On Science Technology Engineering And Management (ICONSTEM), 2017

[3] A. Aladrén, G. López-Nicolás, Luis Puig, and Josechu J. Guerrero, "Navigation Assistance for the Visually Impaired Using RGB-D Sensor With Range Expansion." IEEE Systems Journal 2014

[4] Laviniu _epelea, Ioan Gavrilu_, Alexandru Gacsádi, “Smartphone Application to Assist Visually Impaired People”, 14th International Conference on Engineering of Modern Electric Systems (EMES), 2017

[5] Kabalan Chaccour and Georges Badr," Novel indoor navigation system for Visually Impaired and blind people",2015

[6] Jinqiang Bai, Shiguo Lian, Zhaoxiang Liu, Kai Wang, and Dijun Liu, "Smart Guiding Glasses for Visually Impaired People in Indoor Environment", IEEE Transactions on Consumer Electronics, Vol. 63, No. 3, August 2017,pp.258-266

[7] K. Li, “Electronic travel aids for blind guidance,” An Industry Landscape Study IND ENG 290 Project Report, EECS, UC Berkeley, USA, 2015.

[8] L. Tian, Y. Tian and C. Yi, “Detecting good quality frames in videos captured by a wearable camera for blind navigation,” in 2013 IEEE Int. Conf. Bioinformatics and Biomedicine, Shanghai, 2013, pp. 334-337.