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Godeye: An Efficient System for Blinds

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ABSTRACT

The technology is growing vastly. Everyone in humanity has some limitations. One of those limitations is visual disability. So we are here with a system that helps the visually disabled people. The framework here contains object detection with voice assistance within an app and a hardware part attached to the blinds stick for distance calculation. The app is designed to support the blind person to explore freely anywhere he wants. The working of the framework begins by surveilling the situations around the user and distinguishing them utilizing a camera. The app will then detect the objects present in the input video frame by using the SSD algorithm comparing it with the trained model. The video captured is partitioned into grids to detect the object/obstacle. In this way, the subtleties of the object detected can be achieved and along with it distance measurement can also be calculated using specific algorithms. A Text to Speech (TTS) converter is utilized for changing over the data about the object detected into an audio speech format. The framework/application passes on the scene which the blind people is going in his/her territorial language with the snap of a catch. The technologies utilized here makes the framework execution effective.

KEYWORDS: *visual impairment, android phone, object/obstacle detection, text-to-speech*

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I. INTRODUCTION

Real time object detection is vital for several real-world vision applications. Recent studies show that certain objects like a face can be detected reliably and fairly quickly. The speed of object detection isn't fast enough as needed by the applications. The goal of this paper is to supply a way which can help the visually impaired person to detect obstacles through object detection. One essential sense among human sense is vision and also vision plays an important role inhuman perception about the encompassing environment. Hence, thousands of papers are published on these subjects that propose a selection of computer vision products and services by developing new electronic aids for the blind. This paper aims to introduce a proposed system that restores a central function of the visual system which is that the identification of surrounding objects. Our contribution is to introduce the thought of a visible substitution system based on features extractions and matching to recognize/identify and locate objects in the video in real-time through an android app.

Computer vision technologies, especially the deep convolutional neural network, have been rapidly developed in recent years. It is promising to use state-of-art, computer vision techniques to assist people with vision loss. The main aim is to find the possibility of using the sense hearing to know visual objects. It is not often realized by many people that we are capable of identifying the spatial location of a sound source just by hearing it with two ears. The work aims to guide blind people through the output of the system by voice to navigate them through an android app. The methodology of this work includes Object Extraction, Feature Extraction, and Object Comparison.

One of the issues faced by visually impaired individuals is to travel in a corridor. They cannot find either they need to turn left or turn right once they reach the end of the corridor and they get stuck in between the objects if it comes along their way. When the visually impaired individuals enter the corridor, they need to find the border of the sidewalk within the corridor. They use their walking stick to define their current location. the existing solutions somewhat helped visually impaired individuals. But all the solutions has its drawback. And there's no existing method that helps to solve the all basic needs of blind people. All the existing systems are designed just for a selected purpose.

Although object tracking represents a fundamental problem in the computer vision community due to the wide range of related applications (e.g., automatic video surveillance, wearable assistive devices, robot navigation, structure from motion, or human-machine interaction), it is still an open issue of research. Despite significant progress achieved within the last decade, tremendous challenges still exist in designing a strong object tracker able to handle important changes in viewpoint, object motion, light variation, object occlusion, or background clutter. Through this paper, we propose a completely unique joint object detection/recognition frame-work, called GOD EYE, based on computer vision algorithms and offline trained deep convolutional neural networks. The proposed framework is integrated within a device, dedicated to visually impaired (VI) users. Here we making an android app for the users.

There are several object detection strategies/algorithms which will be used here like YOLO[2][21], SSD[11], RCNN[16], Fast R-CNN[9], Faster R-CNN[10], R-FCN[12]. These algorithms give different rates of performance. So, by considering the implementation simplicity and for improving performance comparing with other object detection algorithms SSD gives better performance and simple implementation.

So, our contribution is an android app for visually impaired people using the better performing object detection algorithm with voice assistance and measuring the distance using an ultrasonic sensor which is helpful for the blinds in their day-to-day life like staying off from the obstacles and easily wandering in the new surroundings by the voice output and the alert signal.

Here we are using the model SSD for object detection. Here we are employing a trained model SSD MobileNet V1 coco model, so that we can implement the system godeye easily. the object detection algorithm used here gives a better performance than the other existing object detection algorithm as it follows the bounding box prediction method for detecting the objects. So we are using a better algorithm here for detecting the object efficiently and with great accuracy.

The method that we propose here has the following specification:
- Real time processing & output.
- Better efficiency than other existing methods.
- Easy to handle.
- Alert signal after measuring distance.

The object detection CNN i.e. SSD ensures real-time processing and this deep learning model method used here is much helpful in implementing the system easier than using other object detection algorithms and therefore the detected object will be given as voice feedback by using TTS[18]. The distance measurement and alerting also become easy by using the ultrasonic sensor.

We summarize our contributions as follows:
- We propose GODEYE, with an object detection app based on SSD, it achieves an accurate detection result.
- We propose GODEYE, with a distance calculation and alerting system based on an ultrasonic sensor, it helps users by alerting from the moving obstacles.
- The camera and ultrasonic sensor are attached to the blind stick. The camera will be connected to the app to detect the object and provides the voice assistance.

II. PROBLEM DEFENITION

Visually impaired people face many challenges and one among the main challenges faced by them is self-navigation. It's very difficult for them to travel through a corridor. This is one among the main challenge faced by them. They find it hard to locate the directions i.e. they can't find whether or not they need to either turn left or turn right once they reach the end of the corridor and that they get stuck in between the objects. While walking through the corridor they should find the border of the sidewalk. They use a walking stick to define the situation. Although the present arrangements helped them yet these arrangements have downsides. There's no existing solution that solves all the requirements for the assistance of a visually impaired person. The existing solutions designed for a selected purpose. Each solution solved only a selected problem. Those never solved the whole problems as an entire.

III. RELATED WORK

NETRA[3], the smart hand glove which acts as an electronic eye is among the related works. The glove detects the obstacles within the path of the visually impaired person and it warns them. It works as an artificial eye for the person. The glove extracts the text from any image that contains text and converts that into speech. Another feature of this glove is that it helps the people to spot the object around them. The glove sorts out all the issues faced by the people. All the above tasks are very essential for the safe navigation of blinds.

NavBelt[4] is another related technology. this is often a guidance device that uses a mobile robot obstacle avoidance system. NavBelt is worn by the user like a belt and is equipped with an array of ultrasonic sensors. This will be utilized as both primary and secondary aid. This consists of a portable computer, ultrasonic sensors, and stereophonic imaging technique to process the signal from the ultrasonic sensors. Acoustic signals are provided via a group of stereo earphones which guides the user around obstacles or displays a virtual acoustic panoramic image of the traveler's surrounding. Acoustic signals are transmitted in the form of discrete beeps or continuous sounds. Experimental results with the NavBelt simulator and a portable prototype shows that users can travel safely in any unfamiliar and cluttered environment at speed of up to 0.8m/s.

The walking cane or the guide cane is another related technology. It detects the obstacles on the way using IR sensors and produces a buzzing sound as a warning. Using walking cane the obstacles only up to the knee-level within a limited range of 2-3 feet can only be detected. The main drawback is that the buzzer's sound isn't audible within the traffic sounds on the roads[5].

The Voice-enabled smart walking stick is another related technology. Ultrasonic sensors, Pit sensing unit, Water sensing unit, GPS module, GSM module Voice synthesizer, relay, speaker, embedded system, and battery are used in the system. The ultrasonic sensors are used in different sensing units of the system. If the smart walking stick is made with at most accuracy, then it'll help the blind people to move from one place to a different without other's help. This could also be considered an unrefined way of giving the blind a sense of vision. The usage of the stick can reduce the visually impaired from relying on other family members, friends, and guide dogs while walking around. The proposed combination of various working units makes a real-time system. The position of the user monitored is the system and also provides dual feedback. This feedback makes navigation more safe and secure. Objects or obstacles ahead of the users are detected using the smart stick and warning voice messages are sent as feedback instead of vibrations. The automated room equipment switching incorporated within the stick are going to be useful while they're indoor. The advantage of the system lies in the fact that it will prove to be a low-cost solution to many blind people worldwide[6].

Another related work is a smart navigational shoe. An electronic kit that is fixed in the shoe can be used by the blind or visually impaired person. The hardware kit consists of four vibrators, one Arduino, Bluetooth connection, and one battery. The obstacles along the path are sensed by sensors while moving along the path, if any obstacles encounter the path this will detected and informs the user. An android application that can be integrated with the smart navigational shoe is developed here. The starting point and the destination point are given as input by the user. The path for navigation is displayed using maps to users. The application which is integrated with shoes directs the person. The vibrators will vibrate along the path if an obstacle is detected. If it's a left turn that is to be taken according to the navigation, the vibrator assail the left side will vibrate. If it's a right turn that's to be taken according to the navigation, the vibrator set on the right side will vibrate[7].

A smart cap for the blind using the Raspberry Pi system is another related work that's easy to understand and maintain. This technique uses Raspberry pi which is a small processing device that works as a computer at a comparatively low cost. Visually impaired people find difficulties in detecting obstacles while walking in a street. By making use of Raspberry Pi, the system is intended to provide artificial vision and object detection, real-time assistance via GPS. The system consists of Ultrasonic sensors, GPS module, and therefore the feedback is received as audio. Voice output works through TTS (text to speech). The proposed system detects an object around them and sends feedback in the form of speech that's warning messages via earphones. It can also provide navigation to a selected location through GPS. the general system aims to provide a low cost, efficient navigation, and obstacle detection aid for the visually impaired which provides a sense of artificial vision by providing them with information about the environmental scenario of the static and dynamic object around them so that they can walk independently[8].

IV. GODEYE

The system is known as GODEYE. It includes an object detection app with voice assistance and Ultrasonic sensor for distance calculation and alerting. Normally, visually impaired people use a cane as a guide for them to protect themselves from obstacles. Most of the surrounding area are often covered with the assistance of the cane, especially the area nearer to their legs like stairs, etc. The system is designed to provide complete navigation for the user within the environment around them. It guides the user about obstacles, also it provides information about the appropriate obstacle-free path. This technique is an intelligent monitoring and alert system that involves the observation of real-time activities, with real-time constraints on video surveillance. The system consists of an android app connected to the camera attached to the blind's stick. This camera detects the obstacles/objects that come along the path of the visually impaired people or the users and an ultrasonic sensor attached to the blind stick measures the distance between the user and therefore the obstacle. The information is provided through voice output by the app and therefore the sensor gives an alert signal if the obstacle is extremely near to the user. Fig.1 shows the diagram of the system.

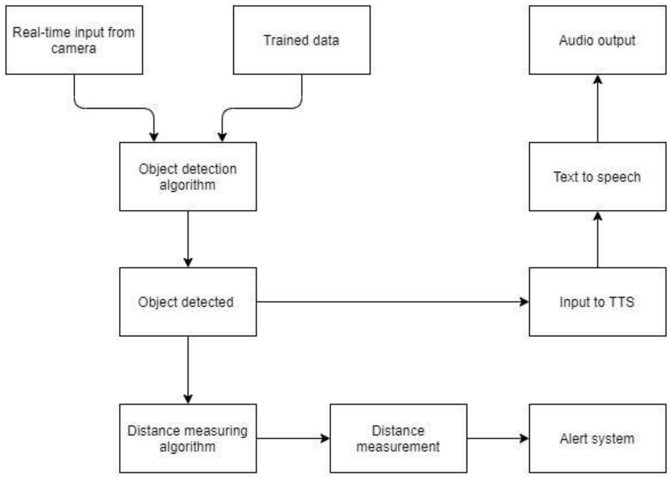

Fig.1. A block visualization of the system

The main challenge is to get the response in minimum time and also that the efficiency and accuracy of detecting the object should be maximum and it should also guide the user correctly. to overcome these challenges, here we are using better technologies and algorithms. We are using the SSD algorithm for better object detection and accuracy and Ultrasonic sensor for measuring the distance. To alert the user we are using buzzer which produces a beep sound. On opening the app the video surveillance begins. The streaming video is provided as an input to the object detection algorithm. Using the object detection algorithm the obstacles/objects that come along the navigation path of the user are detected. The backend used for object detection is Tensor Flow. the object detection algorithm gives the output as a string and therefore the string is given as an input to the TTS[18]. The TTS provides a voice output to the user. The architecture diagram of the android app is shown in Fig.2.

Simultaneously the distance calculation between the user and the obstacle is done using the ultrasonic sensor attached to the blind stick. For distance measuring the ultrasonic sensor is attached to Arduino UNO[19], and for the signal alert, a buzzer is attached to it. The space between user and object be calculated. A minimum distance is fixed, then the calculated distance and the minimum distance is compared if the distance between the user and the obstacle is less than the fixed minimum distance or equal to the fixed minimum distance the alert system gives a beep sound to the user which is inbuilt on the stick. The connections of distance calculation with a buzzer are shown in Fig.3. This how the GODEYE works.

A. OBJECT DETECTION

The detection of objects within the videos is done using feature extraction and detection. Feature matching using invariant features has obtained significant importance with its application in various recognition problems. These techniques have helped us to match images regardless of various geometric and photometric transformations between images.

The visual substitution system here is based on the identification of objects around the visually challenged person using an android App connected to the camera attached to the blind's stick. This technique should find the invariant characteristic of objects to viewpoint changes, provide the recognition, and reduce the complexity of detection. The method we've proposed here is based on the key-points extraction and matching in the video. A comparison is formed between the query frame and database objects to detect the objects in each frame. For every object detected a string file will be created and stored. Hence object detected string are going to be stored and given as input to TTS.

The video will be loaded using the real-time camera for object detection; then feature extraction is done. SSD (Single Shot Detector) algorithm is employed here for object detection. When the app is opened the video surveillance begins. The streaming video is provided as an input to the object detection algorithm. Using the object detection algorithm the obstacles/objects that come along the navigation path of the user are detected. The object detection algorithm gives the output as a string and therefore the string will be stored. Then the object detected string is given TTS for audio/Voice output of the object detected.

Here for object detection, we are using SSD300. By using SSD300[20], we only need to take one shot to detect multiple objects. It achieves a 74.3% mAP at 59 FPS. The network architecture of SSD300[24][25] is shown in Fig.4. to urge more accurate detection results, different layers of feature maps also are browsing the convolution for object detection. Each convolution will provides a specific number of bounding boxes for object detection. So, in total SSD300 gives 8732 boxes in total which is more than that of YOLO[13][14][15]. Due to this much bounding box, object detection is accurate and efficient. The model used for object detection here is the ssd mobile net v1 coco model. In SSD the image is divided into grids and each grid cell is responsible for object detection in that region. By dividing into grid cells there maybe loss occurs while detection. based on this the loss function of SSD is defined as:

$$L(x; c; l; g) = \frac{1}{N}(L_{conf}(x; c) + L_{loc}(x; l; g)) \quad (1)$$

Where L is loss function [20], L_{conf} is the confidence loss, $L_{l}oc$ is localization loss, is the weight for the localization loss, l is predicted box, g is ground truth box, N is the matched default boxes, c is the multiple class confidences and x is the indicator for matching default box with the ground truth box.

Based on the above object detection algorithm technique the object detection is implemented in-app. In this, the input frame must be 300x300. The SSD300 gives a faster and accurate results of object detection. The object detection is the major a part of the GODEYE system for visually impaired people.

B. TEXT-TO-SPEECH

The Google Text-to-Speech API is employed for getting the voice output of the detected object. The objects detected by class predictions in every frame will be a string e.g. "cat" and it'll be stored. This string will be given as input to the TTS converter. The TTS converter will convert the string that got into the user's natural language using the gTTs package used in the system. The TTS converter will do text analysis to the string given as input for converting it to the user's natural language. After the text will be searched in the speech database and choose the units compared to that. The speech generation module that presents within the TTS converter will make the text/string into speech and given as speech. This TTS process is completed by a text-to-speech synthesizer. The general process steps are shown in Fig.5. The speech made up of the input string will be given as the output from the android app. this is the main part of the implemented system. If multiple objects detected from one frame then based on the accuracy of the object the speech out will be got on the user's natural language. The speech from the TTS[22] is the major output from the app for the visually impaired person and it's heard by the user using earphones or by the phone speaker[18].

C. DISTANCE MEASUREMENT

The ultrasonic sensor is employed here for distance measurement between the user and the object/obstacle[23]. The ultrasonic sensor[19] attached to Arduino UNO are going to be attached to the blind's stick. The ultrasonic sensor one eye produces waves to detect the object, when the waves hit the object the waves will reflect the opposite eye of the ultrasonic sensor shown in Fig.6 by that the space is measured

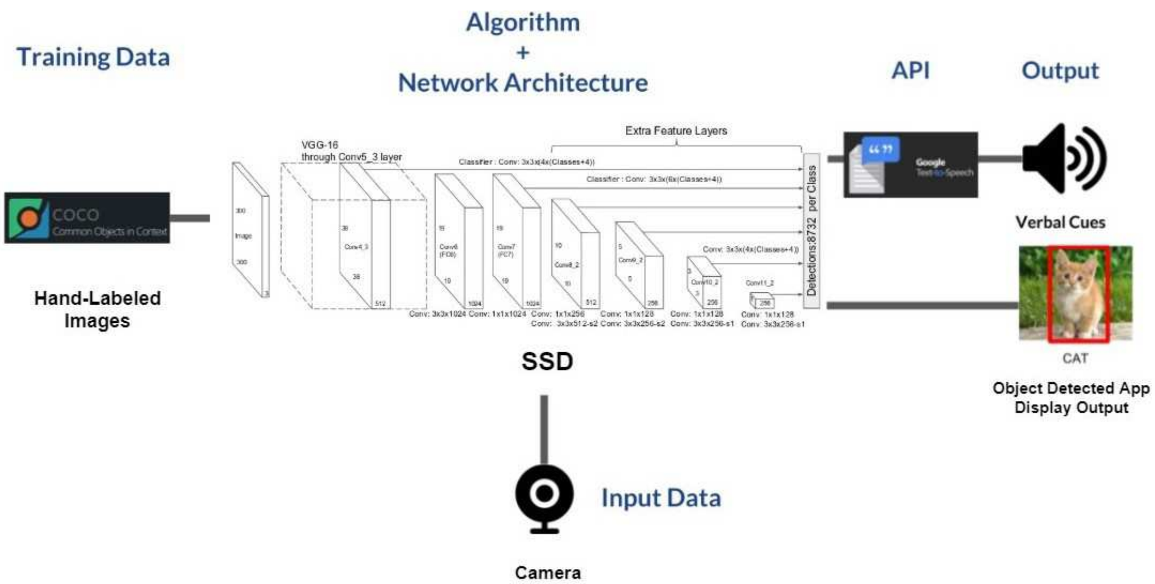

Fig.2. The system design of Android App.

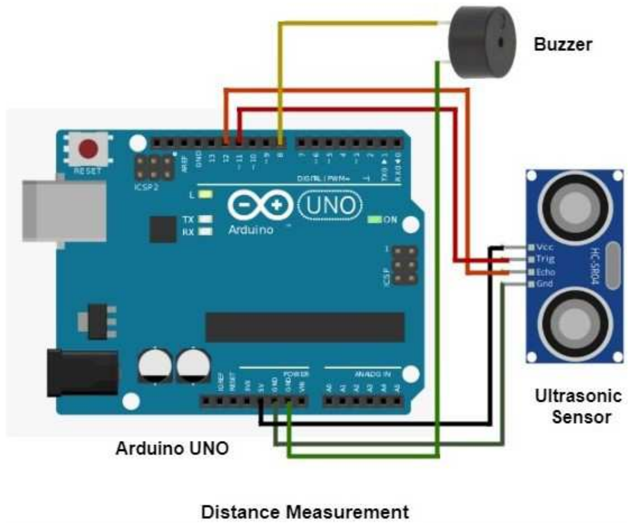

Fig.3. The connections of distance calculation and alert.

between the thing and therefore the user. The Arduino IDE is employed here for coding the ultrasonic sensor. It uses embedded C for coding the sensor. within the sensor, we set a threshold distance so that when the obstacle/object is equal or less than the threshold distance then an alert signal will be given to the user. The ultrasonic sensor can detect only the distance from 2cm to 400cm of non-contact measurement functionality with a ranging accuracy which will reach up to 3mm. But it's a sufficient distance for the user to get alerted. The ultrasonic sensor will update the distance between the user and the obstacle during a specific interval of time. So that the alert system can alert the user/visually challenged person on reaching the threshold distance.

The ultrasonic sensor uses sonar waves for echolocation, which be able to measure the distances. The ultrasonic sensor module has 4 pins- Ground, VCC, Trig, and Echo. The VCC and Ground pins of the ultrasonic sensor need to be connected to the 5 volt and ground pins on the Arduino Board and the echo and trig pins to any Digital I/O pin on the Arduino Board. The distance between the sensor and the object is defined as:

distance = speed x time
$s = v\,t$ (2)

The speed of the sound above water level is 340 m/s or 0.034 cm/µs. From the Echo pin, we'll get the time duration which will be double because the wave must travel forward and return backward. to get the distance in cm, we need to multiply the received duration time from the echo pin by 0.034 and divide it by 2. so that the correct distance between the sensor and object is defined as: here V = 340 m/s or v = 0.034 cm/µs, so,
s = 0:034 t=2 (3)

This is how distance measurement is done by the ultrasonic sensor present within the system. Based on the distance measured the threshold distance will be set and on that basis, the alert signal is given to the user by using buzzer with a beep sound. The alert will continue if the user is moving closer to the object. the major contribution from the distance measurement system is:

- Measure distance between user and objects.
- Give alert signal to user based on the distance measured.

V. SPECIFICATIONS

Android Mobile phone, Arduino UNO, Ultrasonic sensor, Buzzer, Earphone, and White cane.

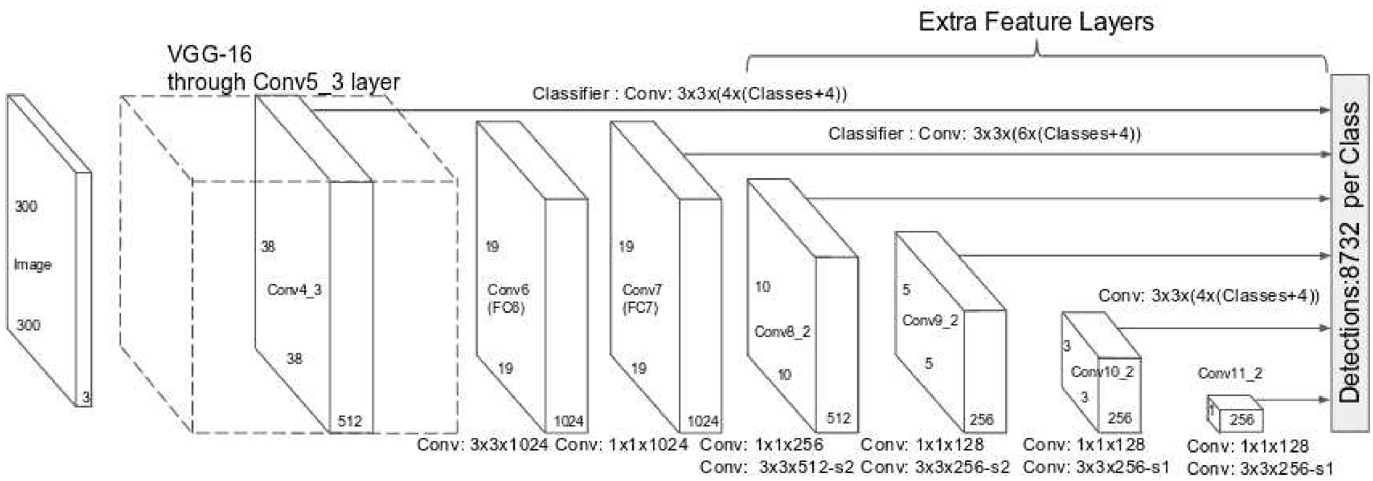

Fig.4. The system design of SSD.[20]

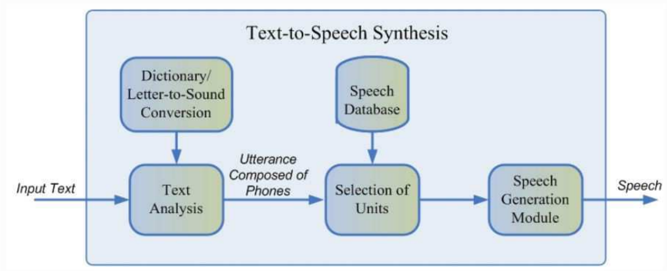

Fig.5. The system architecture of Text-To-Speech.[22]

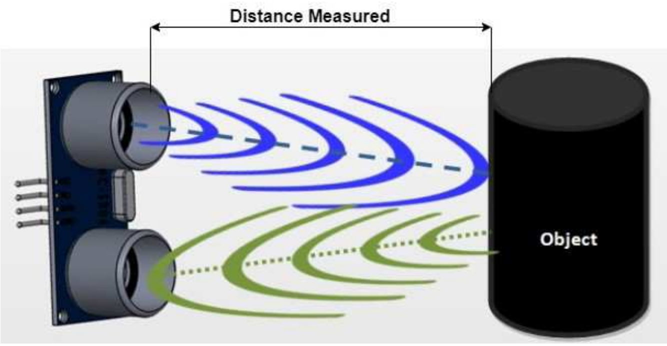

Fig.6. Distance measurement using ultrasonic sensor.

VI. EXPERIMENTAL EVALUATION

By evaluating the experiment here the prediction time taken by the object recognition android app is 70ms to 500ms. The distance calculation and cautioning was given elite with a deferral of 10ms. The threads given in the app makes the class expectation simpler.

Table 1 shows the comparison of various systems that is related works and the implemented work. From the comparison table we can see that the system we proposed here is effective and performs superior to other/existing systems. The above comparison table shows that GODEYE is a very efficient system for blinds.

TABLE I COMPARISON OF VARIOUS SYSTEMS

Systems	Power Consumption	Range	Response time
NETRA	Low	Medium	Slow
Nev-Belt	Medium	Low	Slow
Smart Cap	Medium	Low	Fast
Smart Shoe	Medium	Low	Slow
GODEYE	Low	High	Fast

While calculating distance for this experiment the system is associated with the serial monitor of arduino IDE to check the outcome exactness and the alarming sign accuracy. At the point when the distance calculated arrived at the threshold distance then the alarm sign will begin at that point onwards with a particular time stretch. It proceeded until the user or object moves farther. The distance calculation yield to the serial monitor of arduino IDE is appeared in Fig.7.

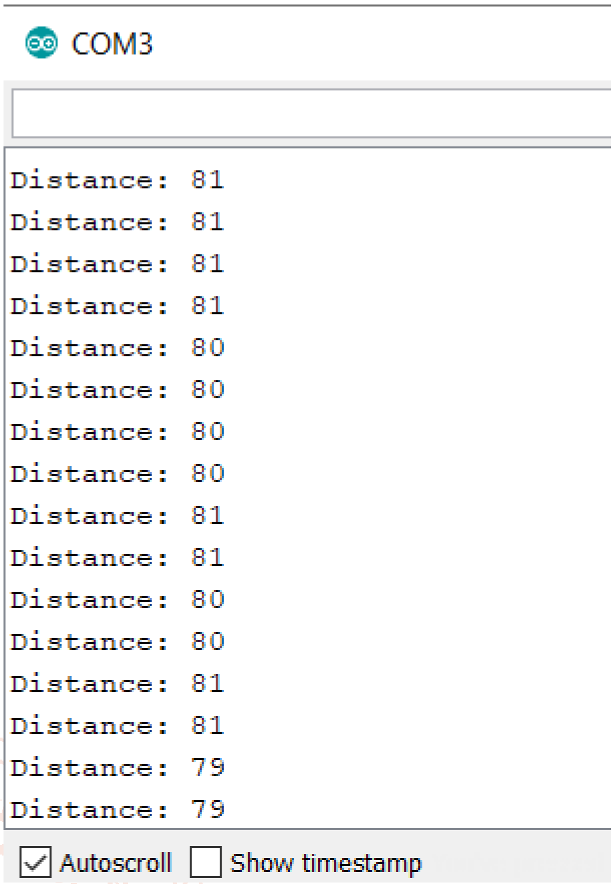

Fig.7. Measured distance from user to object using ultrasonic sensor

The output of the system proposed here is an audio output of the object detected and the alert signal that is beep sound that occurs if the distance calculated not exactly or equivalent to the threshold distance. The experimental evaluation shows that the framework executed is productive and superior to the existing system for visually disabled people.

VII. CONCLUSION AND FUTURE WORK

Here, we implementing a system GODEYE. A system for visually disabled people. This system is introduced to overcome the difficulties faced by the visually disabled. Our system consist of two parts: Object detection with voice assistance and Distance measurement. SSD300 is used for objection detection. This strategy is favored due to its productivity, exactness, and accuracy. This makes the object recognition more faster, so the obstacles can be easily located by the user. Voice feedback is provided after object detection. This is done by the text-to-speech conversion using a text-to-speech converter, i.e. text-to-speech API. The distance between the obstacles and user is calculated using an ultrasonic sensor joined to the stick. The ultrasonic sensor is used to calculate the distance. These features are clubbed in our system. This makes our system efficient and enables self-navigation for the visually impaired. We feature the presentation of our framework as far as the speed of recognition with exceptional proficiency in distance calculation and high accuracy of detection.

In the near future, the framework can be modified with SSD-MSN technology. Currently, SSD300 is used. With the usage of SSD- MSN several images frames can be detected. Now the distance calculation is done using the ultrasonic sensor. In the future, the distance measurement can be advanced by measuring the distance using the camera. By including these progressions to our framework the framework transforms into a high performance and efficient app.

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