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VOICE ASSISTED REAL-TIME OBJECT DETECTION USING YOLO V4-TINY ALGORITHM FOR VISUAL CHALLENGED

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Abstract

Visual impairment is a problem that is frequently getting worse everywhere. The World Health Organization estimates that 284 million individuals worldwide suffer from near- or distance vision impairment. The suggested work's goal is to create an Android application for blind persons that works with a smartphone and white cane. As the primary distinction between the proposed system and the current one, we use the cutting-edge "You Only Look Once: Unified, Real-Time Object Detection" technology. When compared to other algorithms, YOLOv4-tiny performs twice as quickly. To recognise the actual things in front of the visually impaired individual in real time, YOLOv4-tiny algorithm was trained on both Custom dataset and COCO dataset. Then determine how far that object is from the individual and produce an audio output. The camera is initialised using the OpenCV library, and it then starts taking frames and feeding them to the system. Other than that, we are using Python 3 for this project. The system then employs the YOLOv4-tiny algorithm, which has been trained on both the Custom dataset and the COCO dataset, to recognise and gauge the distance between the objects in front of the user. Text to voice conversion is then used to turn the objects that were detected into an audio segment. Our system outputs an audio segment that tells the user the name of the object and its distance from them. The user may now visualise the objects around him using this knowledge. The suggested method will even shield the user from running into nearby objects, keeping him safe from harm. An android-based application that represents the full system is available. The user of the Android application has the choice between an internal camera and an external camera. The esp32-cam is the external camera, whereas the internal camera is the one found in the android phone, which is attached to the white cane. Real-time video from their mobile phone camera or esp32-cam will be used to detect objects. The user opens the camera and feeds the real-time footage when he decides to begin the object detection procedure. The YOLOv4-tiny programme processes each frame, detecting objects and calculating their distances from people. Then, the label and distance of the object are converted into audio format by the audio system. The user can then hear the audio using their smartphone's speaker.

Keywords: Machine Learning, YOLO V4-Tiny, Visually Impairment, Real-Time Object Detection, Data Mining, Hypotenuses, STEM-Based Smartphone

1. INTRODUCTION

Information technology has become one of the most advanced and evolving technologies for improving individuals' lifestyles. This assistive technology has the potential to enhance the better quality of life for all and especially for people with visual impairment. IT-based assistive technology has a very broad range to provide computer interaction to blind people [1]. There are millions of visually impaired people worldwide and the majority lies in the above 50 age group of blind people who are living in deprived countries. In the advanced technological society, many blind people are capable to manage their daily lives with help of non-digital approaches such as white cane users, tactile tiles, and many other assistive technologies. Still, they face many hurdles and obstacles in an unknown environment like signs and landmarks due to visual impairment. There are several navigation assistive and mobile device technologies for visually impaired people [2]. As technology has evolved from computers to tablets and smartphones. Technology creators have developed smartphone applications, a program, or software that make the way easier for daily life needs. Visually impaired people face much harder outdoor barriers as compared to indoors so it is very important to develop portable devices that should also be cost-effective. These modern smartphones are usually touch-screen, giving challenges, especially for students and youngsters with visual impairment [3]. Mobile computing devices provide a flexible and standard platform for people of all age groups to use for communication and mobility. Recently several customized mobile phone applications are industrialized for visually impaired people for making their lives better and smartphone devices have become the pioneer of evolving technology giving an opportunity to enhance quality. They have opened a user-friendly interface and integrated several way findings like navigation assistance modules, virtual audio displays, electronic travel aids, and text-to-speech applications to present a variety of possibilities for blind people [4]. The use of mobile phones for education is becoming a more common need and learning ability, intelligible and performance are the main quality attributes meeting the user criteria. Touchscreen-based smartphones enable VI users to assist by performing different tasks easily for example making calls, taking pictures, voice input, listening, text-to-speech application, and inverted screen color [5]. Visually impaired students need special self-supporting devices and assistive technology for better performance in studies and laboratory work. There are many learning and STEM-based smartphone applications designed for students [6].

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2. LITERATURE REVIEW

Kuriakose along with his co-workers. Present a review of different articles and investigate different smartphone sensory systems and assist travel aids that are helpful for blind and visually impaired people. They describe the general information on assistive travel aids which includes Electronic Orientation Aids, Radio Frequency Identification technology, and Position Locator Devices also some common sensing devices like depth cameras and modern smartphone cameras and a section on an assistive navigation system to classify the optical navigation and methodology to establish verbal communication with the users. They concluded all the possible interesting applications that can be beneficial for BVI people [7]. In a study, development of titration ColorCam (TCC) android application by implementing a java programming language for color blind and visually impaired people was carried out. This app has a list of indicator names and types of titrations that help to detect the color and saturation of HSV data and provide useful data analysis. The effective methodology presented the interest of students in the field of science. Results reveal the application's potential and make it a user-friendly mobile app. In the coming future, this developed application can enable blind students in interesting challenging activities [6]. Similarly, another paper presents an assessment for developing potentially reasonable and cost-effective electronic travel aid (ETA) systems in smartphones that can provide advanced accessible information for indoor and outdoor navigation. Scientific achievements were studied using the PRISMA methodology. Meta-analysis results prove ETA prototypes have a better navigation and assistant orientation with limited interest in touch interfaces and computer vision methods as there was no evaluation of an existing single navigation solution [4]. In a study author designed assistant depth camera function using Android Smartphone that can identify the object to avoid obstacles for blind and visually impaired people. The 3D depth camera can calculate distance, objects, and obstacle detection integration, and can help the user interfaces through different smartphone features like voice commands and gestures. The results of the study show that this application successfully provides flexible and moveable assistive navigation for blind and visually impaired people [8]. Martiniello et al. studied and present mainstream devices for the replacement of traditional aids for visually impaired people. Smartphones and tablets are the latest technology that also helps blind people in their activities. In this paper, an online survey was conducted with a teenage group using such developed technology for more than 3 months. Most of the participants show more interest in having beneficial and supportive devices over traditional tools. As these technologies have the capability to navigate more efficiently and fulfill many different requirements needed by blind people like audiobooks, object identification, recording memos, color identification, etc. This study proves that mainstream devices and smartphones are becoming more useful and widely adopted by visually impaired people [9].

In a study regarding examining the issues and challenges of smartphone-based assistive technologies blind people are having in performing their daily life activities such as identification of currency notes, the appearance of the interesting object, and many others. This paper provides a comprehensive overview of the need for advancement in

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the latest assistive technology. Smartphone base technology needs room for improvement in orientation and cognitive mapping in a complex environment vision base substitution and sensor-based solutions in a cost-effective manner. They need to provide better accessibility to media and nonvisual information [10]. In a study, Abraham and his co-workers explore the use of smartphones and studied the limited resource system visually impaired and blind people are challenged. Smartphones have the potential to provide assistive devices for such people. This study directs the interview of 166 candidates individually from different centers. 53.1% of the majority use only a basic phone and 46.90% of people found the usage of a smartphone mostly for social media and web browsing. Frequently used functions were image and color description. Unfortunately, 90% of the participants were unaware of already existing functions and assistive capabilities on smartphones [11]. Similarly, Nimmolrat et al. produced a pharmaceutical mobile application for visually impaired people. This application contains five necessary functions on the bases of the design and development of smart technology. This mobile application potentially supports visually impaired people by enhancing the efficiency of health care. Even with the high capacity of design and development of application, there is still room for improvement in health care services [12]. In a study for the development of a mobile application for visually impaired people and some children who are challenged by birth for better communication with others. The present work develops the system using an android application for the user interface design using Axure rp 9 app. In the present work, some existing developed technologies and smartphone applications were utilized for blind people to communicate with their families more conveniently [13]. A paper focus on the developing factor of useful evaluation of mobile applications for blind people. This paper unifies the systematic literature review (SLR) for efficient usability to evaluate developed mobile applications for persons with visual impairment. Besides modified and general usability evaluation methods study focuses on the factors influencing satisfaction, simplicity, and efficiency which are the most important attributes and sufficiently helpful for visually impaired people. The analysis successfully proves the usability dimensions which are efficiency, effectiveness, and satisfaction that can provide an important evaluation in the mobile usability for impaired and blind people [14].

In a study related to investigating mobile applications adopted by blind people based on the unified theory of acceptance and use of technology (UTAUT) model. With an online survey, the social influence, facilitating conditions, performance expectancy, and self-efficacy were examined for the different age groups. The qualitative data analysis shows the accessibility of mobile phones for blind people. The results reveal the practical implementation for the development of the mobile app and day-to-day activities. Older age group people were less impacted by social influence. The study proved that the qualitative findings provide practical implications for the design of mobile app development for persons with visual impairment [15]. A paper on the user-centered design of a mobile app that can provide appropriate information about drugs and medicine to visually impaired people. The mobile app executes four phases’ identification, requirement, interface design, and usability. Results reveal the incorporation problem

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that was identified in the usability test. Overall Farmaceutic App is capable to use medical information efficiently and improve the adherence therapy (AT) of visually impaired people [16]. In another paper related to the public transport systems through RF communications based on MOVIDIS and embedded systems to use more safely and efficiently. These developed systems assist people with visual disabilities through their mobility in public transport autonomously. The products used for ATmega328P microcontrollers, HC-12 series communication, and TI-CC1101 RF transceivers. With the help of radio frequency, various modules can communicate with each other and allow users to interact successfully and make their lives easier [17].

Real and Araujo studied and examine comprehensive perceptions of the development of multidisciplinary nature for blind people. The advanced and updated analysis was described with the help of previous reviews. The article is based on the recent navigation systems of artificial visions and sensory substitution devices. The study reveals the current benefits in technological areas to attain self-sufficiency for BVI people. The investigation discusses major flaws in the design of the navigation system, the diversity of assistive technology, and sensory disability insufficient to provide enough data to users [18]. Botzer and his co-workers developed a system that could help blind people with the distance through sounds of different frequencies and analyzed the system with the Hebb William maze. Eight visually blind people were selected for this experiment, and they complete the last three trials faster out of five. The developed system had the potential to assist blind people efficiently and was investigated for further navigation [19]. Lin et al. came up with a simple smartphone-based guiding system to avoid navigation problems for visually impaired people. This improved technology system enables blind people to travel safely and more conveniently. A combination of Image recognition systems and smartphone applications was used in this research to produce a simple and efficient assistive system for blind people. Operating modes can be chosen according to the network availability. On operating the system, the smartphone sends the captured image to the server that uses the ConvNet/CNN algorithm to recognize obstacles in the image and afterward sends more than 60% of the results back to a smartphone which is sufficient to assist the visually impaired people [20]. In a case study by approaching different user-friendly techniques to get progressing experience. A unique communication experience was associated with visually impaired people using camera applications. The usability analysis was performed with the number of contestants by the retrospective think-aloud method and test their performance. Different design assistive technology and related suggestion camera applications on smartphones were analyzed to develop and help visually impaired people [21]. In a study attempts to develop accessible mobile application design guideline for visually impaired people. They investigated a specific task with few participants to observe the behavior of visually impaired people operating mobile applications. Interview analysis was performed to find the accessibility problem in typing and voiceover functions. The second adopted method was the Heuristic walkthrough method to improve the current condition for disabled people and develop accessible mobile phone applications for future guidelines [22]. In a study for the development of mobile phones and other handheld devices accessible through different sensory channels

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such as audio and touch to facilitate visually impaired people. The advance and improved mobile assistive technology need a successful association of computer science to obtain the potential application of such technology. This paper conduct more effective accessibility of mobile phone for visual impairment. The results discuss distinct assistive applications designed using mainstream devices that can be used in surroundings [23, 24].

3. METHODOLOGY

The proposed system is presented on an android application that detects different objects in real-time.

3.1 System Working

In the android application the user has two options for camera that are Internal and External camera. The Internal camera is the camera that is present in the android phone and External camera is the esp32-camera that is placed on white cane. The object detection will be done from real-time video taken from their android phone camera or esp32-camera. When visually impaired people decide to begin the object detection procedure he opens the camera of android phone or esp32-cam and feeds the real-time video to YOLOv4-tiny model. The object detection is done by using YOLOv4-tiny algorithm which is trained on both Custom and COCO dataset. After this, the distance is calculated by using distance formula. Then audio system converts the object's label and distance into audio format. The audio is then played on the android phone speaker as an output for the visually impaired (Fig. 1).

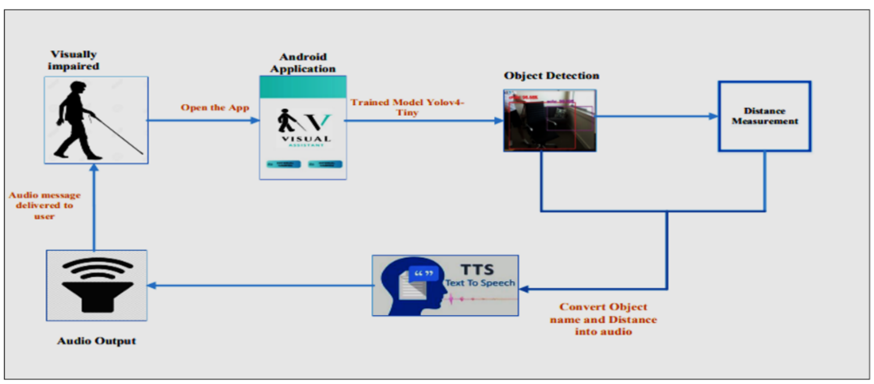

Figure 1: System Working

3.2 System Implementation

The whole system is implemented by the integration of various techniques that are discussed below:

3.2.1 Preparation of Dataset

For object detection different datasets are available on internet that contain classes for the purpose of assisting the visually impaired people. In the proposed system both

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Custom and MS-COCO (Microsoft Common objects in Context) image datasets are used [25]. Data acquired from the MS-COCO image dataset can be used to identify objects. 3, 30,000 images make up this dataset, although more approximately 2,000 000 of them have labels, divided equally between training and testing. This dataset has 80 classes and 640x480 image quality [26]. For Custom dataset the images are taken from "Kaggle Repository" and "Chrome web store" which contains 4500 images for object detection. In this dataset, we collect 500 images of each object. For object detection Custom classes are bed, chair, couch/sofa, table, wall, door, machine, stairs, and person. Images that are collected from Kaggle are already arranged but those images that are collected from chrome web store are not arranged firstly these must be arranged in an order. These images are arranged by using python script. After these images are labeled by using labelImg tool. A bounding box is created around the images. In this way the needed area of image is selected. The size of images with image format that is yolo is saved in the selected directory and two types of files are generated that are annotated image file and text file [27-42] (Fig. 2).

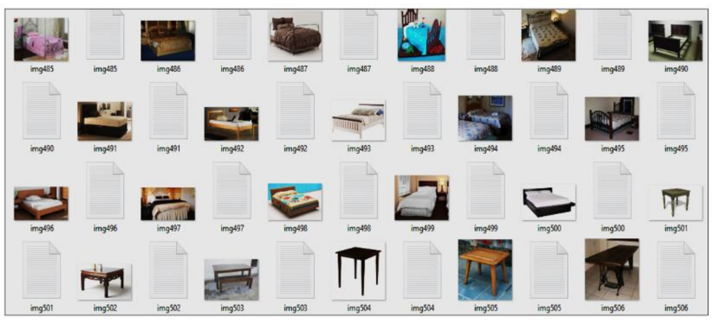

Figure 2: Annotated images samples in Dataset

3.2.2 Object detection model

In the proposed system python programming language is used for building the deep learning model [43] OpenCV library is used to initialize the camera for capturing the video frames on real time [44]. There are several algorithm's that are used for training the object detection model such as Fast R-CNN that are used for the detection of objects and used for finding the spatial location of objects, but this algorithm cannot detect and identify objects in a fast way on real time. In this project, YOLOv4-tiny algorithm is used to train a model for object detection. For implementing the YOLOv4-tiny algorithm the Darknet framework is used [45]. YOLOv4-tiny is a real time object detection model trained on both Custom and MS-COCO image dataset. When using YOLOv4-tiny, the object identification task is split into two parts: regression, which identifies the object position using bounding boxes, as well as classification, that defines the item's class. YOLOv4-tiny algorithm is fast and accurate enough as compared to other algorithms. YOLOv4-tiny algorithm has faster speed of detection on real time [46] (Fig. 3).

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3.2.3 Distance Measurement

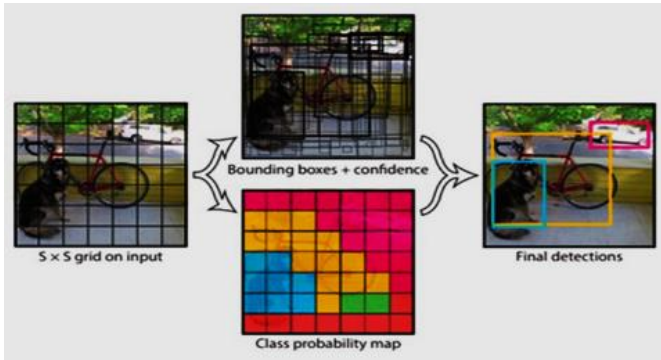

Figure 3: Object Detection

Previously, Ultrasonic sensors are used to determine the distance of any object. To determine the distance of every object, the HC-sr04 as well as other high frequency sensors that produce sound vibrations are employed. In this proposed system, distance of objects is calculated without using extra hardware. It is not possible to get the real distance of detected object. Because focal length varies every time depending on the objects and manually calculating focal length is not an effective strategy each time. To solve this issue, we have already integrated a camera for detecting the objects. The camera utilizing the information of depth to construct the bounding boxes for localizing the objects and the proposed system utilizing this information for calculating the distance of the hurdles/objects.

When object is localized, we will receive the four variables from the object localization. The two variables are used for adjusting the bounding box. The other two variables are height and width, and these two variables are utilizing in the calculation of distance. Height and width variables will change when an object gets farther away from the lens of camera.

Since we all know, once an image passes through lens, it is refracted since light could also entering the lens, however when an image passes through such a mirror, light could reflect, giving us an accurate reflection of the images. However, the image is slightly stretched when using a lens.

There are three variables with the names:

- a (Object's distance as from lens)
- b (The distance between the refracted picture and the convex lens)
- c (focused distance)

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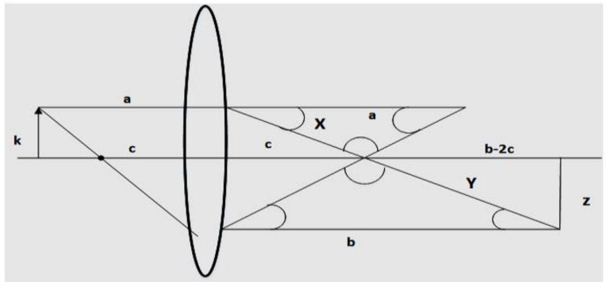

Figure 4: Image passes through a lens; it appears along with the relevant angles

The exact distance of such object as from convex length is shown by the line "a." Additionally, "b" describes how the real image appears. Imagine a triangle with a baseline of "a" on the left edge of the image (the new light refracting image), and then construct a triangle on the right side that is identical to the triangle here on left. This means that the new bottom of the reverse triangle will maintain the same vertical angle. This means that the new bottom of the reverse triangle will maintain the same vertical angle.

Furthermore, if we examine the two triangles from the right side, we can see that "a" and "b" are identical and that the angles formed on every side of both vertices are located at an acute angle to one another. It leads us to believe that both of the triangles on the upper edge are comparable. Since they are comparable, so the ratio of the adjacent angles will always be comparable. So $a/b = X/Y$. If we contrast two triangles on the right edge of the image, one of which has a right angle (90°) while the other two have opposite angles that are equal. As a result, X and Y are both hypotenuses of a triangle that is comparable to them both and has a right angle. In this case, the new function can be expressed as:

$$a/b = X/Y = c/(b-c) \qquad (1)$$

When we calculate that equation, we would discover:

$$1/c = 1/a + 1/b \qquad (2)$$

And will finally arrive at

$$\text{Distance} = c + Z/k \qquad (3)$$

By just using the given equations, where c seems to be the focal length, commonly known as the arc length:

$$c = (180 \times 3.14 \times 2)/360 \qquad (4)$$

With the use of this distance calculation, we can get our ultimate result in "meters." The distance is calculated using this formula.

$$\text{Distance} = (180 \times 3.14 \times 2) / ((\text{width} + \text{height} \times 360) \times 1000 + 3)/3.937 \text{ [47].} \qquad (5)$$

3.2.4 Audio Output:

In this project, Google Text-To-Speech (gTTS) library is used to generate audio output for the visually impaired. This library converts the text into speech and saved as a mp3

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file. The audio segment is the output of our system that gives the name of the detected object as well as distance from that object to the person. The audio output helps the visually impaired people in understanding their surrounding environment [48-51].

3.2.5 ESP32-Camera Module

For object detection process esp32-camera is also used that is placed on white cane. In the proposed system model gets feed from the camera using webserver running inside esp32-camera. When esp32-camera gets power, it searches Wi-Fi by a name dlink-51C4. After entering password android application gets an IP address and connected to esp32-cam. Later android application takes video stream from the esp32-camera and feed the model through IP address.

4. RESULTS AND DISCUSSION

Advancements and research related to human computer interactions have led to the development of various innovative and assistive technologies with recent designs that make them easier, accessible, and handy and more user friendly for visually impaired people. Over the past two years, the technology of assistive devices such as mobile phones especially touch screen smart phones and android operating systems have evolved rapidly. In addition to touch screens, the use of visual function, gestures or audio facilitates human-technology interactions. These facilities improve the smartphone accessibility to visually impaired people as well. Smartphones with audio feedback aid visually impaired people to overcome the hurdles of daily challenges. In current study the android application detects multiple objects that are present in front of the camera. Then distance of detected objects is measured in meters between zero points something to three decimal points. The audio system speaks out the name and distance of the detected object. For example, if a car is present in the frame of the camera the car is first detected and system measures the distance of the car then audio system speaks out the label car and its distance.

Figure 6: The output of the camera detecting images In front and measuring it in meters

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5. CONCLUSION AND FUTURE WORK

Use of smartphones by the people having visually impairment is considered as one of most challenging problems that can now resolves with the help of computer vision, object detection technology. Detection algorithm based on deep learning have been widely applied in many fields. So, by using this feature of detection algorithm yolov4-tiny a system is Developed which can detect Hurdles along with distance and in Future by using these techniques definitely more efficient systems can be developed through which some specific face like someone's family members and fellows and also his daily base useful things. In the future, it can be possible to develop such an interface for an android application that is specifically developed for blind people by just making gestures on the screen it will be possible to open an internal camera or external camera and can easily switch cameras. Moreover, it will also be possible in the future that during the use of an External camera if Accidentally External camera is stopped working then after waiting for a few seconds to develop a connection with external camera and after no response, it should automatically convert to an internal camera. Moreover, any Robotic Assistant like google assistant or Siri can also be developed which can Assist Visually Impaired by just getting information through this model.

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