REAL TIME OBJECT DETECTOR FOR VISUALLY IMPAIRED

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NATIONAL UNIVERSITY OF MODERN LANGUAGES

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ABSTRACT

"Real Time Object Detector for Visually Impaired" is an android application that detects objects and generates sound notification. The system detects the objects in real time and helps visually impaired person to walk safely. The user has to display the android phone in front of him/her for camera view. The obstacle detection caters for two types of objects, the one for which system is been trained and others not been trained or unknown obstacles. Object is detected using machine learning algorithm YOLO (You only look once). The sound notification is generated through android TextToSpeech library.

The application has been developed in android studio environment. XML has been used to develop interface and Java for backend development of the application. The training script has been developed in anaconda, an IDE for python. The system is trained for different objects (table, chair, wall, tree, car) using Tensorflow. The system contains the features of object identification, obstacle detection and sound notification.

Different test cases have been developed to check functionalities of the system. Unit testing has been conducted after the development of each module. The integration testing has been performed to test the complete working of the application. Application is tested using android phone with different versions and satisfactory results have been achieved.

CERTIFICATE

Dated: _____

Final Approval

It is certified that the project proposal titled **"REAL TIME OBJECT DETECTOR FOR VISUALLY IMPAIRED"** submitted by **Khadija Rashid, Nazish Rashid, Muhammad Mudassar,** and **Ghayoor ul Hassan** in partial fulfillment of the requirement of **"Bachelor's Degree in Software Engineering"** is approved.

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DECLARATION

We hereby declare that our dissertation is entirely our work and genuine / original. We understand that in case of discovery of any PLAGIARISM at any stage, our group will be assigned an F (FAIL) grade and it may result in withdrawal of our Bachelor's degree.

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PLAGIARISM CERTIFICATE

This is to certify that the project entitled "**REAL TIME OBJECT DETECTOR FOR VISUALLY IMPAIRED**", which is being submitted here with for the award of the "**Degree of Bachelors**" in "**Software Engineering**". This is the result of the original work by **Khadija Rashid, Nazish Rashid, Muhammad Mudassar,** and **Ghayoor ul Hassan** under my supervision and guidance. The work embodied in this project has not been done earlier for the basis of award of any degree or compatible certificate or similar title of this for any other diploma/examining body or university to the best of my knowledge and belief.

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Submitted to University of Wales Institute, Cardiff on 2017-06-04

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CHAPTER 1
INTRODUCTION

1.0 Introduction

In first chapter a brief introduction of the project and project report is given. Project's scope, application areas and key features are described. Problem domain, problem statement, aims and objectives, proposed system, system's features, scope, resource requirements, significance, project's contribution and report layout are mentioned to give a clear idea about the application and to understand what is application supposed to do and in which way it can help visually impaired persons.

Good vision is a valuable yet however loss of vision is common now a days. Loss of sight may emerge from any situation, damage or different other situations that are breaking points of vision and furthermore because of which Blind person have many troubles each day.

It is very often that loss of sight impacts a man's capacity to self-explore outside climates and even essentially walking down a stick pressed road. It impacts a person's capacity to complete a few assignment obligations and also tasks which are apart from office work, for example, games and academics. A large portion of these social troubles restrict a visually impaired individual's ability to fulfill people's need, and in addition this lone incorporates into low confidence.

Mobile is too much common now a days, almost every person uses it. Blind persons also uses mobile. So what, if mobile camera is used instead of cane? Mobile camera can be used as a very helpful machine for blind persons. It can be used to help them out in detecting what is placed around them. Though it is very complex and difficult to detect each and everything but specifically some of the categories of objects can be detected. Our aim is to use the mobile camera and detect obstacles in their way. This effort can help blind to walk easily through streets and also help them out while they are going to grocery store.

There are category of the objects that can be detected by the system. As an example we can say glass, cup, chair and laptop. And the other thing is the detection of obstacles, obstacles are any kind of object that can resist a blind person when he/she is walking.

1.1 Problem Statement

Visual deficiency is an issue which influences a man's capacity to self-explore outside understood situations and even just strolling down a swarmed road. It influences a man's capacity to perform numerous activity obligations and furthermore exercises outside of a working environment, for example, games and academics. Huge number of these social

difficulties restrict a visually impaired individual's capability to meet individual's needs, and this is lowering down confidence of a visually impaired person. Beside that they are unable to go to market to bring out food material for themselves.

1.2 Developed System

Cane or stick is not something that can visualize things, it can only give idea of what thing is in front of person. The range of cane is very small, exactly of its length. Better solution to this is use of mobile camera. Mobile camera can be used to identify obstacles in a far range. It can visualize things in a better way. Proposed System is android application that uses mobile camera to detect obstacles, and also objects which are been recognized by the system i.e. the system will be trained for a specific category of objects. After detecting obstacle/objects it produces voice message in English language. There are category of the objects that can be detected by the system. . It can visualize things in a better way. As an example we can say glass, cup, chair and laptop. The other thing is detection of obstacles, obstacles are any kind of object that can resist a blind person when he/she is walking. There are categories of the objects that can be detected by the developed system.

1.2.1 System Features

There are three main features of the system. Object detection, obstacle detection and speaking capability. Features of the system are been given below.

1.2.1.1 Real Time Obstacle Detection

Camera focus is considered 45 degrees to ground. First step is to get image (from video) using "Capture (0)" function of OpenCV. Then image is converted into gray image. Image should be resize into a fixed dimension since all the images are not of same size. Image is segmented into fixed matrix of M x N numbers. Numbering is done for each segmented images. One of the segmented image is taken and process is applied to find obstacle. Then all the segmented image in the process are checked and images which contain obstacle are obtained [1].

1.2.1.2 Can Detect Defined Objects (glass, cup, chair and laptop)

System is trained for some of the objects. System is trained by giving inputs of images containing those objects. A file is created which is of protobuff format and is having template of images. On runtime captured image and template are compared to identify objects. Template is having weights in numbers, which is probability of object. If probability of object is more than 0.3 it is known object.

1.2.1.3 Sound Notification

System has capability that it can generate sound notification that is done Using TextToSpeech Library (Android built in library).

1.2.2 Scope of the System

Real time obstacle detection and object detection of predefined objects (glass, cup, chair and laptop).

1.2.3 Limitations of Developed System

Intensity of light and position of camera effects detection. It cannot detect everything. As camera is continuously working so consumption of battery is little more than normal. There is a special case where multiple objects are in front of camera so it detects nearest one first, process it accordingly and then go for other. So in between there is a little pause.

1.2.4 Resource Requirements

Following are the hardware and software resource requirements for development of the system and to test and use the application.

1.2.4.1 Hardware Requirements

Intel Core i5-4150, 2.0 GHz processors 4 GB RAM with Intel 4400 HD Graphics card and 4MB Cache memory is required for the development of application. Smart phone having Android operating system version 4 or higher having at least 512 Mega Bytes of RAM and 1.2 Giga Hertz Quad core processor is required for using and testing application.

1.2.4.2 Software Requirements

Android Studio is used mostly in development of android applications because it is official IDE so it is been used for developing front end and back end of the application. For development of this application Android Studio (2.3.3) with SDK (version 21) is required.

1.2.5 Development Methodology

There are multiple modules of this application, three different languages are used for development these are c++, Java and python. C++ is used to program tensorflow basic JNI functions, Java for android development and python for training the model. Application uses trained model. And model is in protobuf format which is good for communication. SDLC methodology is used for the development purpose. In SDLC, incremental method is used as there are integration of different modules so for those conditions incremental method is efficient and easy to implement.

1.2.6 Contribution

This application has many benefits. It is cost effective because it does not need any extra hardware device and also works without internet. Following are some contributions of this application.

1.2.6.1 Cost Benefits

This application is very cost effective, because it works without internet and also uses camera so does not need any extra hardware device. There are many applications that are working for visually impaired but are very expansive and most of them are only compatible with IOS devices which are more expensive. And also some of them are only working when internet is turned on, so there arise a problem if there is no internet. The core and main contribution of this application is that it has many cost effective benefits this application can work without the use of internet, it is internet independent android application it uses only mobile camera and speaker to work properly. As this application can be a better replacement of blind's cane and other hardware instruments which are available for blinds, so it reduces cost. Now a day mobile is too much common and camera is part of mobile so this application only uses camera and gives better results than those hardware instruments. There are many applications that are working for visually impaired but are very expansive and most of them are only compatible with IOS devices which are more expensive. This one application can perform the work that is done by three different instrument, canes and applications each perform one functionality only with having flaws, limitations, some have internet dependency and problem in them as well. This application have capability to merge functionality of all these things in one single application and have no internet dependence and also all these in free of cost.

1.2.6.2 Socialism

Visually impaired are part of society but unfortunately they have lack of resources and also have lack of technology approach so they are unable to work like normal person. This application is a very helpful for visually impaired to contribute in socialization among people. Visually Impaired are able to work with normal people and got rid of cane. This application can also be utilized for social campaigns that enhance people, society and morals. Also helps to generate awareness among special class of people for particular cause that leads to constructive society thinking values. Blind persons are of great capabilities so if we can help them in this regard they might be able to get success in their life.

1.3 Report Layout and Structure

The initial phase describes the introduction, trouble domain, problem statement, proposed system, goals and objectives, proposed system functions, scope of system, Source requirements Software and hardware requirements, value and payment of system. The devices as well as modern technologies which have actually been made use of throughout the growth of application are additionally reviewed in this phase. In second phase intro of existing systems their features and their troubles are talked about, suggested system, its examination, contrast with various other existing system and also its limitation are reviewed. While in chapter three usage cases/work information and series diagrams of key functions in accordance with technical point of view are specified to reveal the circulation of job diagrammatically. In 4th chapter entire development of system is described. Screenshots of android application is specified detailed flow representation. In fifth chapter screening and validation is specified as well as described. Examination instances are specified which are made during testing stage. System testing, integration testing and also approval testing occurs which are explained in this chapter. In sixth chapter limitations, future referrals as well as conclusion of project is specified.

CHAPTER 2
BACKGROUND AND EXISTING WORK

2.0 Introduction

In this chapter, existing systems features, their prominent problems and limitations, existing systems evaluation, functional and non-functional requirements, proposed application flow, limitations, comparison with existing systems is discussed.

People are working for blind and their work is really helpful for them. Mostly obstacle detection is been done through hardware i.e. using specially designed stick that detect object by ultrasonic sensors fixed in them. Greater than 285 million individuals on the planet deal with problems that are causing trouble for visually impaired and are helping technology to finish blindness. Loss of vision has impacts on almost each and every task of daily living. Without vision people have trouble when they walk, drive, read or identify objects. Technology that can aid aesthetically damaged people in at least numerous of these jobs might thus have a very appropriate social result. Research study in assistive modern technology for Visually Broken individuals has actually resulted in some actually valuable software application and hardware tools in widespread use. One of the most effective products to this day consist of text magnifiers and display visitors, Braille note takers, in addition to paper scanners with optical character recognition (OCR). This blog post focuses particularly on using computer vision systems as well as solutions to sustain Visually Broken individuals in their day-to-day tasks. Computer system vision looks like a natural choice for these applications in a feeling, transforming the shed sense of view with a "fabricated eye." Yet, despite the success of computer system vision contemporary innovation in countless various other fields (such as robot navigating, surveillance, and user interface), few computer vision systems as well as solutions are currently utilized to assist Cosmetically Broken people [2].

2.1 Existing Work

There are many numbers of systems that are available in the market having different functionalities. For example, Sainet for image processing as an assistive innovation committed to visually impaired customers. The app is targeted to the Android system and typically performed in a mobile device outfitted with a back electronic camera for image capture. Additionally, a wireless Bluetooth earphone offers the audio responses to the customer. Sainet has been developed as a support tool to the user in a social interaction situation. It is capable of providing audible details concerning the number as well as position (range as well as alignment) of the dialogists in the customer frontal scenario. For validation objectives the app has been evaluated by a blind customer that has

provided important insights regarding its stamina as well as weak points. Various other existing systems offered in market are discussed as adheres to:

2.1.1 Google WalkyTalky

This application uses GPS to track the individual all the way to the location. Has ability to navigate to a get in touch with if that contact has address info. Altered talking actions to just start after the screen has actually been switched off or after Navigation has begun. This makes it easier to set the location by lessening distracting messages while you are attempting to type [3].

2.1.1.1 Features

WalkyTalky is an available navigation help. It updates the status bar occasionally with present place to the closest street address. It has Ability to input a location and directly launch maps navigation in walking instructions mode [3].

2.1.1.2 Limitations

WalkyTalky works only when GPS is turned on. It cannot work without internet connection. [3].

2.1.2 Aioply Vision

Aioply is an IOS application that recognizes colors and objects, it helps color blinds, visually impaired and blinds to understand what is in their surroundings. It is simple to turn on artificial intelligence in this application, simple way is to point phone at any object that is of interest and there is a large button at the bottom of the screen which turns on artificial intelligence. This application is helpful for both color sighted and visually impaired [4].

2.1.2.1 Features

This application has ability to recognize large number of objects with speed of one thrice of a second. Internet connection is not required to recognize objects. If user help this application by writing down what it sees, it will learn more objects [4].

2.1.2.2 Limitations

Only run on Apple devices. It will and can make mistakes while you point it to any object, because it is unable to understand every object. It is restricted to those machines which are very expensive and common persons are unable to buy those devices [4].

2.1.3 AccessNote

This is an official application that is being developed by American Foundation for Blind and is specially designed for IOS devices. It is note taker application. It is developed

particularly for those who have voiceover problem and they need very reliable and efficient note taker. It is the first note taker for IOS platform. AccessNote is not only a very reasonable and standard note taker but also it allows users to gain benefit of having lot of other features along with features of IOS devices. This helps and enables visually impaired as well as blind persons in meetings. It is the first note taker for IOS platform gatherings and classrooms to have benefits of using exact same IOS tool that their sighted friends are using [5].

2.1.3.1 Features

This application is having custom designed keyboard commands which takes inputs for refreshable brail display keyboards and QWERTY and this feature is not available in any other application. It comprises major powerful search capabilities, one can easily find text globally within all notes and also can find text within a single note. There is another feature of tracking cursor; it helps to track the place when reader returns to a note. Also there is capability to have job done with very few keystrokes, which makes it keystroke efficient [5].

2.1.3.2 Limitations

It cannot detect things using camera and only run on IPhone and these devices are much expensive, so a common person might not be able to purchase that device [5].

2.2 Developed System

Developed System is android application that uses mobile camera to detect obstacles, and also objects which are been recognized by the system i.e. the system will be trained for a specific category of objects.

2.2.1 Functional Requirements of Developed System

During requirement gathering functional requirement are stated explicitly by user. These are those requirements which are must for the user. Following are the functional requirements of the system which must be fulfilled. Functional requirements of the system are obstacle detection, object detection and sound notification.

2.2.1.1 Obstacle Detection

It detects obstacles that can be a hurdle for blind. Detection of obstacle depends on some factors, like light, angle at which person is holding mobile, speed at which person is moving and resolution of the camera. Obstacles are not defined in the system these are any of the objects in front of camera.

2.2.1.2 Object Detection

Objects are predefined and system has a definition for each object. If there is any object which is already defined, system detects that object and produces sound notification. Detecting objects include detection of predefined objects for example chair, glass, cup and laptop.

2.2.1.3 Sound Notification

When application is started, it gives sound notification to clarify that application is successfully launched.

Also proposed system provides the functionality of giving sound notification when it detects and object or obstacle. That particular type of sound will be a little different from the sound on starting application.

2.2.2 Nonfunctional Requirements of the System

These set of requirements of the system are those system requirements which explains particular area that is utilized to judge functions of the system and user does not explain them in requirement elicitation phase. Proposed system has many non-functional requirements which must be fulfilled to assure quality of the system. Developed system is specially designed for visually impaired so that it is easy to use by them and is a quality product.

2.2.2.1 Reliability

Reliability is the most valuable attribute of the developed system. Reliability is defined as average time in which system fails. As blind person is relying on the system but if system is failed then it can cause big damage. System is reliable and is available for use for longer period of time.

2.2.2.2 Maintainability

Developed system is flexible and maintainable because if in the future there is any change required or some new features are to be added, they can be added successfully and easily because comments are added with each line of code so is readable and understandable for new developers who wants to make any change in the system. As there are few updates that will be done in future like making IOS application and increasing efficiency of the system so comments are maintained throughout the coding phase. As comments are much helpful for new developers to understand the logic and they can easily update code. Developed system is maintained in such a way so developers are able to make changes in functionality and quality.

2.2.2.3 Portability

Portability is to check that if the application is working well and correct in various versions of android operating system. Application is portable as it successfully runs on various versions of android operating system without making errors.

2.2.2.4 Testability

"Real time object detector for visually impaired" is able of being tested in various testing environment. Different levels of testing are performed on the system, unit testing is performed on each module of the system, white box testing is performed on whole system, after integrating all modules integration testing is performed and at the end user testing or black box testing is performed. Coding is done in such a way that it is simple and more importantly it is efficient, each line of code is commented so that code is readable and understandable for white box tester. The design of the system is done in such a way that it is helpful in individual test cases development and then integrating them to perform system testing.

2.2.2.5 Usability

System is designed in such a way that it provide an easy access to the system. As users are blind or visually impaired so there interaction to the system will be very less, and also it is difficult for them to work on widgets so most of the interaction is done through tapping or voice message.

2.2.2.6 Accessibility

Accessibility is the characteristics of non-functional requirement that check that each user that is using the application on smartphone or tablet can easily access all functionalities of application easily and error free. As this application is not having any detailed interface so it is accessible on each screen width.

2.2.2.7 Availability

In non-functional requirement availability deals with the characteristic of application that assure working presence of application whole day without having any bug that can cause application to be non-available. Application is available and is working 24 hours a day, when there is dark or night then flash is turned on automatically for detecting objects.

2.2.2.8 Security

Non-functional requirements attribute which can ensure that this application is not damaging or unsafe to any person in the society. This application is secure and developed for society and to remove the dependencies, limitations and problems faced by visually impaired while they are walking or going to market or office.

2.2.2.9 Operability

The ability to check the application is in complete functioning condition, according to pre-defined functional requirements and there are no problems and issues in it. It has completely checked the operation of full application when it is checked. Application is completely operational when it is implemented in obstacle and object detection needs.

CHAPTER 3
SYSTEM MODELING

3.0 Introduction

In "System Modeling" chapter the complete use cases and their prescription, class diagram, sequence diagram and architectural design are described. Use cases are defined which shows the steps while interaction between system and user to perform specific task. Actor is the normal person here but also it can be external system. To show and prescribe order of processing of system sequence diagrams are used.

3.1 Use Case Diagram

Use cases of the system are defined in figure 3.1. User can start application by tapping three time on screen. In response application gives a sound notification to user to clarify that application has started. There are some functionalities provided to users. As the actor here are visually impaired or blind so they are unable to see screen hence there will be very less interactions by the user. When application is launched, it will start capturing video so all the actions are now done by applications and user can only listen to the voice notifications that are been generated in response to detected object or obstacle. And it will also check if user has not sent request to close the application.
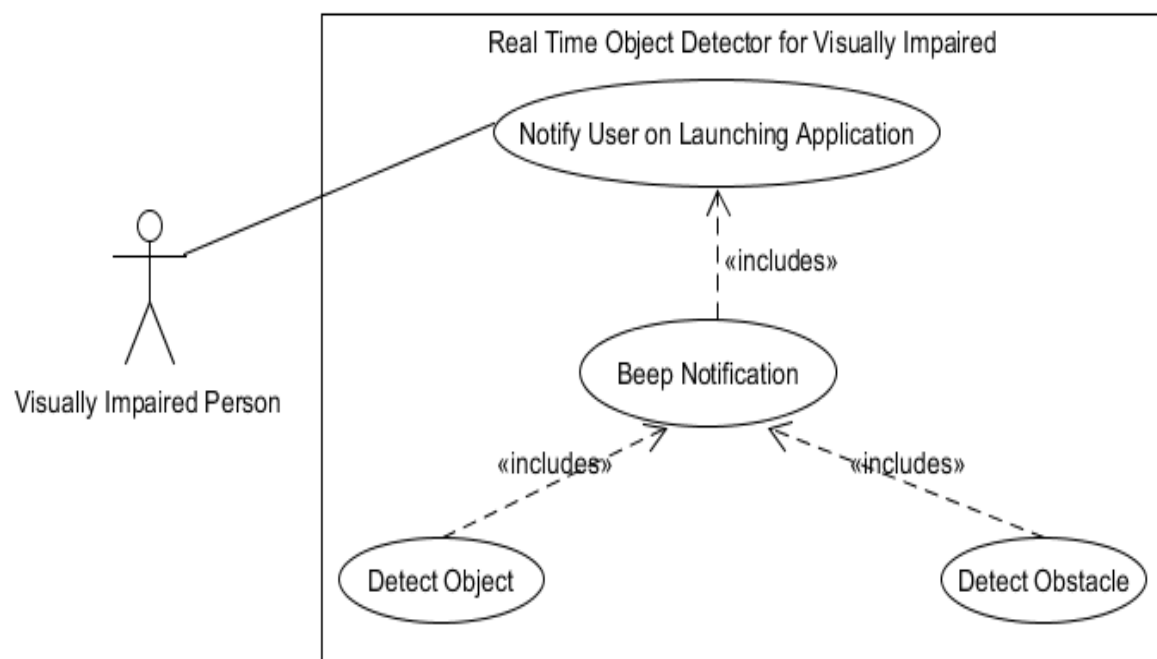
Figure 3.1 Real Time Object Detector for Visually Impaired.

3.1.1 Notify User on Launch Application Use Case

Fig 3.2 shows the Launch Application use case diagram. Use case begins as the user tap screen three times and application is giving a voice notification to clarify that it is been started. Sound notification is produced when application is launched and camera has started capturing video.

Figure 3.2 Notify User on Launching Application Use Case Diagram

Table 3.1 describes the actors included, set of conditions which are in terms of pre-condition and post condition for the use case Launch Application. First of all, user taps three time on the screen and then it gives sound message to clarify that application is been started.

Table 3.1 Notify User on Launching Application Use Case

Use case Id	UC-2
Use Case Name	Notify User on Launching Application
References Requirement	Requirement No 1
Actors	User (Blind Person)
Purpose	To start application
Overview	By tapping three time on the screen application is been started and it gives sound notification.
Type	Primary and essential
Pre-condition	The camera should be embedded on the system.
Post-condition	The application start capturing video and gives voice notification to the user to clarify that application is been started.
Typical Course of event	

Actors Action	System Response
1. Use Case begins as the user taps the screen three times.	2. The application start capturing video and gives voice notification to the user to clarify that application is been started.
Alternative flows	
1a. The camera is not in functional state.	1b. The camera is functioning but application is not started.

3.1.2 Detect Object Use Case

Fig 3.3 shows the Detect Object Use Case diagram. Use case begins as system detects any recognized object. When the system recognize the object then it gives sound notification for that particular object.
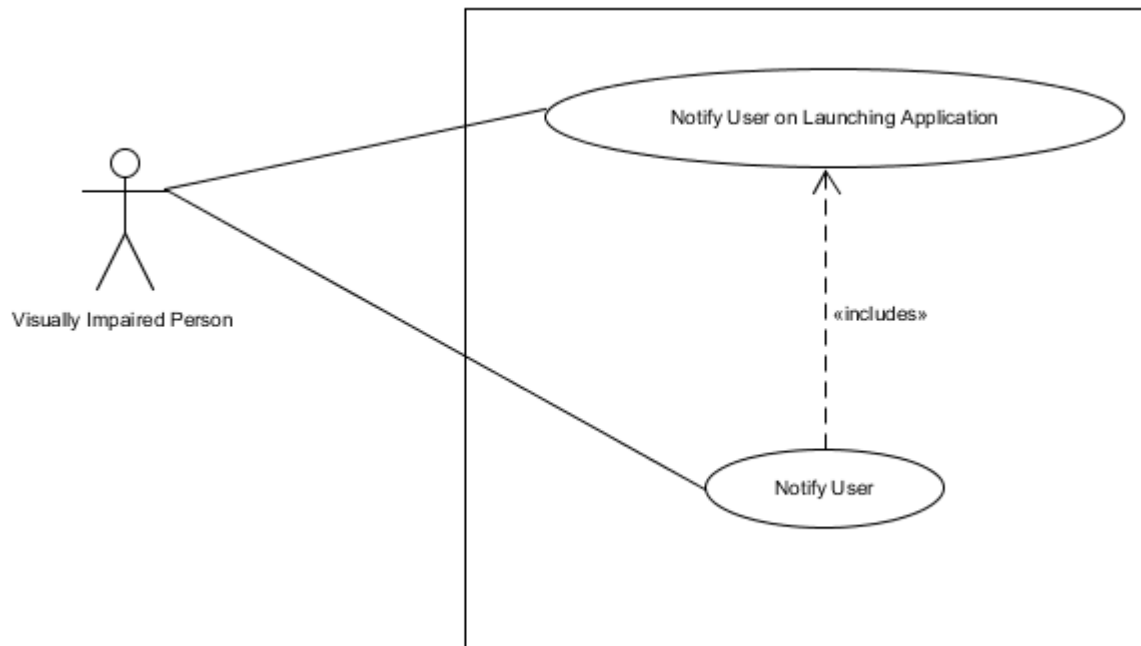

Figure 3.3 Detect Object Use Case Diagram

Table 3.2 describes the actors included, set of conditions which are in terms of pre-condition and post condition for the use case Detect Object. User is just holding the mobile camera and system will give voice notification on detecting any object that is being detected by the system.

Table 3.2 Detect Object Use Case

Use case Id	UC-3
Use Case Name	Detect Object
References Requirement	Requirement No 1
Actors	User (Blind Person)
Purpose	To Detect object of known category.
Overview	The user is holding the mobile and application is running, it detects object and give voice notification.
Type	Primary and essential.
Pre-condition	The camera should be able to capture video.
Post-condition	There must be a notification on detecting object.
Typical Course of event	
Actors Action	**System Response**
1. User is holding camera and passing from a place where some objects of known category are.	2. System gives a voice notification.
Alternative flows	
2a. User is not holding mobile with right angle.	2b. System doesn't give any voice notification.

3.1.3 Detect Obstacle Use Case

Fig 3.4 shows the Detect Obstacle Use Case diagram. Use case begins as system detects any obstacle. When the system recognize the obstacle then it gives sound notification. Sound notification is important because visually impaired person is unable to see things so sound notification is given to user.
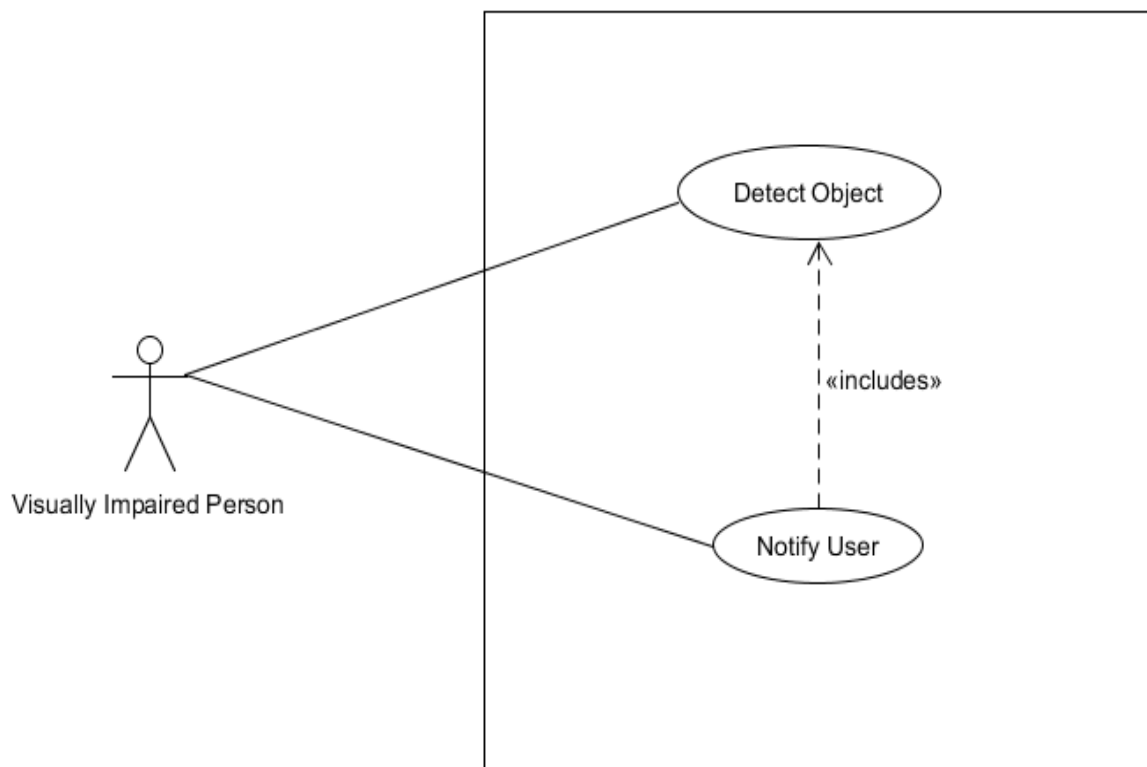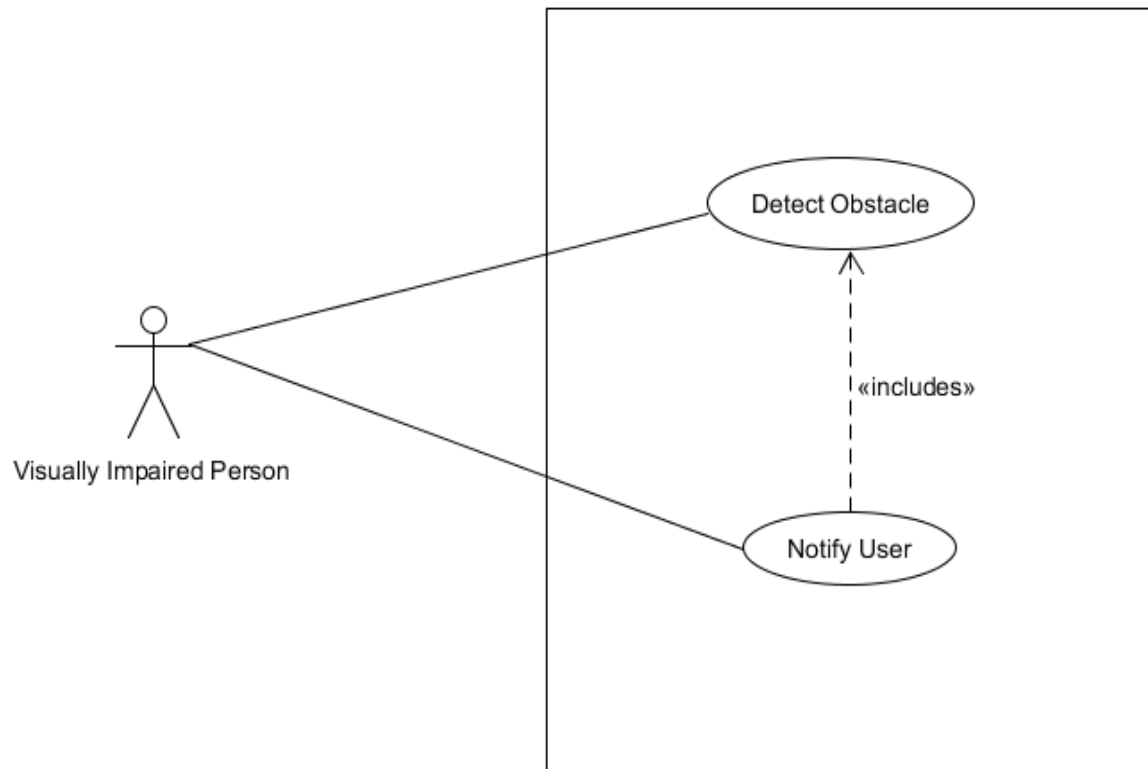

Figure 3.4 Detect Obstacle Use Case Diagram

Table 3.3 describes the actors included, set of conditions which are in terms of pre-condition and post condition for the use case Detect Obstacle. User is just holding the mobile camera and system will give voice notification on detecting any obstacle.

Table 3.3 Detect Obstacle Use Case

Use case Id	UC-4
Use Case Name	Detect Obstacle
References Requirement	Requirement No 1
Actors	User (Blind Person)
Purpose	To Detect obstacle.
Overview	The user is holding the mobile and application is running, it detects obstacle and give voice notification.
Type	Primary and essential.

Pre-condition	The camera should be able to capture video.
Post-condition	There must be a notification on detecting obstacle.
Typical Course of event	
Actors Action	**System Response**
1. User is holding camera and passing from a place where some obstacles are.	2. System gives voice notification.
Alternative flows	
2a. User is not holding mobile with right angle.	2b. System doesn't give any voice notification.

3.2 Sequence Diagram

It is defined as the diagram which shows interactions between processes and also interactions between processes and users. Sequence diagram prescribes and shows interaction of objects that happens in sequence of time. A sequence diagram shows object interactions arranged in time sequence. It depicts the objects and classes involved in the scenario and the sequence of messages exchanged between the objects needed to carry out the functionality of the scenario. Sequence diagrams are typically associated with use case realizations in the Logical View of the system under development. Sequence diagrams are sometimes called event diagrams or event scenarios.

3.2.1 Notify User on Launching Application Sequence Diagram

Figure 3.5 shows how information flows between system, user and interface. In this sequence the user tap the screen and then system give voice notification when application is started. Once application is started sound notification is generated by system. Following sequence diagram shows how components of system are working to generate sound notification for user. As this can be seen in diagram, when user taps on the screen this is interaction of user with interface and then interaction is between interface and system. Once application is launched and main activity is loaded then sound notification is generated and user is aware that application is started.

The interactions are shown in the following diagram and response from each component is also shown.
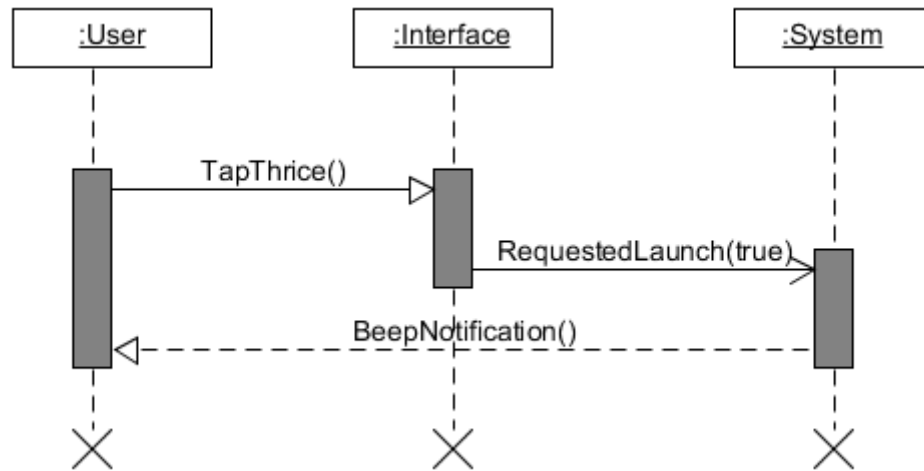
Figure 3.5 Notify User on Launching Application Sequence Diagram

3.2.2 Detect Object Sequence Diagram

Figure 3.6 shows how information flows between system, user and interface which is camera. In this sequence object is been detected and voice notification is given to user.
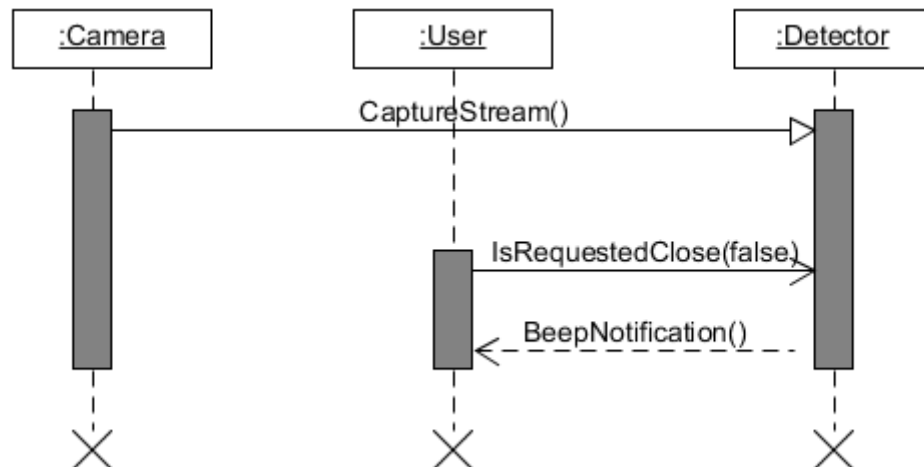
Figure 3.6 Detect Object Sequence Diagram

3.2.3 Detect Obstacle Sequence Diagram

Figure 3.7 shows how information flows between system, user and interface which is camera. This figure shows how camera is interacting with detector by sending capture stream to detector, once it returns true then notification is given to user but if in the meantime user requests for closing application then detector and camera will be giving no results i.e. no response will be generated. Each time when there is something is detected sound notification is generated. There are responses between camera, user and detector. Camera is sending response to detector, detector then gives sound notification to application users.
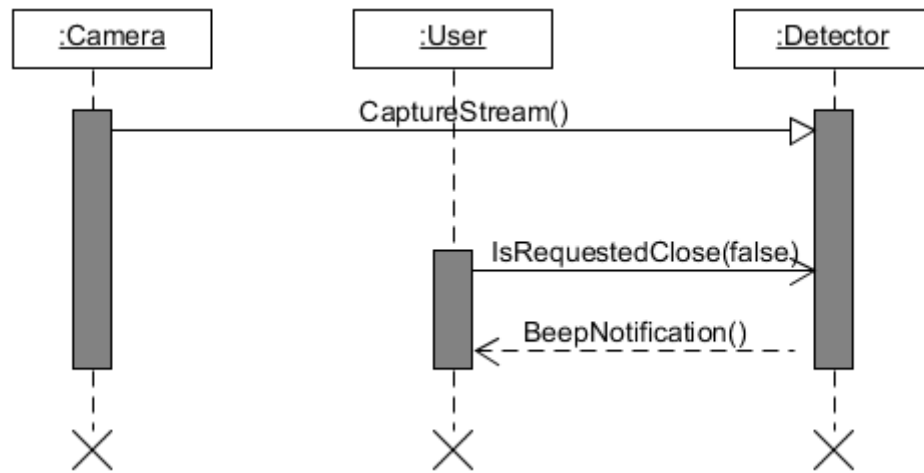
Figure 3.7 Detect Obstacle Sequence Diagram

3.3 Proposed System Flow

Figure 3.8 shows the flow diagram of system where user starts application by tapping three times on the screen. Camera is opened. If camera is working then get frames. First step is to check whether it is predefined object or not. For that, system is trained for at least one month. Training include set of different images of the object that are been given as input to the system, and system made template from those images, when system is in processing mode it compares image with template and then returns true or false accordingly. Obstacle detector is next component when object detector says no, in which each frame is processed and processing includes converting image into gray scale, segment frame into matrix. Obstacle detector returns true if it detects object. If it returns true voice notification is been given to the user and after the process analyze next frame. If it returns false it will skip frame and go for next frame, until user requests to close application. There are three main components that are major part of the system. One is object detector, second is obstacle detector and third is sound notification which is produced after detecting sound notifaction.

Purpose of object detector is to detect object and return the name of that object so it is getting inputs from camera and produces relevant output. Input here is frame of image and output is a label. Label is in form of string and that string is used as input for sound notification component. Obstacle detector has a little different functionality it gets the image some image processing is done to detect weather it is object or not, if it is an object then it produces labeled input for sound notification component. Sound notification component just uses string to generate voice notification. Role of camera is very important in the process, it gets video stream and then passes it to object and obstacle detector.
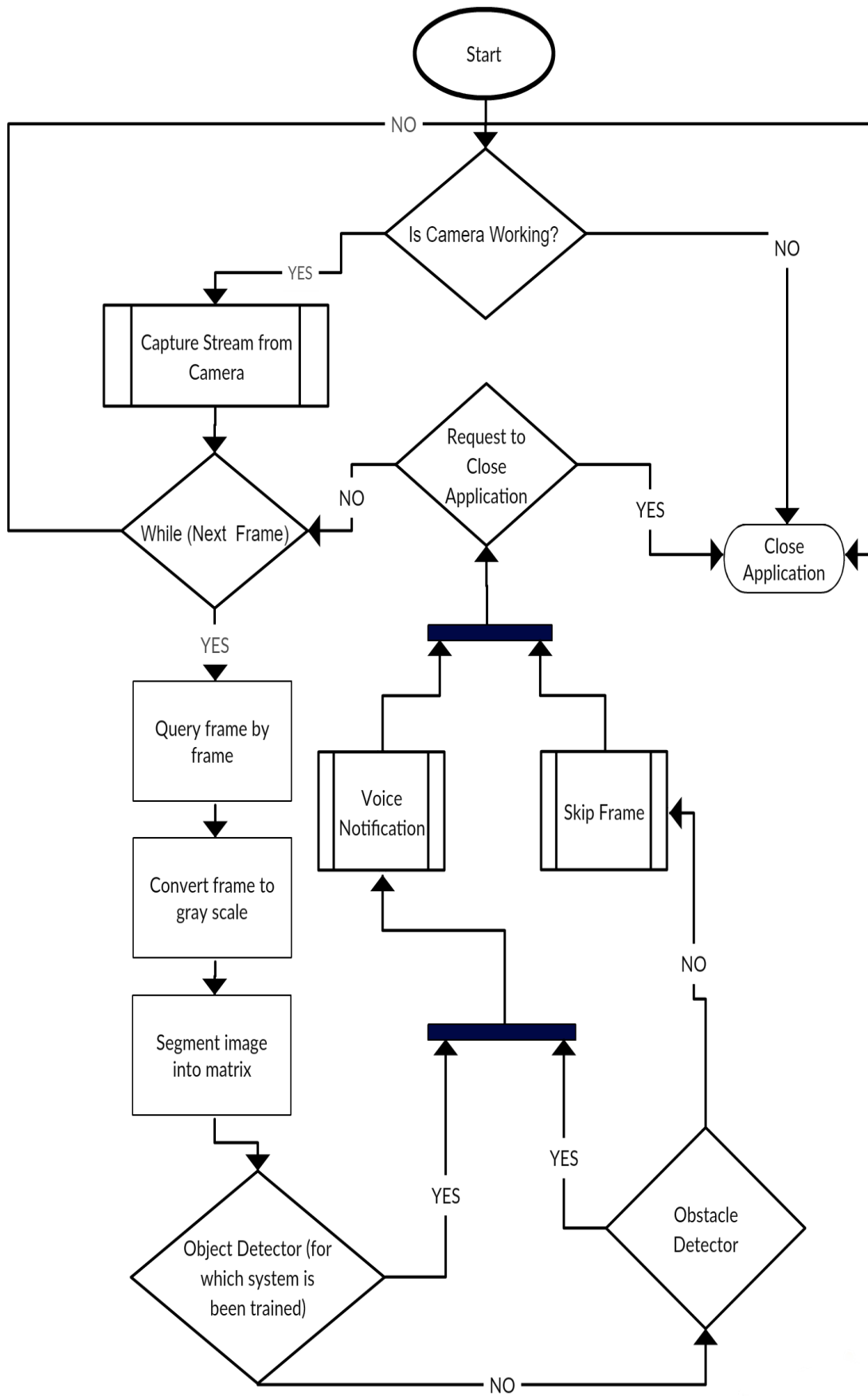
Figure 3.8 Flow Diagram of the System.

CHAPTER 4
DEVELOPMENT METHODOLOGIES

4.0 Introduction

In "Development Methodology" chapter all set of information which is about the development of the "Real time Object Detector for visually impaired". All the tasks performed by the system and process of developing the system are described. This chapter also describes the process how user is interacting with interface and then how that particular interface is interacting with the system to perform a specific task for user. There is also description of the limitations achieved, that were in existing systems. Also, the limitation of this system. Development of the system includes two parts, one is system training that is been done through Python language, a model is been developed. And other part is to develop android application by using that model.

Application is launched by tapping three time on screen. If screen is locked it does not launched application, but if screen is unlocked then application is launched and sound notification is produced to acknowledge user that application is launched. To recognize the objects, system uses trained model which is part of system and each time when images are given as inputs, these images are compared with model to predict about the object. Model is produced by using python language. There are many methods to produce model, but comparatively reliable method is to use Tensorflow. It uses data flow graphs for computing numerical values. It is an open source library. Edges in graph represent multidimensional data arrays these arrays are called tensors. Nodes represent mathematical operations. It has flexible architecture which allows to deploy computation to one or more CPUs in desktop, server and mobile devices with a single API. By using tensorflow, raw images are collected to make a tensor model. This model is a sequential model which means it is a linear stack of layers. Then each model is converted to 3 convolutional blocks. Then pooling is performed to extract max value [6].

First step is to load the data, this is basically reshaping data. As purpose here is to make a model form pixel values. So vectorization of input data is performed. Vectorization means to convert or reshape raw image into tensorflow map so that it can be inserted into the model. Two types of data sets are returned, one is training set and other is testing set. Model is initialized as sequential model, with three convolutional blocks. Convolution is applied on it, then pooling is performed to get maximum value out of those blocks. Again convolution is applied to get more images out of it. And once got the tensor then flatten that tensor to one dimension array. First step is to perform optimizations to the model get and rid of losses and then fit function to define session, graph and to iterate through all

the batches. One month is utilized to train the model on a laptop by giving hundreds of images of defined categories. Once model is been trained it is exported in 'protocol buffers' or 'protobuf' format. This format is very fast and helpful in communication among the device and model. Protocol Buffers is a technique for serializing organized information. It is valuable in creating projects to communicate with each other over a wire or for putting away data. The strategy includes an interface portrayal dialect that depicts the structure of a few information and a program that creates source code from that depiction for producing or parsing a surge of bytes that speaks to the organized information. Google created Protocol Buffers for utilize inside and has given a code generator to numerous dialects under source permit. The plan objectives for Protocol Buffers underlined straightforwardness and execution. Specifically, it was intended to be littler and speedier than XML.

4.1 Application Development

As in this application interface is not much effective. In the process of development there are two phases, one is to train model for different objects and other is to utilize that model in application. So most of the functionality is in background processing. Once application is working it needs to communicate with model for each of the frame it processes and so it needs very fast processor.

4.1.1 Interface Screen

Interface screen has only got the camera feed that is video stream. So once camera is working it'll continuously display video. Interface is really simple and not having any purpose as blind persons are using application so interface is invisible to them. That is why interface just shows video stream and a rectangle box which is drawn around any object.

4.1.2 Image Capturing

Once application is started, it starts capturing images after each thirty millisecond. Basic camera of mobile device is used for this purpose. Detection of object will be much better on the devices with high resolution camera. Also camera is locked so no other application can open it up. In the camera preview the user has to turn the camera to ground so it is able to make an angle to capture video. If person is moving too fast it might not be able to detect object. Once image is captured it is now used by texture view to call functions of tensorflow.

4.1.3 Tensorflow

It is a Machine Learning library, there are many other libraries used for machine learning, but for most reliable results tensorflow is best. When images are available tensorflow functions are used to map image and train model. There are set of images and labels, each image category has a specific label. Camera feed is passed to Tensorflow's functions which compare image and model and return a label. The process of getting frames and comparing each time with the model is very fast so it generates results in milliseconds. Tensorflow here provides a communication bridge between application and model and it is very fast.

4.1.4 Image Processing

Digital image processing is the utilization of computer calculations to perform picture handling on advanced pictures. As a subcategory or field of computerized flag handling, advanced picture preparing has numerous favorable circumstances over simple picture handling. It permits a substantially more extensive scope of calculations to be connected to the information and can keep away from issues, for example, the development of commotion and flag contortion amid preparing. Since pictures are characterized more than two measurements (maybe more) computerized picture preparing might be demonstrated as multidimensional frameworks.

Images are not input directly into tensorflow functions, some processing is been done before comparing images. There are many ways of doing image processing and many of applications of image processing are available now a days. Real Time Object Detector for Visually Impaired also uses image processing for detecting objects. Before comparing images with model, some refinements are done with images, like filtering image.

4.1.5 Object Detection

Once image is been captured and is in processing stage, it is first checked by Object Detector to recognize the object whether it is defined in the model or not. If it is defined and probability is near to one, it returns label of that specific object. If object is unclear then system will not been able to recognize it. There are many techniques to detect an object using camera, but here YOLO (you only look first) is used. All earlier location frameworks repurpose classifiers or localizers to perform identification. They apply the model to a picture at numerous areas and scales. High scoring locales of the picture are thought about identifications. Here is a very surprising methodology. A solitary neural system is utilized to the full picture. This system separates the picture into locales and

predicts bouncing boxes and probabilities for every area. When question is identified, sound notice is created.

4.1.6 Obstacle Detection

If object is not recognized by the system and object detector has returned false then it is obstacle. Obstacle is any object which is in front of camera but not defined in the system or model. Continuous flow of images from camera is analyzed one by one, each check point is having functionality to return a label by getting image input. Then each label is utilized to generate output. If object is not recognized, model returns very low probability for that, so that object is named as obstacle. Once obstacle is detected sound notification is given to user.

4.1.7 Notifications

There are several notifications for visually impaired in this system, as they are unable to see things. So to communicate with them, voice is the best solution. That is why Real Time Object Detector for visually Impaired produces different notifications. Like sound notification and vibration.

4.1.7.1 Sound Notifications

If there is any object or obstacle is detected there is sound notification. If object is detected then sound is the name of that object. If there is obstacle then sound notification is in the form of beep. When image is processed it generates specific label in return, that label is used to make an argument for android TextToSpeech library. Which produces sound notification.

4.1.7.2 TextToSpeech Library

Android TextToSpeech library is used to convert text to speech. It takes text as input and returns sound. There are multiple functions of TextToSpeech. Speak function is used to produce sound notification. If there is any object or obstacle is detected there is sound notification. If object is detected then sound is in form of beep.

4.2 Development and Build Environment

In application for the advancement and manufacture condition, developers must have some key info in their minds. They must think about the way that application is utilized on various forms of android versions. Design configuration ought to be responsive and same with the goal that it can run same on all sort of gadgets like cell phones of each size. Engineer plans the application in straightforward easy to use way with the goal that it can without much of a stretch justifiable and easy to every individual who needs to utilize this

application. UI must be benevolent so clients might not have any inconvenience to utilize it while they use this application. There must be a user direct accessible guide for application users with the goal that nobody faces inconvenience to utilize the application.

CHAPTER 5
TESTING, ANALYSIS AND VALIDATION

5.0 Introduction

This chapter explains the processing of testing the system. It explains about the functionalities and results of testing and validation of the system. Specially designed test cases are used for that purpose. Test cases are very important part of testing so test cases are designed to fit all the functionalities of the system. Each condition is checked, and correctness of application is validated. Camera is major part of the system so system is tested in different conditions of camera to make sure that application does not crash. To test if response of the application is enough fast. Basic aim of testing is to find bugs, errors and to assure quality product.

5.1 Test Bed

Test bedding process in software development is the process of testing specific module of software product like a function, class or object in a specific testing method. Test bed consists of specific hardware, software, Operating system, and network configuration, the product under test, other system software and application software. "Real time object detector for visually impaired" is an android application that is been tested on 512 RAM with android OS, without internet connection and by testing it on different versions of android OS.

5.2 Test Cases

Test cases in any testing process define how a system or small parts of a system like a specific functionality or a module of system should be tested in order to get an error free product in the end for users. Normally a single test case only tests a single module. In some systems it is required to test different modules in a single test case to check their functionality and also there integration property with other modules in that system. Each test case is specifically designed for a specific scenario. This test case covers mostly all the possible ways in which the user can interact with the system. In any testing phase each module of the system is first tested alone. After this step integration testing is performed in order to check the system's functionalities as a whole. Basically testing is focused on functional requirements but nonfunctional requirements are also check in this process. In each test case its expected result is listed and after test case is performed both of its results are compared in order to see the possible difference. If the difference is tolerate able it is ok but if the difference is way more than expected either test is performed again or some changes in system are done so that expected results can be achieved. Following are the test cases for the developed system.

5.3 Unit Test

In the system "Real Time Object Detector for Visually Impaired", every single unit should be deliberately tried to guarantee that every one of the units in the system are working legitimately. This framework contains units that should be checked that these are working legitimately. In equipment, design of camera is tried by opening camera through commands or java code.

5.3.1 Camera Configuration Test Case

The system uses android built in camera. But that needs to be configured so it can be opened by using camera services through coding. It is checked whether the camera is functioning properly and whether it is configured successfully or not. Based on the inputs, system confirms that the camera is working properly, or if there is any issues it says exception occurred and terminates successfully.

5.3.1.1 Conclusion

To verify working of camera there was no error message when command for opening camera is run, and if there is error message or any exception when camera is tried to open through command then there must be fault in camera or compatibility issue will be there with system.

5.3.2 Speaker Configuration Test Case

System requires speaker to work properly to produce sound notification. If speaker are working fine then they can produce sound notification. An object has detected by turning on the application if it produces sound notification then speaker are working if it is not then speakers are not working.

5.3.2.1 Conclusion

The functionality of speaker is verified when object is detected by the system it produces sound notification.

5.3.3 Sound Notification on Starting Application Test Case

Launch Application is first step of using this application. During the process of installation, user is asked about some of permissions, if these permissions are allowed then application is installed. User taps three time on screen to turn on the application. When application is launched sound notification is produced. Testing is performed by launching application multiple times, with different conditions. Three tap is done within one and half second and application launches without any error and sound notification is

produced. This launch application test case is shown below in Table 5.1 Launch Application Test Case.

Table 5.1 Sound Notification on Starting Application Test Case

Test Case ID	Use Case Reference	QA Test Engineer	Name of Personnel
TC-1	UC-1	Programmer	Muhammad Mudassar
Test Date	11-12-2017		
Revision History	None.		
Objective	Produce Sound Notification on Launching Application.		
Environment	User Mode.		
Assumptions	User is tapping on screen without watching.		
Pre-Requisite	Application is properly installed on user's device.		
Steps #	Execution Description		Procedure Result
1.	Tap on screen three times.		Application is launched and sound notification is produced.
Status	☑ Pass ☐ Fail ☐ Not Executed		

5.3.4 Start Application with Locked Screen

Launch Application is first step of using this application. During the process of installation, user is asked about some of permissions, if these permissions are allowed then application is installed. User taps three time on screen to turn on the application. Testing is performed by launching application without unlocking screen. Three tap is done within one and half second and application doesn't launch. This test case is shown below in Table 5.2 Launch Application when screen is locked use case.

Table 5.2 Start Application with Locked screen Test Case

Test Case ID	Use Case Reference	QA Test Engineer	Name of Personnel
TC-2	UC-1	Programmer	Muhammad Mudassar
Test Date	11-12-2017		
Revision History	None.		
Objective	Application is not launch by taping three times if screen is locked.		
Environment	User Mode.		
Assumptions	User is tapping on screen without unlocking.		
Pre-Requisite	Application is properly installed on user's device.		
Steps #	**Execution Description**		**Procedure Result**
1.	Tap on screen three times.		Application is not launched.
Status	☑ Fail ☐ Pass ☐ Not Executed		

5.3.5 Detect Object Test Case

Objects are recognized by the system, user is not still while objects are detected. User is continuously moving, when object is detected sound notification is produced. Application is tested by moving along objects which are known to the system. These objects include chair, table, bottle and laptop. Application produces sound relevant to that specific object. One important factor is response time, and it is depending on RAM and Processor of device. It detects object correctly in one half of a second with 512MB of RAM. This test case is shown below in Table 5.3 Detect Object Test Case.

Table 5.3 Detect Object Test Case

Test Case ID	Use Case Reference	QA Test Engineer	Name of Personnel
TC-3	UC-2	Programmer	Nazish Rashid
Test Date	11-12-2017		
Revision History	None.		
Objective	Detect Object correctly and produce sound notification.		
Environment	User Mode.		
Assumptions	Camera is working and it is capturing video.		
Pre-Requisite	Application is properly installed on user's device and permission of camera is allowed.		
Steps #	**Execution Description**		**Procedure Result**
1.	User walks by turning on the application.		Sound notification is produced when object is detected.
Status	☑ Pass ☐ Fail ☐ Not Executed		

5.3.6 Detect Single Objects Test Case

Objects are recognized by the system, as user is not still while objects are detected so there can be multiple images in front of camera in single unit of time. If multiple objects are in front of camera, each object cannot be detected at a single unit of time. Application is tested by moving along objects which are known to the system. These objects were placed in same location. Application produces sound relevant to the object which is nearest to camera. This is also important factor that application is not detecting multiple objects in a single unit of time. This test case can be seen inn Table 5.4.

Table 5.4 Detect Single Object Test Case

Test Case ID	Use Case Reference	QA Test	Name of Personnel

		Engineer	
TC-4	UC-2	Programmer	Nazish Rashid
Test Date	11-12-2017		
Revision History	None.		
Objective	Detect only one Object correctly and produce sound notification.		
Environment	User Mode.		
Assumptions	Camera is working and it is capturing video.		
Pre-Requisite	Application is properly installed on user's device and permission of camera is allowed.		
Steps #	**Execution Description**	**Procedure Result**	
1.	User walks by turning on the application.	Sound notification is produced when object is detected.	
Status	✓ Pass ☐ Fail ☐ Not Executed		

5.3.7 Detect Obstacle Test Case

Obstacles are hurdles which are in front of user during movement. If there is any object which is not recognized by the application then it is an obstacle. User is in motion while camera is working and getting video stream. If there is any obstacle in front of camera sound notification is produced. Application is tested by moving camera through obstacle which are not defined in the model. Application produces sound. Here also response time is very much depending on RAM and processor. But if RAM and processor both are suitable for the application then it runs smooth and never gives delay.

Table 5.5 Detect Obstacle Test Case

Test Case ID	**Use Case Reference**	**QA Test Engineer**	**Name of Personnel**
TC-5	UC-3	Programmer	Khadija Rashid

Test Date	11-12-2017
Revision History	None.
Objective	Detect Obstacle correctly and produce sound notification.
Environment	User Mode.
Assumptions	Camera is working and it is capturing video.
Pre-Requisite	Application is properly installed on user's device and permission of camera is allowed.

Steps #	Execution Description	Procedure Result
1.	User walks by turning on the application.	Sound notification is produced when obstacle is detected.
Status	☑ Pass ☐ Fail ☐ Not Executed	

5.3.8 Detect Single Obstacle Test Case

There can be multiple obstacles in front of camera. Multiple obstacles are treated same as multiple objects. Application detects only the nearest obstacle. Application is tested by moving camera through multiple obstacles which are not defined in the model. Application produces sound by focusing on nearest obstacle. Following Table 5.6 is test case for Detect Single Obstacle.

Table 5.6 Detect Single Obstacle Test Case

Test Case ID	Use Case Reference	QA Test Engineer	Name of Personnel
TC-6	UC-3	Programmer	Khadija Rashid
Test Date	11-12-2017		
Revision History	None.		

Objective	Detect nearest Obstacle correctly and produce sound notification.	
Environment	User Mode.	
Assumptions	Camera is working and it is capturing video.	
Pre-Requisite	Application is properly installed on user's device and permission of camera is allowed.	
Steps #	Execution Description	Procedure Result
1.	User walks after turning on the application.	Sound notification is produced when obstacle is detected.
Status	☑ Pass ☐ Fail ☐ Not Executed	

5.3.9 Tensorflow Model Test Case

In order to check availability of tensorflow model in this system needs to check two things i.e. presence of graph.pb in assets and connectivity with the model. Model is having definitions for the objects and it also contains label for each object.

5.3.9.1 Conclusion

Application is tested by launching application and by detecting object, it detects object successfully without giving any error so Model is available and application can run successfully.

5.4 Result of Test Cases

After a thorough process of testing application there is a result in which overall progress of application is noted. All the test cases went through without any error and application is performing all the tasks correctly. All features are achieved by the application and all functionalities are fulfilled. User is able to launch application by tapping three time on screen. Once it is launch it gives sound notification that it is launched. After application is launched it starts getting video stream, detects object and give sound notification. Same case for obstacles, it detects obstacles and gives sound notification for obstacles as well. So visually impaired persons can easily use this application to walk. Application works

without errors and accuracy is one of the important factor of this application. Table 5.7 Test Case Result is showing results of all test cases below.

Table 5.7 Result Test Case

Serial #	Test Case ID	Test Case Description	Test Case Actual Result	Status
1	TC-1	Notify User on Launch Application	Launched Successfully	Pass
2	TC-2	Launch Application when Screen is Locked	Does not launched	Fail
3	TC-3	Detect Object	Detected Successfully	Pass
4	TC-4	Detect Single Object	Detected Successfully	Pass
5	TC-5	Detect Obstacle	Detected Successfully	Pass
6	TC-6	Detect Single Obstacle	Detected Successfully	Pass

5.5 Black box testing

This method in software testing is used in which there is not any knowledge of structure of the application and also there is no knowledge of implementation of the system. In short words, system is unknown to the tester in terms of implementation and internal structure. This application will be used by blind persons so to verify functionalities of application is very important. Black box testing is performed because focus is on functionality of the application so it should work perfect.

5.5.1 System Testing

System testing is done on the total system. Distinctive data sources are given to watch that the system is giving the required output or not. The system "Real Time Object Detector for Visually Impaired" is tested by confirming that on the off chance that it is working as indicated by its determination so additionally test the system to check if the fundamental usefulness of the system is accomplished i.e. producing sound notification when there is any object in front of camera.

Test started when user install application and while installing user allow it to use camera and storage, once installed then user unlock screen and taps three time on screen to launch application. Application is launched and it gives a voice notification to acknowledge user.

Now user moves by holding mobile phone and facing camera to opposite side. It produces sound notification when there is any object in front of camera. User keeps moving when there are objects placed in front of camera and application produces sound notification. If user taps two times then application is closed.

This test is performed to verify that each of the functionality is working. The system shows different results on different conditions for example if there is not sufficient light system cannot work properly and will generate warning. Also, if there are multiple objects in front of camera it detects only the nearest one.

5.5.1.1 Conclusion

The system testing of this system is useful in light of the fact that every single part of the system is working as needs be. At the point when the whole test has been taken then plainly the whole system usefulness is working as indicated by its determination. The system has been tried on different conditions to test whether system can deal with any sort of false input and can manage any error.

CHAPTER 6
CONCLUSION AND FUTURE WORK

6.0 Overview

This chapter have all the conclusions and it covers all the aspects of report, including suggestion of future work that can be added to this application, limitations of the application which are great challenges for developers. There are many updates which can be done in future to make this application more useful. There are many factors which needs a lot of work to be done on them, so all of these factors are described in this chapter. Purpose of developing this application is to help visually impaired, so there are many things which might not fully satisfy blind persons. These things are describe here in detail.

6.1 System Overview

To develop this application, java, python and c++ programming is used. Use of artificial intelligence make this system more complex but reliable. A lot of research is also done before starting development. Best techniques are used to train the model. All of the futures are achieved which are given in undertaking and these are working fine. Testing is performed on each of the module and functionality, and test cases passed successfully.

This application is developed specially for visually impaired who are using android smart phones and tablets. This application is helpful for visually impaired, as they can walk using this application without using cane. Application is very easy to use and is friendly for visually impaired. Installation is very simple then launching application is easy as well, as there is no need to find application icon instead user can simple tap three times on screen to launch application. Once application is launched it gives sound notification. This is really helpful for visually impaired, as it is giving response to user in form of voice message. After it is launched, it detects objects and obstacles and gives sound notifications to users. As application is using trained model for object detection so it is working on probability. If probability is nearly one then sound notification is produced. Model is trained for one month and hundreds of images are given as input to the system. Once model is ready then it is utilized in application, model contains definition for objects. When application is launched it continuously get images and each frame of image is compared with graph or model, so when image and object definition in model matches with more probabilities then label relevant to that object is returned which is used by application to convert into sound notification. If camera has not focused the object then it does not return any label, so to detect object, focus of camera is very important and to do that autofocus is used.

6.3 Achievements and Objective

Most of objectives mentioned in undertaking are completed and achieved and project is developed with success. Easy design and simple architecture is achieved. All the functionalities of application are achieved which are stated in undertaking. Some of new functionalities are also achieved. Image processing is used along with Machine Learning. Image processing is used in application at front end level and Machine Learning as a back end level for the application is used.

Using Machine Learning library Tensorflow, a model is been achieved which contains definition for objects. By giving bulk of images as input to the system as training data, model is been exported. Model is exported in protobuf format so that it can be used easily by application and communication is very fast. On front end level android open source APIs are used, performance and response of application is been improved by using new features of android. For testing application during development, android device is used. As emulator is not much effective for image processing. Testing is performed on different smart phones with different versions of operating systems. Some of new functionalities are also achieved

Second task that has been achieved is the technique of using Java language for android mobile application development and also learned some ways to write clear as well as clean codes. The whole application is developed using windows operating systems on which android studio runs, Java and Java native is used as a programming language, XML is used for layout as this is light weight layout. Application is designed to run on Android 4.0 and also top version of Android operating systems.

6.4 Limitations

There are many limitations of the application as well. It consumes more battery as it is using camera all the time and also it is using speakers for sound notifications. Also response time in devices having low RAM is also a limitation. As there are lot of calculations running on the device while this application works so response time is little more.

Some of the limitations of the system are given below.

6.4.1 Consumption of Battery

Whenever camera is working and getting video stream, it uses more battery than normal. Also sound notifications are produced many times, which utilizes battery a little more than normal.

6.4.2 Exceptions on multiple objects

When there are multiple objects are in front of camera there will be exception because at one time it detects only one object.

6.5 Future Recommendations

This system is designed especially for visually impaired and to make is user friendly sound notifications are added. This system has actually been developed to make it easy to use user interface and also more work could be done quickly to readjust the system inning accordance with future demands of customers. Assist in work might focus to boost the aspects, technology and the user interface. In future, designers could present more APIs of Android application progression that upgrades the advancement and improvement. Android offers an open source change to style and furthermore create application with entry of time and furthermore different fields of training.

6.5.1 IOS Application

This Application is developed only for android phones. In the future this application can be enhanced and converted to IOS application. That will run on iPhone. These are expensive devices so have very good architecture, which can do all the calculations very easily within less time. So response rate is very good with these devices. Coding is readable and done clearly so that it is understandable and it can be done for any other platform like windows phone.

6.5.2 Multiple Objects Detection

This application is developed for detecting one object in one frame. In future this application can be enhanced to detect multiple objects in a single frame. For that purpose a technique which is called YOLO.

6.5.3 Improving Response Time

Right now application is having more response time. It is detecting object each time by communicating with model which then calculates all the things and return probability. This is time consuming so in future objects can be cached in temporary memory so it will detect objects with more speed. Also some other techniques can be used in future to have more quick response when any object or obstacle is detected. For this reason tensorflow light can be used to make it faster because this library is available in demo version, once it will be available in full version then it can be used in application to make it works faster.

6.5.4 User can Define Objects

Right now application is detecting only predefined objects, for which system is trained. In future, system can allow user to add new object and enter its name. Then it get bulk of images from internet and train model for that object.

APPENDICES

Appendix I – User Manual

Sound Notification on Launch Application

When system starts, it gives sound notification, so that user is aware that application has started.

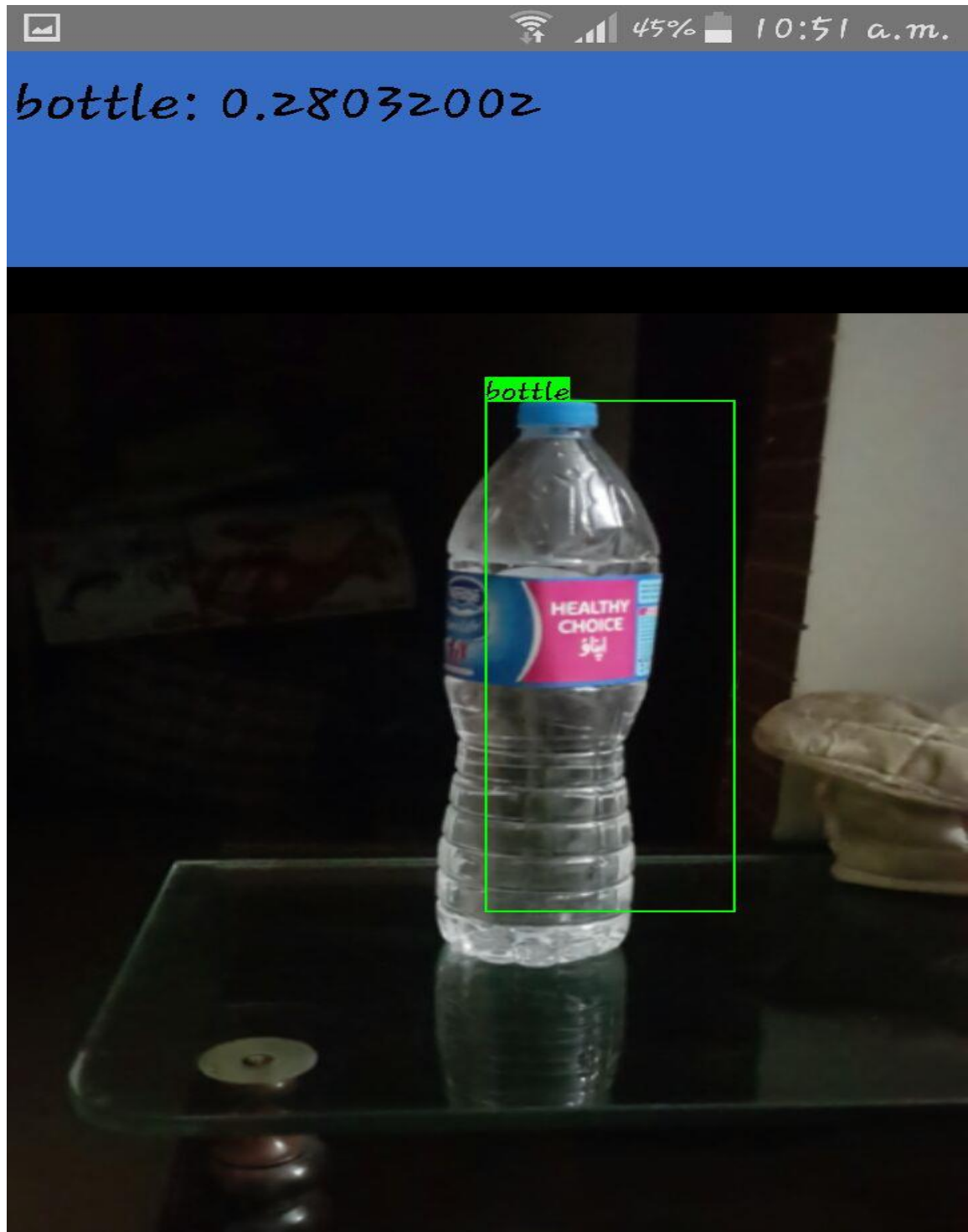**Sound Notification on Object Detection**

When system detects any object for which it is been trained, it generates sound notification and also recall the name of the object. Here is picture of detecting chair.


A-1.1 Detect Chair

Along with making a bounding box against the object, it also generates sound notification to notify blind person.

Below is picture of detecting bottle, when it detects bottle it generates sound notification along with a bounding box around the object.

A-1.2 Detect Bottle

Below is picture of detecting monitor. System detects the monitor and generates sound notification to identify that it is a monitor.
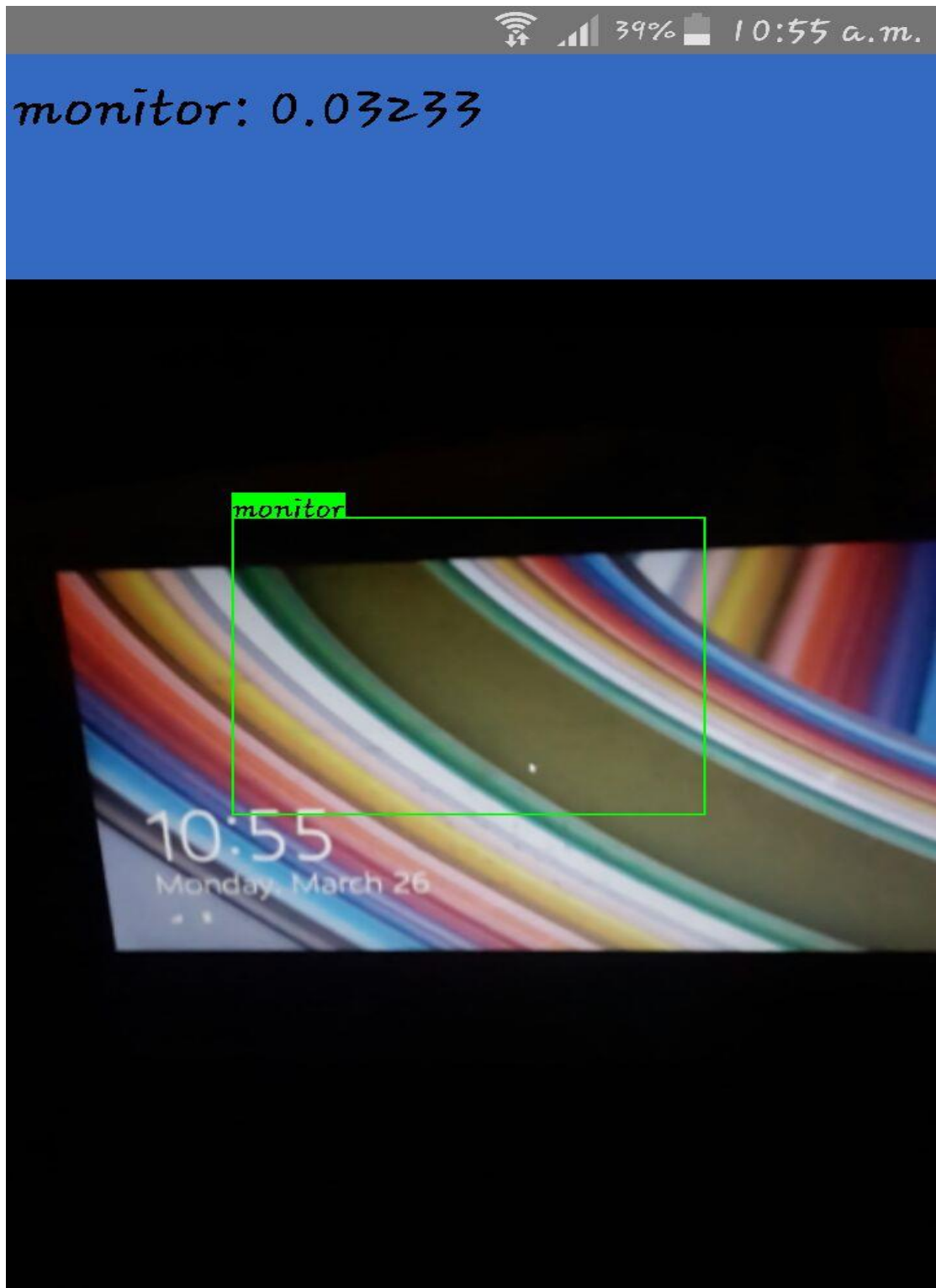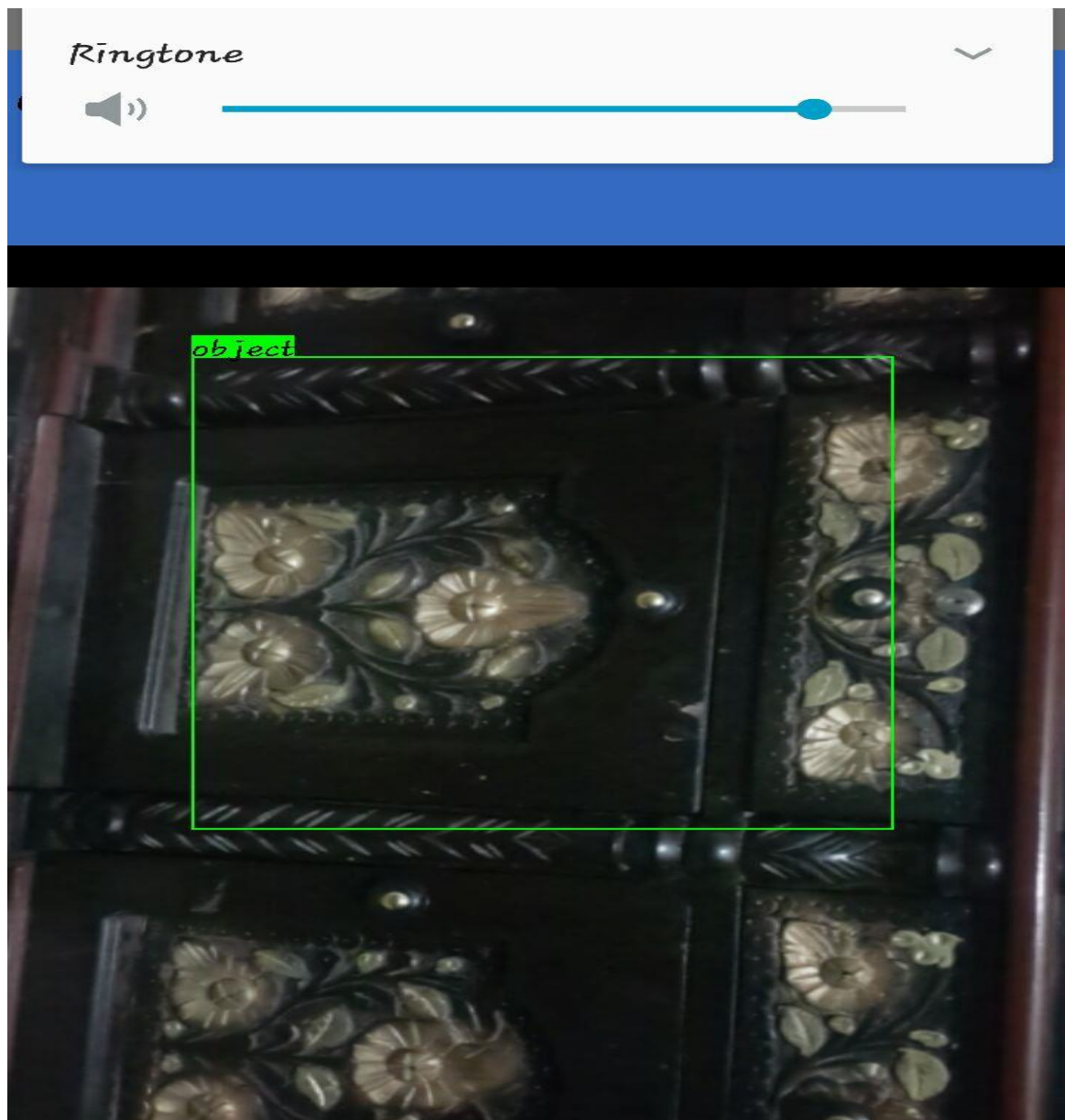
A-1.3 Detect Monitor

Sound Notification on Obstacle Detection

When system detects any obstacle for which it is not been trained, it generates sound notification but this time it only recall that it is object.

As in the figure A-1.4, system detects object for which it is not been trained and generates sound notification. Bounding box is also there around the object.

A-1.4 Detect Object

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