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VIZIYON : Assistive handheld device for visually challenged

Sreeraj M[a,*], Jestin Joy[b], Alphonsa Kuriakose[c], Bhameesh M B[d], Anoop K Babu[d], Merin Kunjumon[d]

[a]*Department of CSE, Sree Ayyappa College, Chengannur, Kerala*
[b]*Department of CSE, Federal Institute of Science And Technology (FISAT), Angamaly, Kerala*
[c]*Department of CSE, Viswajyothi College of Engineering and Technology (VJCET), Vazhakulam, Kerala*
[d]*Department of MCA, Federal Institute of Science And Technology (FISAT), Angamaly, Kerala*

Abstract

There are about 253 million people in the world living with visual impairment, of which about 36 million are blind. 217 million people have moderate to severe vision impairment. It is very important to consider the difficulties of visually impaired people to help them perform with their daily activities. Through sensation, these people identify and understand the obstacles. VIZIYON is a device based on IoT system for identifying obstacles, in a cost-effective manner. In this device, the identification is carried out based on the distance vector and object detection. The object recognition is done using the concept of Convolutional Neural Network. The device is able to identify the objects with an accuracy of 91% and recall of 94%.

Keywords: Machine Learning; Image Processing; Open CV; Python; Arduino Uno; Raspberry Pi.

1. Introduction

Blindness is a problem that afflicts millions of people everywhere. When performing everyday routine work, blind people may face many types of difficulties. Even in their own homes, they must exhibit efforts to navigate from one place to another and to locate objects. So visual impairment can affect one's ability to function independently, to perform day-to-day activities of life and to travel safely. According to the World Health Organization (WHO), 253 million people in the world live with visual impairment, out of which 36 million of them are blind and 217 million people have some form of vision impairment. Though canes for visually impaired people help them to avoid obstacles on their way, that don't help to identify the type of object and to locate them. Hence identifying and finding out the distance of the object will be of great help for them.

* Sreeraj M. Tel.: +919447704583
E-mail address: sreerajtkzy@gmail.com

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Due to the difficulty in getting visual information, in many circumstances blind people seek the help of others. Several technologies have been developed to assist visually impaired people. Among the various technologies, due to their affordability and accessibility computer vision based solutions are emerging as one of the most promising options. This paper proposes an assistive system for visually impaired people and the main idea behind this is to create a handheld device that detects and identifies the surrounding objects and notify the user with an audio message. This will help people with vision problem to carry out daily activities without much external help.

The aim of the Viziyon system is to assist the blind by visual inspection to detect objects using image processing and provide audio output to identify the objects and distance between them. In other words, it takes an image of the object as input and outputs the distance between the blind and obstacle. It also converts the object's name to audio. It uses different techniques and hardware like the HC-SR04 ultrasonic sensor, Arduino UNO, Raspberry Pi, Pi camera, etc. The real-time object detection has 3 major stages:

1. Distance calculation: This is the first stage of the system. In this stage the distance between the blind and obstacle is calculated. It inputs real time detected object and outputs distance to the object.
2. Real time object detection: In second stage real-time objects are detected. It inputs real time video, which contains a lot of objects and outputs the detected objects.
3. Convert output to audio: In this stage it produces an audio output of the detected object. Real time detected object is given as the input and it outputs the corresponding audio.

Object detection system for the blind is one of the accurate systems which can help the blind to explore their surroundings more better. This helps to identify the obstacle and assist them to navigate from one location to another. And by detecting each object it calculates the distance between the blind and object. Finally, it provides the audio output about the obstacle. So it will be more user-friendly and portable for the blind. And it helps the blind to understand the surroundings without the support of another person.

2. Literature Review

Even though there had been lot of innovations carried out for visually impaired people,the technological advancements in this area has a larger scope than most of us could ever imagine. When we analyse the struggles of such people the ability to detect the obstacles before them come upfront. A method used by them was guide dogs and walking sticks. So an assistive technology is needed for them to navigate comfortably, independently and safely.

Many systems have emerged in the market for the purpose. Some of them are wireless communication, Visually impaired people face quite a lot of struggles in their daily life, but most of the struggles have been rectified with technological innovations. Among them mobility still haven't been a possibility E.A.B Santos et al.[11] proposes a module with the help of smartphone and embedded system to communicate through wireless medium for public transport. While Giva Andriana Mutriara et al.[8] described about a tool that tells the destination of building with the help of GPS module that visually impaired people want to go. Another method introduced by Zaid. O et al.[1] was rehabilitative shoes and spectacles for the blind. This system uses an ultrasonic transducers to detect the obstacles before them. The depth, pit and object can be detected using this.

Cang Ye et al.[13] put forward a 3D object detection method that could implement an automatic real time detection to identify structural obstacles in indoors. But Bor-sting Lin et al.[7] proposed a smartphone based guiding system to help the visually impaired people. It provides obstacle avoidance by giving an overview of their surroundings. The smartphone can capture the scene in front of the user and the processing done using Convolutional Neural Network or YoLo and give the result to the smartphone itself. Because of the availability of network they can use it in two modes, either online or offline. Hsueh-Cheng Wang et. al[12] introduced a system based on wearable device consisting of camera, an embedded computer and vibration motors. It is able to identify the location of the chair, distance from the obstacles based on the depth from camera and provide the vibration feedback. A. J. Ramadhan[10] described about the remote monitoring functionalities on a wearable smart system endowed with modules like sensors, GPS and alarms to family members and caretakers. Makarem Aljahdali[2] designed an IoT based walker system with a mobile phone for elderly and visually impaired people. W. M. Elmannai et.al[5] implemented an obstacle avoidance system with .NET Gadgeteer-compatible mainboard based on fuzzy logic. It can detect 10 objects.

Monica Gori et.al[6] through their work discusses the problem of low user acceptance of technology based tools for the visually impaired people. Lack of tools for visually impaired children is discussed and also discusses available technology.

Everyday at least a new technology is being invented across the world and especially in the field of automated systems, the progress has been rapid and steady. This world could have never imagined visually impaired people wearing an automated helmet mounted with wearable computer, stereo cameras and stereo earphones to ease their navigation. T G.Balakrishnan et al.[4] suggests such a breakthrough in mobile technology that uses a sensor to capture images and process the captured images to detect objects and provide an audio message using stereo headphones. This can be useful in every environment-indoor and outdoor.

Diulhio Candido de Oliveria et al[9] introduce another methodology dependent on CNN for ongoing individuals acknowledgement on flying pictures got from cameras appended to little UAVs. This methodology consolidates pictures from an ease warm camera to distinguish competitor items and CNN for the order task. By using saliency map identification and course classifiers along with CNN, acquired a higher rates of 95% of accuracy. These outcomes have been obtained inside constant handling of 1.08 fps in the most pessimistic scenario on an equipment with no GPU preparing. Arora, A., Grover, A., Chugh, R. et al.[3] proposed as Deep Neural Network (DNN) based approach for detecting objects for helping visually challenged people. It uses mobileNet model for object detection.

The existing approaches have many drawbacks such as high cost, lacking to be user friendly, requirement of many sensors. The proposed system overcomes these drawbacks. Figure 1 shows the currently used systems by visually impaired people.

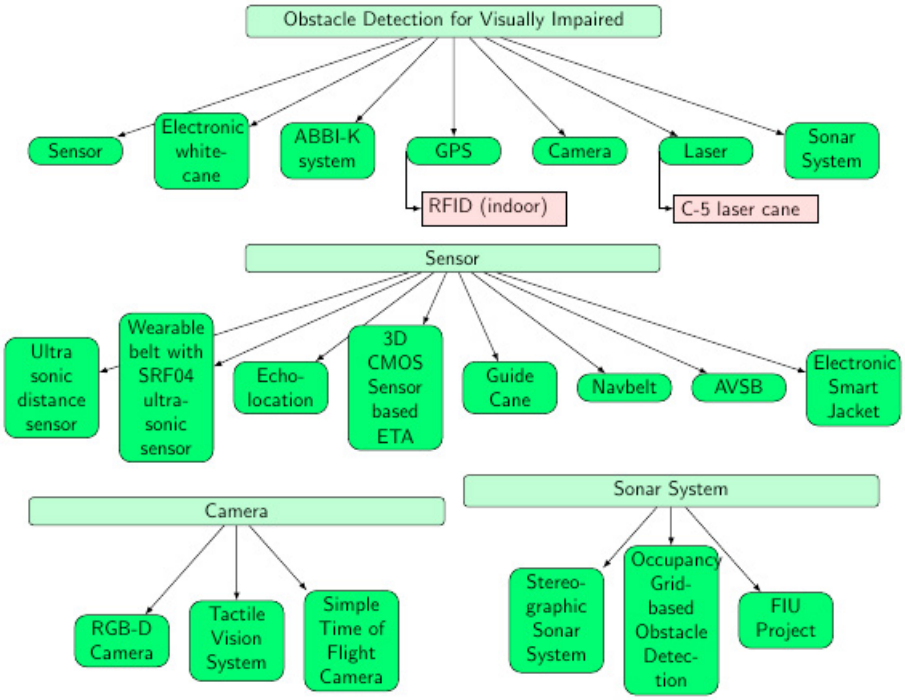

Fig. 1. Taxonomy of existing system

3. Design and Implementation

Different modules of the proposed system is illustrated in Figure 2. System takes video as input and uses a sensor to calculate the distance and provides feedback to user as audio.

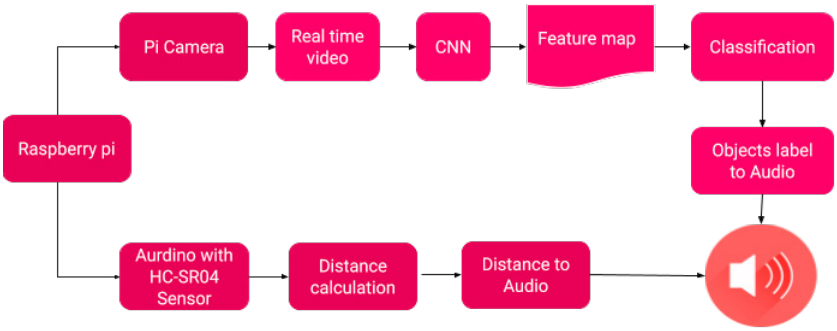

Fig. 2. Block diagram of the proposed system

Interaction with visually challenged people revealed that difficulty in using wearable device, its high cost are some of the problems faced by blind people. Providing depth information will be helpful. Viziyon is designed with this in mind. Viziyon is able to provide a real-time object detection device. Through pi camera real time video is captured and converted into different frames. These frames are fed to Convolutional Neural network for identification of objects.

Object detection is done using Faster R-CNN. In Faster R-CNN, both region proposal generation and object detection task are done by the same convolutional networks. With such design, object detection is much faster than the other algorithms.

DNN architecture consists of several layers. The layers usually contains combination of convolution, max-pooling and normalization stages. For object detection DNN takes pixel values as input and propagates information feed-forward through the layers. Thus, activating the neurons at each successive layer with particular activation values.

Convolution layer consist of set of independent filters which is convoluted with the image and produce feature map and each feature map consists of neurons with same connection weights. Pooling layer is progressively reduce the spatial size of the representation and operates on each feature map independently. This helps to reduce the amount of parameters and computation in the network.

In Faster R-CNN, RPN(Region Proposal Network)using selective search is replaced by RPN using CNN.And this CNN is shared with detection network. The occurrence of objects is identified by the classifier and regressor predicts the anchor/boxes corresponding to the objects from the output of the region proposal network(RPN).This has the ability to identify and classify the overlapping objects in efficient manner. Later it refines the anchor being background and foreground. Architecture of F-RCNN is shown in Figure 3

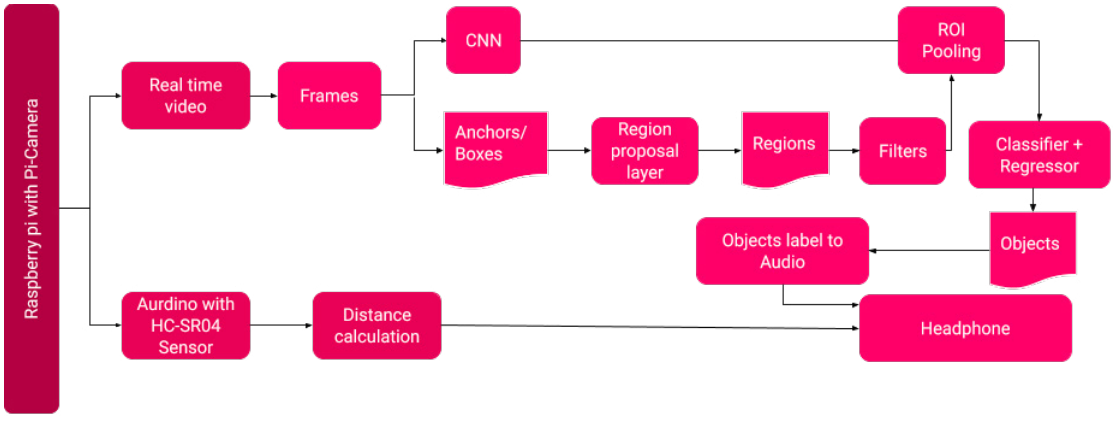

Fig. 3. Architecture of Faster RCNN

After RPN, we get proposed regions with different sizes. Different sized regions represents the CNN feature maps of different size. Later, the feature map is reduced into same size using the max pooling function into a fixed number of roughly equal regions in Region of Interest. Once the object is identified from the video the name of the object is given as an audio to the visually impaired person. In case of overlapping objects the system produce result with the help of the position and intersection of anchor.

Viziyon uses Pi camera to capture real time video, from which frames are extracted. It uses hardware such as HC-SR04 ultrasonic sensor integrated with Arduino UNO. Camera pooled with Raspberry Pi is used for object identification.

1. *Raspberry pi:* The Raspberry Pi is a low cost, small sized computer that can be connected to a computer monitor or any other external display and also with the mouse and keyboard via USB. This device is capable of computing and programming languages like C and Python. The device is powered by 1.4GHz 64-bit quad-core ARMv8 CPU and 1 GB of RAM. The same device also includes on board Wi-Fi and Bluetooth, 40 pin GPIO, 4 x USB ports, composite video and HDMI port, Micro SD port and Micro USB power source.
2. *Pi camera:* The Pi's camera module is a add-on for Raspberry Pi. It is attached to one of the sockets on the upper surface of the board. It has a dedicated CSI-2 interface, which facilitates the connection for small camera module. 5 MP Pi camera is used to take high resolution video and the output is fed to Raspberry Pi for further processing.
3. *Ultrasonic sensor:* HC-SR04 Ultrasonic sensor is a 4 pin module which is used in measure the distance within a wide range of 2cm to 400cm. It has a transmitter and receiver module which transmits an ultrasonic wave that travels through the air and receiver module observed the reflected wave reflects from the objects by any material. Thus it helps to avoid and detect obstacles like wells, pits etc to the user.
4. *Open CV and Python:* OpenCV is an open source computer vision library used for image processing, computer vision and machine learning. In Viziyon we used DNN module of OpenCV.

4. Results

The statistical measures such as precision, recall and accuracy are used to analyse the detection process. Table1 shows the overall performance of the device. The Proposed system focuses on identification of objects and convert it into audio. The system is efficient , user friendly and portable. The real time video is captured using pi camera module which is connected to raspberry pi and converted into frames. The object is detected from the real-time video and provided as Audio output to the user. Figure 4 shows the overview of the system. Figure 5 shows the object detection in real-time video. The detected object is displayed as Label with the Accuracy of Detection. This Label is converted to audio and provide that as output to the user. This makes them aware of the object before them.

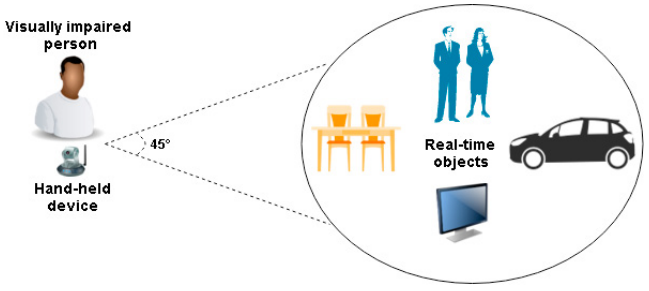

Fig. 4. Overview of the system

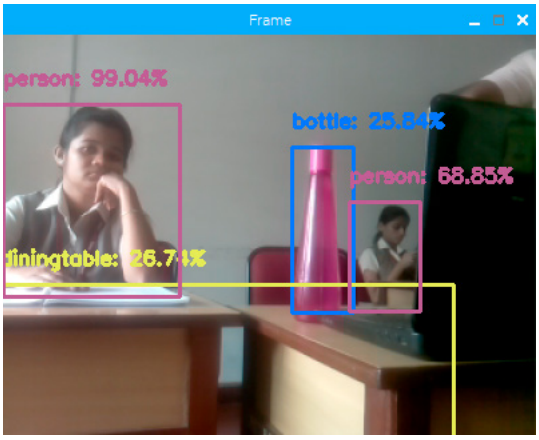

Fig. 5. Real-time object detection result

Sensitivity(Recall)	0.94	TPR=TP/(TP+FN)
Specificity	0.84	SPC=TN/(FP+TN)
Precision	0.92	PPV=TP/(TP+FP)
Accuracy	0.91	ACC=(TP+TN)/(P+N)

Table 1. Performance

For obtaining efficient classifier to detect the real time objects from videos we made a comparison with three classifiers such as SVM, DNN and Faster-RCNN. Figure 6 illustrates the comparison measures between SVM, DNN and Faster-RCNN and Faster-RCNN outperforms than other classifiers.

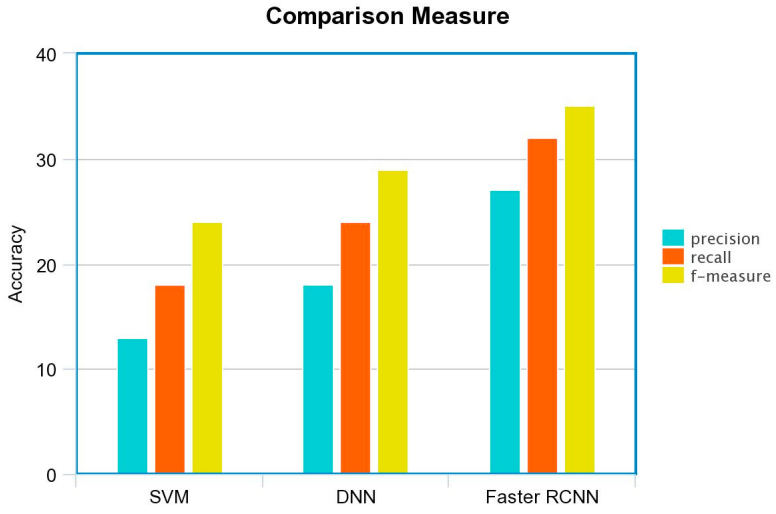

Fig. 6. Comparison between different classifiers

Another experiment was conducted to obtain the efficient angle to detect the objects. Thus it helps the people to detect the objects within that angle. Table 2 gives the accuracy of the system for different angles.

Angle (in degree)	Accuracy (in percentage)
10 - 20	64
20 - 30	76
30 - 40	89
40 - 50	68

Table 2. Different angle with accuracy

5. Conclusions

This paper describes Viziyon, a low cost handheld device for aiding blind people. Equipped with deep learning techniques, this device provides audio feedback to the user regarding the objects detected and distance from the user. This novel feature is helpful since it helps the user in identifying how far each object is. Results shows that Viziyon using Fast-RCNN technique is efficient for object detection as compared to other mechanisms and can easily be used by deaf people. For this Fast-RCNN is compared with SVM and DNN based techniques.

References

[1] Abu-Faraj, Z.O., Jabbour, E., Ibrahim, P., Ghaoui, A., 2012. Design and development of a prototype rehabilitative shoes and spectacles for the blind, in: 2012 5th International Conference on BioMedical Engineering and Informatics, pp. 795–799. doi:10.1109/BMEI.2012.6513135.

[2] Aljahdali, M., Abokhamees, R., Bensenouci, A., Brahimi, T., Bensenouci, M., 2018. Iot based assistive walker device for frail visually impaired people, in: 2018 15th Learning and Technology Conference (L T), pp. 171–177. doi:10.1109/LT.2018.8368503.

[3] Arora, A., Grover, A., Chugh, R., Reka, S.S., 2019. Real time multi object detection for blind using single shot multibox detector. Wireless Personal Communications 107, 651–661. URL: https://doi.org/10.1007/s11277-019-06294-1, doi:10.1007/s11277-019-06294-1.

[4] Balakrishnan, G., Sainarayanan, G., Nagarajan, R., Yaacob, S., 2006. A stereo image processing system for visually impaired. International Journal of Signal Processing 2, 136–145.

[5] Elmannai, W.M., Elleithy, K.M., 2018. A novel obstacle avoidance system for guiding the visually impaired through the use of fuzzy control logic, in: 2018 15th IEEE Annual Consumer Communications Networking Conference (CCNC), pp. 1–9. doi:10.1109/CCNC.2018.8319310.

[6] Gori, M., Cappagli, G., Tonelli, A., Baud-Bovy, G., Finocchietti, S., 2016. Devices for visually impaired people: High technological devices with low user acceptance and no adaptability for children. Neuroscience & Biobehavioral Reviews 69, 79 – 88. URL: http://www.sciencedirect.com/science/article/pii/S0149763415302864, doi:https://doi.org/10.1016/j.neubiorev.2016.06.043.

[7] Lin, B.S., Lee, C.C., Chiang, P.Y., 2017. Simple smartphone-based guiding system for visually impaired people. Sensors 17, 1371.

[8] Mutiara, G.A., Hapsari, G.I., Rijalul, R., 2016. Smart guide extension for blind cane, in: 2016 4th International Conference on Information and Communication Technology (ICoICT), pp. 1–6. doi:10.1109/ICoICT.2016.7571896.

[9] Oliveira, D.C.D., Wehrmeister, M.A., 2016. Towards real-time people recognition on aerial imagery using convolutional neural networks, in: 2016 IEEE 19th International Symposium on Real-Time Distributed Computing (ISORC), pp. 27–34. doi:10.1109/ISORC.2016.14.

[10] Ramadhan, A.J., 2018. Wearable smart system for visually impaired people. Sensors 18. URL: https://www.mdpi.com/1424-8220/18/3/843, doi:10.3390/s18030843.

[11] Santos, E.A.B., 2015. Design of an interactive system for city bus transport and visually impaired people using wireless communication, smartphone and embedded system, in: 2015 SBMO/IEEE MTT-S International Microwave and Optoelectronics Conference (IMOC), pp. 1–5. doi:10.1109/IMOC.2015.7369087.

[12] Wang, H., Katzschmann, R.K., Teng, S., Araki, B., Giarr, L., Rus, D., 2017. Enabling independent navigation for visually impaired people through a wearable vision-based feedback system, in: 2017 IEEE International Conference on Robotics and Automation (ICRA), pp. 6533–6540. doi:10.1109/ICRA.2017.7989772.

[13] Ye, C., Qian, X., 2018. 3-d object recognition of a robotic navigation aid for the visually impaired. IEEE Transactions on Neural Systems and Rehabilitation Engineering 26, 441–450. doi:10.1109/TNSRE.2017.2748419.