PARTHA: A Visually Impaired Assistance System

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***Abstract*—Blindness is very common and unendurable disability among many disabilities. According to the World Health Organization(WHO), there are 285 million visually impaired people [1]. The proposed VI (Visually Impaired) Assistant System is developed to assist the visually impaired people have four modules which are obstacle recognition, obstacle avoidance, indoor and outdoor navigation, and real-time location sharing. The proposed system is a combination of smart glove and smart-phone application which works fine in the low light level also. The smart glove as a part of the proposed solution is used to detect and avoid obstacles and to enable visually impaired people to identify the world around them. The smart-phone-based obstacle and object detection is used to detect various objects in the surrounding. The system also provides seamless indoor navigation implemented using available Wi-Fi access points. The system also provides security to the blind via real-time location sharing in an outdoor environment. Our proposed system is reliable, affordable, practical and feasible.**

***Index Terms*—Image Processing, Arduino, Indoor Navigation, Speech Commands, indoor localization, visually impaired people, Obstacle detection, Ultrasonic sensors**

I. Introduction

As we look back into our lives, the greatest gift that all of us would undoubtedly cherish is the gift of vision. Vision allows us to see the world around us and also helps to navigate through an unfamiliar environment. According to the World Health Organization(WHO), there are 285 million visually impaired people. Visually impaired people with a very limited power of sight encounter a lot of difficulties in mobility and even fall in dangerous situations. Pedestrians are often forced off of sidewalks that are clutter with vendors, animals, and other obstacles. Blind people typically use a cane but traditional cane can't detect objects higher than the waist.

Therefore it is important to use technology to make their life better and easier. This paper aims to design an efficient blind assistance system for the visually impaired people which can help them to overcome their day to day life problems and to roam around comfortably. There are many systems available to assist visually impaired people for mobility but they have limited capabilities. Therefore we have proposed an integrated system that includes a complete set of functionalities to aid visually impaired person for mobility. The proposed system mainly consists of 4 different modules:

- Obstacle avoidance
- Obstacle/Object detection
- Indoor localization and navigation using WiFi access points
- Real time outdoor location sharing.

For detection of obstacles, we have built a completely independent hardware module (smart glove) which uses proximity sensors and vibration motors to find obstacles as well as the distance between user and obstacle. Other three functionalities are implemented as an Android application. The interaction between user and android application is through voice-based commands. After detecting the obstacle, the object detection module provides information about the obstacle to the visually impaired. Object detection module prompts the names of objects in front of the user. Applications like google maps only provide outdoor navigation. These applications use GPS to provide the location of the user but GPS doesn't work in an indoor environment. We have used a solution for indoor navigation using Wi-Fi access points. It uses RSSI measurements of access points to find the exact location of the user inside the building. Real-time location sharing can be used to track a visually impaired person in an outdoor environment by his relative.

II. Related Work

A conventional method that has been used for decades for the assistance of the visually impaired is the use of guide dogs that are trained to help the blind to navigate and walking cane for avoiding obstacles. There are some devices like smart goggles and shoes are proposed in [2] to assist in mobility safe navigation of blind people. Each shoe is mounted with ultrasonic transducers which help to detect the objects at a specific height. The spectacles also have two ultrasonic transducers for obstacle detection and alert is provided with the help of buzzer. The solution which uses a cane has ultrasonic sensor attached to the cane and Camshaft Position Sensor (CMP) compass sensor 511 which provides information about various obstacle and potholes [3]. There are couple of disadvantages associated with this approach. As the solution uses cane as a primary solution, the obstacles which are present up to knee height can only be detected. Also, the CMP compass sensor can be affected by any iron object in the surroundings. This method assists blind in the outdoor environment but faces issues in case of indoor navigation. The solution only detects the obstacle and does not try to recognize them which can be a major drawback. An image processing system for visually impaired is proposed in solution uses wearable stereo cameras and stereo earphone [4]. These devices are mounted on a helmet. The image of the scene in front of the visually impaired is captured by the stereo cameras. The captured images are then processed and important features are extracted to describe the scene for navigation assistance. The distance parameters are captured by stereo cameras. The system is very complex and cost-ineffective as it uses stereo cameras. Real-Time Visual Recognition with results converted to 3D Audio is a system with multiple modules. Video is captured by a portable camera device like GoPro and the captured stream is processed on a server for real-time image recognition with an existing object detection module [5]. This system has processing delay which makes system difficult for real-time functioning. The objects can be identified and tracked by using the color-based object identification technique [6]. The solution uses color features for feature extraction to identify objects. Also, the classification of images into significant and non-significant categories using a supervised learning technique is proposed with the help of Haar Cascade based object identification [7].

Table I shows the comparison between various TenserFlow mobile object detection models based on the inference time and performance. The mAP performance of the models vary greatly, and more complex Faster RCNN Inception model reaches near-optimal performance but the inference time is much more than less complex Tiny Yolo model for the same.

TABLE I: Inference time and mAP performance of trained models.

Model	Inference(ms)	mAP
Tiny Yolo V2	VOC 2007+2012	87.57
SSD MobileNet V1	COCO trainval	91.16
SSD MobileNet V2	COCO trainval	91.90
SSD Inception V2	COCO trainval	96.82
Faster RCNN Inception V2	COCO trainval	96.69

The existing solutions suffer from drawbacks such as limited scope and functionality, cost inefficiency, systems not being portable, multiple sensor requirements, and fail to navigate visually impaired in indoor as well as outdoor environments in real time. We have made sincere attempts to gather all positives from above solutions and to make a complete, portable, cost-efficient system which can solve real problems effectively.

III. VI Assistant System

The proposed VI Assistance system is mainly aiming at novel approach towards designing and deploying an integrated system that includes a complete set of functionalities to aid a visually impaired person in navigation. The proposed system mainly consists of 4 different modules:

- Obstacle detection
- Object detection
- Indoor localization and navigation using WiFi access points
- Real time outdoor location sharing.

A. Obstacle detection / avoidance

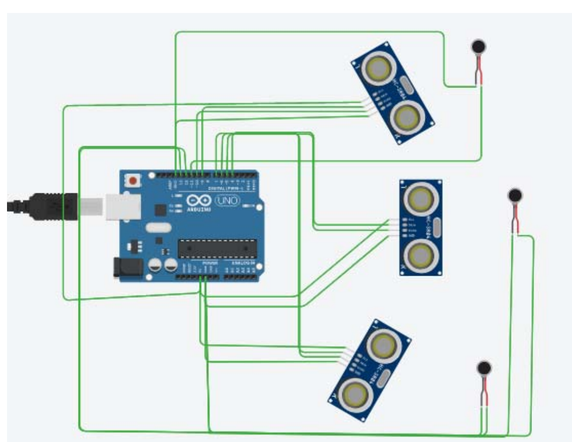


Fig. 1: Smart glove circuit diagram for Obstacle detection module

The module has been developed in the form of the smart glove which integrates Arduino UNO, ultrasonic sensors and flat vibrating motors. Ultrasonic sensors emit short, high-frequency sound pulses at regular intervals. These propagate in the air at the velocity of sound. If they strike an object, then they are reflected back as echo signals to the sensor, which itself computes the distance to the target based on the time-span between emitting the signal and receiving the echo. Such three ultrasonic sensors are used for detecting obstacles in three directions i.e Left, Front, and Right direction. The three vibration motors are mounted on three different fingers of the glove i.e thumb, middle finger and little finger which alerts the user about direction of the obstacles. Vibration motor is a core-less DC motor and the size of this motor is compact. The main purpose of this motor is to alert the user. The main feature of this motor is, it has magnetic properties, lightweight, and motor size is small. Because of the magnetic field, a force can be generated which causes the weight to move. The frequent dislocation of the weight generates an unstable force called as vibration. Motor's commutation points can be used to change the pairs of polarity, so that when the rotator moves, then the electrical coils are continually overturning the polarity. If any static obstacle comes within the range from 20 mm to 10 m respective motors will vibrate.

Algorithm 1 Obstacle Detection

Input:

- dl ← distance from the left obstacle
- dr ← distance from the right obstacle
- df ← distance from the front obstacle

Output: Vibrate respective motor.

```
function_vibrate():

if (dl <= 70) then
    Vibrate left motor
end if
if (dr <= 70) then
    Vibrate right motor
end if
if (df <= 70) then
    Vibrate front motor
end if
```

B. Object Detection

For object detection, we have developed a CNN based model and implemented it using Tensorflow and Android. The model is trained using SSD mobilenet v1 architecture. The proposed model is trained on COCO dataset consisting of 80 object categories.

The CNN model is deployed in android by using interface provided by "Tensorflow android Camera Demo". All the trained parameters are stored in a protobuffer file. Before deploying the model in an android device the CNN graph is converted into a frozen graph. By using the "InferenceInterface" tool android app can read the tensor values from the frozen graph. The input to the application is live video stream from the Android camera. Each frame from the live feed is given to the CNN model which detects the objects in the frame and mark than with the boxes in real time. When the object is detected, the TextToSpeech engine will give audio feedback to the visually impaired person about object and confidence.

The overall app architecture is as shown in Fig.2.

C. Indoor Navigation

Algorithm 2 Estimating the current location of user

Input:

- *ssid_rssi_val*[ ] ← array consisting of real time RSSI values of each AP
- *ssid_rssi_val*[ ] ← array consisting of MAC address of each
- *stored_value*[ ] ← already captured RSSI value of AP

Output: loc (best current location of user).

```
function LOCATION( ssid_rssi_val[ ], ssid_rssi_val[ ], stored_value[ ] )
    for <each MAC_access_point> do
        real_time_value =
        ssid_rssi_val[MAC_access_point]
        location_grade =
        (stored_value-real_time_value)^2
        total_location_grade[loc] =
        total_location_grade
        location_grade
    end for
    for <each loaction_grade in total
    location_grade[]> do
        temp1 = location_grade
        temp2 = how many time location
  is
        grade
        avg_location_grade[loc] =
        temp1/temp2
    end for
    loc = min(avg_location_grade[])
    return loc
end function
```

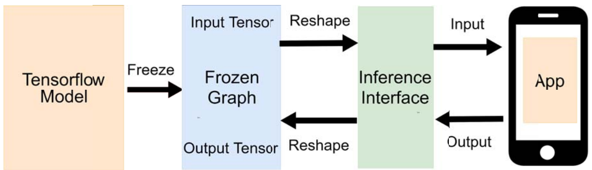


Fig. 2: Object detection architecture diagram.

This module is implemented using already available WiFi access points in the infrastructure. It is achieved using Wi-Fi Fingerprinting which has been commonly used for indoor positioning. Fingerprinting is nothing but building a map for determining the location of the user. It is divided into two parts, first is collecting the RSSI values of WiFi APs in order to build a fingerprint map. This is done by visiting every location on the floor and collecting RSSI values of all APs at that location. In the second part, the user receives real-time RSSI values of each AP using through an app that uses an estimation algorithm to estimate the user's current location.

D. Real Time Location Sharing

Sometimes it may happen that visually impaired person may get lost in the outdoor environment. In that case, he can share his live location through VI Assistance app by giving a voice command. After sharing location notification will be sent to the relatives of a visually impaired person along with SMS so that they can track him in real time. This is implemented using Firebase Cloud Messaging service.

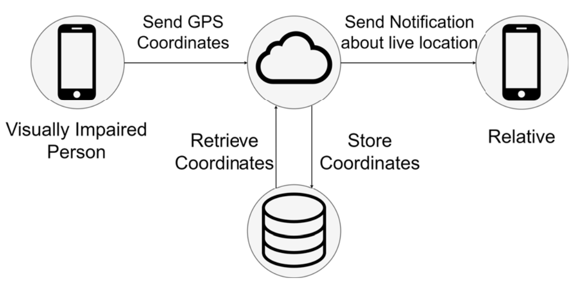


Fig. 3: Real time location sharing using cloud

IV. Results

The main purpose of the proposed system is to assist visually impaired people via obstacle and object detection. One of the modules (smart glove Fig. 5) of the system is very light weight and mounted on hand of the person. The combination of ultrasonic sensors and vibration motors is able to provide information about the obstacles and the direction as well as the range of the obstacles even in the low light.

The user can detect the objects which are detected by the obstacle detection module by providing voice commands to the smartphone-based mobile application Fig.4. The speech input is recognized by the object detection module and the system guides the visually impaired to recognize the object efficiently. Confidence score of the object detection module is given in Table II. The module works in low light as well. If luminosity goes below a specified threshold, the torch is turned on.

TABLE II: Results for the object detection module

Class	Confidence Score	Location
Bottle	0.72	[88, 21, 77, 123]
Chair	0.85	[7, 82, 89, 163]
Laptop	0.92	[18, 21, 57, 63]
Cell Phone	0.87	[6, 42, 31, 58]
Orange	0.88	[100, 30, 180, 150]

The proposed system provides security to a user by using the real-time location sharing as shown in Fig.6 and hence the visually impaired can share his live location just by giving a voice command when needed.

The visually impaired can also be guided in the indoor environment from source to destination as in Fig.7. The user provides source and destination via voice commands to the indoor navigation module which then helps him to reach his destination via step by step audio instructions.

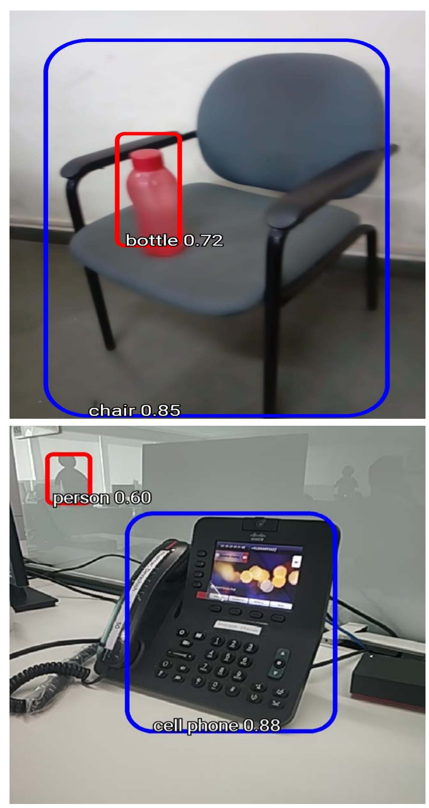


Fig. 4: Real time Object Detection

Fig. 5: Smart glove for obstacle avoidance

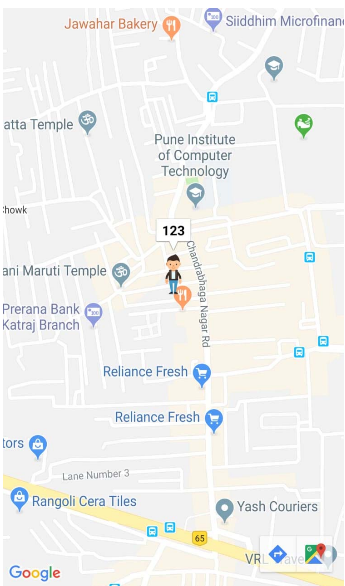
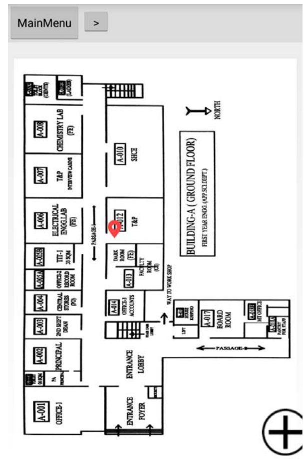
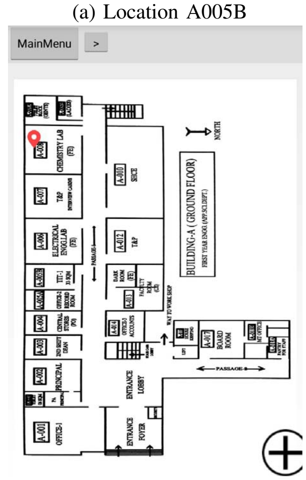


Fig. 6: Real time location sharing



(a) Location A005B



(b) Location A008

Fig. 7: Indoor Localisation

V. Conclusion and Future Scope

The proposed system gives an effective solution to assist visually impaired people. The system has multiple modules and simple architecture which makes it more practical and easy to use. The system claims to assist visually impaired not only by detecting obstacles around them but also recognizing them and providing the respective information like type and distance from the obstacle. The indoor navigation and live location sharing module help the user to navigate in known as well as the unknown indoor environment. The preliminary results show that the system is easy to use, effective, safe and fulfill all the targeted goals to assist visually impaired. The system is user-friendly as it accepts the instruction and gives the response in audio format. The system is affordable, reliable and satisfies other non-functional requirements.

The proposed system can be enhanced by adding certain significant changes as listed below.

Current indoor navigation system requires training for location learning and navigation to be done by an administrator. The system can be enhanced by dynamic training for indoor navigation module by tracking daily movements of other normal people. Real-time scene description can be provided by capturing images around the visually impaired person. In the current system, the path between two different places is set manually by an administrative person. The system can be improved by using the shortest path finding algorithms like Dijkstra's algorithm and representing interconnection between places using a weighted graph.

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