Microprocessor-Based Smart Blind Glass System for Visually Impaired People

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Microprocessor Based Smart Blind Glass System for Visually Impaired People

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Abstract. In this paper, we present a new microprocessor-based smart blind glass for the people who are completely blind. Individuals with completely blind are facing difficulty to communicate effectively with their environment. They always depend on other people. Sometimes they fall into a lot of problems when walking down the road. They do not understand any vehicle how much far from them or a manhole in front of them. So, they lead a sorrowful daily life. Giving blind people the great accessibility to their environment is the objective of the smart blind glass system. This microprocessor-based smart glass system can see the world for them and give voice information through the headphones to the ears of the blind man. This smart glass system will help completely blind people gain increased independence and freedom in the indoor and outdoor environment. This module can detect and recognize common all the object in our daily life, and give corresponding voice information to the blind people. The proposed prototype system is based on Raspberry pi 3 model B and the application in the system is written in python with libraries of TensorFlow. Extended demonstration of the system will be presented to show how the system helps the blind people to “see the world” and work as a good guiding friend. Our proposed system is good, reliable, highly efficient and user friendly

Keywords: Smart blind glass, microprocessor-based system, obstacle detection, blind people, Raspberry Pi, TensorFlow

1 Introduction

According to the WHO (World Health Organization) report, as Around 253 million people live with vision impairment worldwide, of which 36 million are blind. The vast majority lives in low-income settings. More than 80% are aged 50 [1] years or above. Individuals with a visual disability are difficult to communicate effectively not only with ordinary people but also with their environment. It’s very much hard to maintain their life. Visually disable person always depend on the other person in their everyday works. They have a special quality of understanding touch, sound, and another stimulus by these they can understand about the surrounding. It is pretty hard for them to go out alone, not to mention finding a home, subway stations, and restaurants and so on. However, there is not a good device to help them at all in a reasonable price. If the blind man gets a device like a friend always with him and gives necessary instructions, they will gain increased independence and freedom.

Fig. 1. Snapshot of the prototype smart blind glass.

The proposed smart blind glass prototype system is based on Raspberry pi 3 model B. The Raspberry pi 3 [2] is a tiny computer offered as a development system for wearable devices. It is a Broadcom BCM2835 SoC Multimedia processor. It has a CPU as quad-core 64-bit ARM Cortex A53 clocked at 1.2 GHz, GPU of 400MHz video core IV multimedia. It has a memory of 1GB LPDDR2-900 SDRAM. There is also 4 GB eMMC flash on board, Wi-Fi, Bluetooth 4 and USB controllers. Edison is powerful in computing but small in shape like minicomputer which makes it perfect to build a wearable device.

Fig. 1 is the snapshot of the smart blind glass. As you can see, the smart glass is lightweight, convenient for blind users. This device helps the blind man by giving all the information to his/her ear. It will give all kinds of object information and their specific location information and any type of holes information to the blind man. The blind man can send message information to their family member by pressing a button only. So the glass will be a great assistive device for the blind man.

2 Related Work

As this work related to the obstacle avoidance, obstacle detection, hole detection, and the guiding information feedback, the related work with respect to such fields is reviewed in this section.

2.1 Obstacle Avoidance

There are a lot of methods exist on obstacle detection and avoidance. According to the sensor type, it will be an ultrasonic sonar sensor based method, laser scanner based method, and camera-based method. Ultrasonic sonar sensor based method can measure the distance of obstacle efficiently and compare with the specific given distance threshold. By detecting an obstacle in front of the sonar sensor we can notify the blind man in audio information. Sonar sensor has a great problem; it cannot determine the exact direction of going forward. Laser range scanners have frequently been used for obstacle detection for mobile robots [3]. The laser scanner can give the specific location of the obstacle information so we can easily notify the blind people. The camera-based method uses a different camera for obstacle detection. It includes a mono-camera, stereo-camera, and RGB-D camera [4]. Based on the mono-camera, some methods process the RGB image to detect obstacles by e.g., floor segmentation deformable grid based obstacle detection etc. However, these methods are very much costly. So, real-time computation does not satisfy much computation always and in this case, it is hard to measure the distance of the obstacle. To measure the distance, some stereo-camera based methods are proposed. Here also use RGB-D camera which not only captures the image but also gives specific depth information of the obstacles.

2.2 Obstacle detection

Obstacle detection is mainly based on image processing. For image processing, different methods are using nowadays that includes an open CV, ANN, KNN Support Vector Machine (SVM) and different machine learning algorithms. Sometimes object recognition also done by the Matlab simulation software. As a man, bottle, chair, in front of the blind man can easily identify by the Matlab simulation. Different machine learning algorithm also vastly used to identify the object.

2.3 Classification of objects into their specific classes

Nowadays machine learning is very important for classifying objects into specific classes. As the study of flower, categorizing a specific class of flower is important to subject in the field of Botany as well as for a blind man. It can easily identify the specific flower using TensorFlow [5].

2.4 Face Recognition

Face Recognition is very important now day 's. Modern security, recognition of human, based on face recognition technology. It might be important for the blind glass because of recognizing the relatives of the blind man. On the basis of face detection, a Convolutional Neural Network (CNN) based on TensorFlow, an open source deep learning framework [6], is proposed for face recognition. Experimental results show that the method has better recognition accuracy and higher robustness in all environments.

3 System Design

The block diagram of the system is in Fig. 2. As the system block diagram shows, the pi camera on the glass catches the video stream around the blind and then transfers it to the raspberry pi module. There is also an ultrasonic sensor angled at 90 degrees and 30 degrees respectively. It also contains a power supply, headphone.

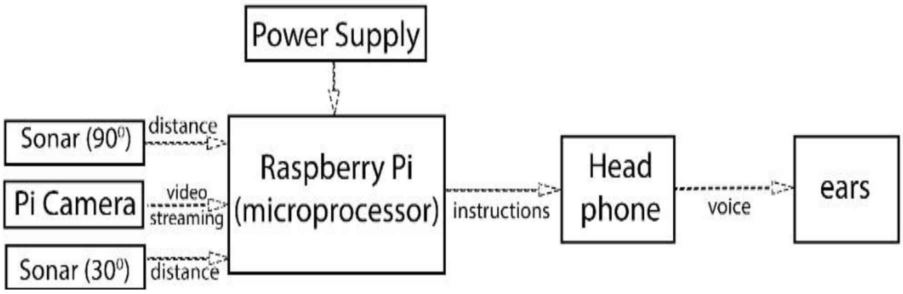

Fig. 2. The block diagram of the proposed system

3.1 Hole and barrier detection:

For all kind of hole in front of the blind man the proposed system used an ultrasonic sonar sensor angled at 30 degrees with the body parallel axis which is shown in Fig. 3.

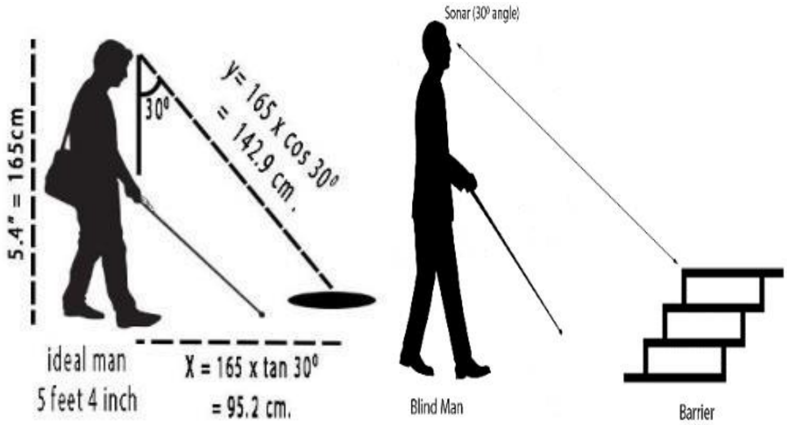

Fig. 3. Hole and barrier detection

Here the calculation is done for a man whose height is 5.33ft or 156cm. As the ultrasonic sensor angled at 30 degrees with the body parallel axis we can calculate both the length Y=165cos30 and it will be the length 142.9cm and also calculate the value of X=165tan30 and will be 95.2 cm.

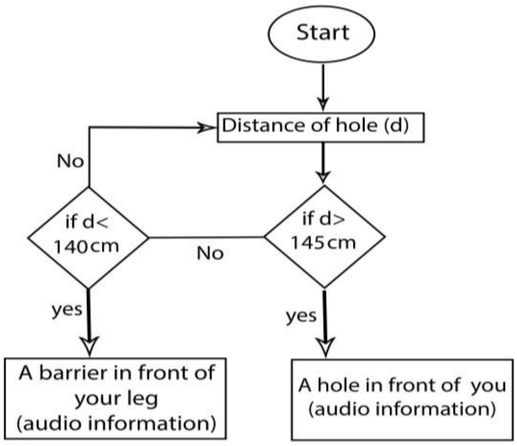

Fig. 4. Proposed protocol for the hole and barrier detection

For a 5'4" man, the sonar to hole distance when more than 240cm only on that moment an audio information will send to the blind man ear like a hole in front of you about 95 cm. It can awake the blind man about the hole accurately so that he or she can avoid it. It can detect 2 cm to any deeper hole in front of the blind man. The same ultrasonic sensor angled at 30 degrees can detect any type of barrier in front of the blind man. It can detect 4cm to any of size barrier in front of the lag of the blind man and give audio information like a barrier in front of your leg. Its accuracy was nearly a hundred percent. The protocol is shown in Fig. 4.

3.2 Obstacles avoidance

The 90 degrees positioned ultrasonic sonar sensor on the smart blind glass can detect any type of obstacles in front of the blind man. It can avoid almost all types of an object like a wall, table, chair, cycle, bus, tracks and so on. The schematic diagram for obstacle avoidance is shown in Fig. 5 and the corresponding protocol is shown in Fig. 5.

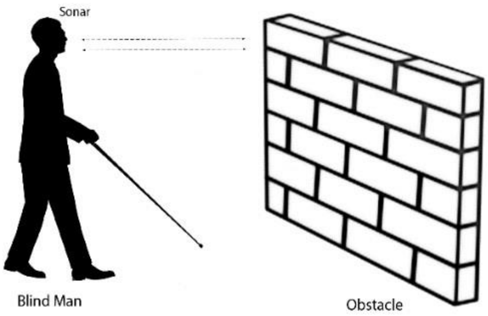

Fig. 5. The schematic diagram is shown for obstacles avoidance.

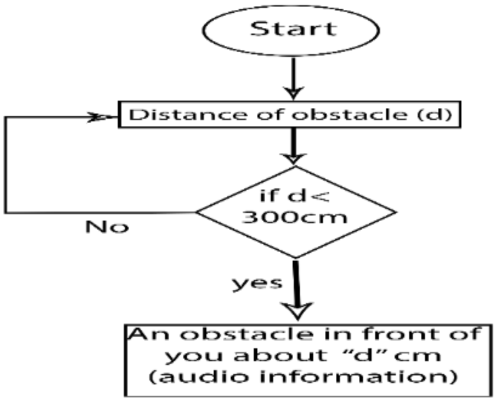

Fig. 6. Block diagram of the protocol for obstacle detection.

Measuring distances has always been a challenge in all environments as it involves a lot of risks and disturbances. One method to measure the distances without any hindrances in almost all environments is via ultrasonic waves which generate 40 KHz sound pulse that travels with the speed of sound to the object and returns it echo that helps in calculating the distance. The US (ultrasonic sensor) sensors described have the precision of less than 1 cm in distance measurements of up to 6m [7]. The ultrasonic sensor is great tools to measure distance without actual contact and used at several places like water level measurement, distance measurement etc. The basic principle of ultrasonic distance calculation based on echo. The trig pin of the US send sound wave in the environment and echo pin collect it when it returns back after striking on the obstacles. So we need to calculate the traveling time of both sounds. As the speed of sound in air is known.so the distance calculation algorithm will be,

$$d = \frac{ToF \times v}{2} \quad (1)$$

Where d is the distance of the object, v is the speed of sound in air, usually taken as 340 m/s and ToF is the time interval between the Trig and Echo transitions [8].

3.3 Object detection

There are a lot of methods actually using at this time for object detection nowadays. Different machine learning procedures ImageNet Large Scale Visual Recognition Competition (ILSVRC), Convolutional Neural Networks (CNN), Tensorflow have become popular nowadays. In this paper, the Tensorflow [9] framework is used to recognize all kinds of object. Tensorflow is the most common and widely adopted today. The Tensorflow provide important frameworks for neural network configuration. In this framework, artificial neural networks are represented by computational graphs. The proposed protocol for object detection is shown in Fig. 7.

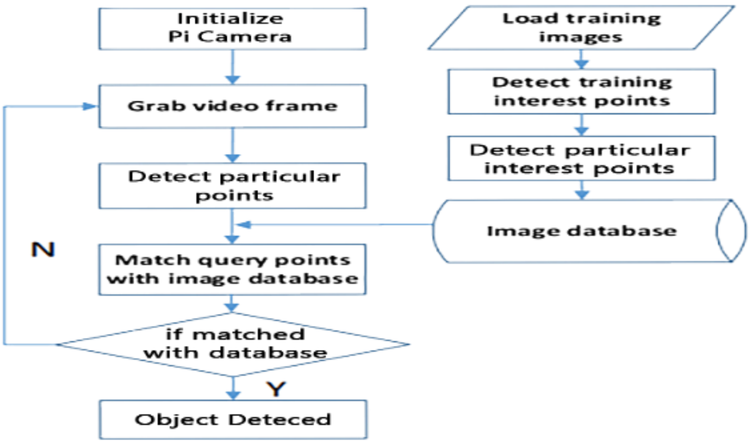

Fig. 7. Proposed protocol for object detection.

4. Results

4.1 Obstacle Detection

In this protocol, an object within the range between 2cm to 400cm distance can be measured. When any obstacle found within the range then a voice command notifies the blind man about that obstacle. Practical obstacles detection image is given in Fig. 8 and the audio information is shown in Table 1.

Fig. 8. The detected images of obstacle are given for 4, 2, 1-meter distance.

Table 1. The obstacle with associated audio information.

Sl#	Obstacle Dist.	Voice information
01	400cm	An obstacle in front of you about 4 meters
02	200cm	An obstacle in front of you about 2 meters
03	100cm	An obstacle in front of you about 1 meter

Figure 8 and Table 1 is a preparation for the specific distance but our proposed model can give specific distance audio information within the range 2cm to 4 meters. Like when the obstacle distance is 250cm at that time the module give audio information (an obstacle in front of you about 2 and a half meters). Our proposed module can only detect an obstacle in front of the blind man.

4.2. Hole and barrier detection

Any type of hole and barrier in front of the blind man is detected by the module. It can detect 4cm to any type of deep hole and barrier in front of the blind man. The 30 degrees aligned sonar sensor can detect the hole and barrier and its accuracy is very good in all environments. The system gives audio instruction to the ears of the blind man at that time which is shown in Fig. 9 and Fig. 10.

Fig. 9. Audio information (a) No (b) Yes (a hole is in front of the person)

Fig. 10. Audio information (a) No (b) Yes [A barrier in front of the leg]

4.3. Obstacle Recognition

Our proposed module continuously capture an image and compare with TensorFlow library database and give audio information that is the name of the obstacle. Some images of that procedure in different places are given in Fig. 11.

Fig. 11. Obstacles detection in different places

Table 2. Objects with associated audio information.

Sl#	Actual → Detected object	Object dist. (cm)	Audio information
01	Car →Sports Car	200	The object in front of you about "2" meters it is "sports" car
02	Chair →Table	308	--- "3 "meters it is "table"
03	Rickshaw →rickshaw	200	--- "2 "meters it is "rickshaw"
04	Table fan →Electric fan	100	--- "1 "meters it is "electric fan"
05	Light →light	250	--- "2and half "meters it is "light"
06	Pen →pencil	100	---"1 "meters it is "pencil"
07	Dustbin→ dustbin	200	--- "2 "meters it is "Dustbin"
08	Ball →ball	430	--- "4 "meters it is "ball"
09	Lighter →Lighter	300	--- "3" meters it is "lighter"
10	Book →book	208	--- "2 "meters it is "book"

Table 2 is based on object detection in different places in the indoor and outdoor environment. Here a few examples are given in Table 2. Actually, it can detect all the objects we found in our day to day life. But the most important things are that the focusing should be perfect. For improper focusing, it can not detect the object accurately. So accuracy is not so high in object detection. We have compared our proposed system with some researchers and this is shown in Table 3.

Table 3. Comparison between the proposed work and other researches.

Ref.	**Research work is done**
4	obstacles detection, obstacles avoidance, traffic sign recognition and guiding information feedback
7	Obstacles detection like coal.
5	Classify flower by using machine learning
6	Face detection using machine learning
8	Distance measurement using sonar sensor
9	Object identification
Proposed	Hole detection, barrier detection, obstacles detection, object identification and give audio instruction to the ears of the blind man.

Comparing with other works, our detection procedure is more robust than others.

Furthermore, our selection of detected objects is more than others.

5. Conclusion

We introduced a prototype system of microprocessor-based smart blind glass for completely blind people. We demonstrated both the hardware and software design of the smart glass. We implemented abundant real-time image processing for object recognition algorithms on the new proposed smart blind glass system. This system can detect and recognize the object in real time and efficiently. The smart blind glass would be useful for completely blind people in the indoor and outdoor environment. And in near future, we will implement more useful applications in the smart blind glass system by incorporating more valuable information.

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