ANDROID APPLICATION FOR EYE DIAGNOSIS SUITE

By

Nabiha Raza

Aatiqa Sohail Khan

Syed Hassan Mussana

Submitted to the Faculty of Computing Software Engineering

National University of Sciences and Technology, Islamabad

ABSTRACT

ANDROID APPLICATION FOR EYE DIAGNOSIS SUITE

Clear vision is one of the fundamental necessities of any human being. An average of 75% of the population at least visits an optician or doctor (ophthalmologist) in 6 months for an eye check-up. The vision test and the color blindness tests, which are the most common tests in the eye domain, takes at least 15-25 minutes of the doctor's time per person. Daily the ophthalmologists (doctors) examine more than 30 patients that only require vision testing or examination of eye for different color vision deficiencies.

With the exceedingly rapid advancements in the field of technology, the entire concept of medicine and patient treatment is evolving and taking a new shape altogether. The idea of telemedicine (the use of telecommunication and information technologies in order to provide clinical health care at a distance) is deepening its roots with every passing day. Keeping this in mind and its significance in today's world, our aim is to develop an android application that is accessible to every android tablet/smartphone user to perform eye tests in order to check defective vision along with color vision deficiencies such as color blindness.

The application will have a modular structure targeting four major eye tests i.e. distant vision test (Visual acuity), Ishihara and FM100 test (Color blindness tests) and fundus imagery (Fundus eye infection test).This application will not only provide free, fast, zero-travelling cost, efficient and accurate results to the users but will also help to reduce the number of patients that the doctor has to treat thereby reducing the doctor's burden. Also the paramedics, health workers and doctors can take this application in the remotest areas and can perform eye tests on patients who are not provided with basic health facilities in routine. Diagnosis suite will also increase the awareness among the general population.

CERTIFICATE FOR CORRECTNESS AND APPROVAL

Certified that work contained in the thesis - Android Application for Eye Diagnosis Suite carried out by Syed Hassan Mussana, Nabiha Raza and Aatiqa Sohail Khan under supervision of Dr. Seemab Latif for partial fulfilment of Degree of Bachelor of Software Engineering is correct and approved.

Approved by

Dr. Seemab Latif

CSE DEPARTMENT
MCS

DATED:

_____

DECLARATION

No portion of the work presented in this dissertation has been submitted in support of another award or qualification either at this institution or elsewhere.

DEDICATION

In the name of Allah, the Most Merciful, the Most Beneficent

To our parents, without whose unflinching support and unstinting cooperation,

a work of this magnitude would not have been possible

ACKNOWLEDGEMENTS

To begin with, there is no greater guide than **ALLAH (SWT)** Himself and we feel blessed that He gave us enough strength to complete this project well in time.

In addition to this, we all would deeply and genuinely like to thank Ma'am **Dr. Seemab Latif** for her persistent guidance and continuous support. Ma'am you are an exceptional supervisor and without you we could not have come this far.

We would also like to extend our profound recognition to **Asst Prof Sarmad Sadik** who is our co supervisor and always helped us, whenever we needed him.

Our project would not have been completed without the support of **Maj Yaseer Nadeem** (M.B.B.S) (specialized ophthalmologist) and a teacher at Army Medical College (NUST). He gave us all the medical tips and requirements we needed to cope up the Doctor-Engineer gap. Sir Yaseer, Thank you very much.

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Chapter 1: Introduction

The World Health Organization estimates that 90% of the more than 385 million people worldwide who are visually impaired live in developing countries 80% of blindness (eye sight tests and color blindness) is avoidable but the major obstacle to its elimination is the lack of effective examination, diagnosis and follow-up of eye patients.

The purpose of this project is to develop and transform a low-cost android based smartphone/tablet into an eye examination and diagnosis suit. The Eye Diagnosis Suite aims to provide a collaboration of four eye tests that are commonly needed and used by the doctors and health workers. The suite includes:

1. Visual Acuity Test (Eye Sight test)

2. FM 100 test (Color Blindness test)

3. Ishihara 24 -Plate Color Blindness Test

4. Fundus Camera Eye Infection Test (using Image Stitching)

The application will have a wide diversity of users which includes Doctors, Health visitors, general public, and anyone who has access to android tablets/cellphones. First three modules will be available for use to the general public (any Smartphone user) whereas the last module will be specific to use for ophthalmologists (eye specialists) and health workers because it requires expert decisions.

1.1 Problem Statement

Proper and clear vision is one of fundamental necessities of any human being. An average of 75% of the population at least visits an optician or doctor (ophthalmologist) in 6 months for an eye checkup. The vision test and the color blindness test, which are the most common tests in the eye domain, takes at least 15-25 minutes of the doctor's time per person. Daily the ophthalmologists (doctors) examine more than 30 patients that just need to test their vision or examine patients on different color blindness tests.

1.2 Scope

Table 1-1: Scope of Project

For	Ophthalmologists and any Average Smart Phone user who wants to examine his/her eye
What	Ishihara Color Blindness Test, FM-100 hue color Test, Visual Acuity Test, Fundus Image Stitching
The	Eye Diagnosis Suite
Is	An android application
That	Provides cost effective, convenient, rapid and accurate diagnosis of certain eye problems.

The Eye Diagnosis Suite shall provide a mobile/tablet application that would run on top of an Android operating system. It has four modules covering four eye tests. Three of the modules (Visual Acuity, FM 100,Ishihara Test) shall be available for use to the general public (any Smartphone user) whereas the last module shall be specific to use for ophthalmologists or health workers. It shall be a mobile/tablet based solution satisfying objectives such as:

1. Mechanism for testing color blindness
2. Display Ishihara 24 -plate images for automating color blindness test
3. Automation of FM 100 test for color vision deficiency
4. Separate modules/interfaces for general public and ophthalmologists
5. Display of guidelines for performing eye tests accurately
6. Automation of Visual Acuity test
7. Take multiple images of the eye through an ophthalmoscope attached to camera of mobile/tablet
8. Show a complete image of the eye fundus
9. Email option for eye images

1.3 Objectives

The objective of the project include:

1. To learn and implement an android based application using java as a programming language
2. To implement the algorithms of FM-100 and Visual Acuity Test

3. To implement the accurate picture stitching which could identify the minute veins and arteries for Fundus imagery.
4. To develop a user friendly software.

1.4 Deliverables

Table 1-2: Project Deliverables

Sr.	Tasks	Deliverables
1	Literature Review	Literature Survey
2	Requirements Gathering	SRS Document
3	Application Design	Design Document
4	Implementation	Implementation of the application on an android device (mobile/tablet), Test Plan
5	Testing	Evaluation plan and test document
6	Training	Deployment Plan
7	Deployment	Complete application along with necessary documentation

1.5 Achievements

1. Industrial Project
2. FICS
3. Industrial mentorship by E-Mumba
4. Funding for prototype development
5. ICT R&D funding Applied for FYP

Chapter 2: Literature Review

2.1 Introduction

Every year, nearly 75% of the total eye patients have been reported to be diagnosed 10 months later on average than the day the disease began. Many of them are children which cannot be diagnosed of being visually impaired in time and most of them end up using spectacles only because they were not diagnosed at the right time.

A common person, who knows how to use a tablet/smart phone will be able to use the application and will be guided step by step to perform the tasks which will help user in answering three main questions regarding eye:

1. How much your eye-sight is weak (Visual Acuity)
2. Are you a color blind person? (Ishihara Test)
3. Intensity of color blindness (FM-100 test)

2.2 Background

The problem of eye related diseases is particularly more in a country like Pakistan where there is very low doctor to patient ratio. The problem increases even more when the topic of budget comes under discussion, as highly specialized equipment is needed to diagnose eye diseases and most of these equipment's are not mobile and thus remote areas do not have access to such facilities. This is the reason why in villages, eye diseases go un-diagnosed for long periods of time. Our team has come up with a novel idea of providing these people with the same facilities and at a very low cost; only one module that is specifically for doctors needs some medical equipment along with our application, except that all tests can be performed by a common person.

2.3 Related Work

Some links that show the work done in the field of eye disease diagnosis are:

[1] This website is about an organization called Peak Vision which offers Easy to use eye care tools for every clinic and health care worker. It talks about turning a smartphone into a comprehensive eye exam tool. Tested in the remotest places, it gives high resolution images of the eye at a fraction of the cost. Peak vision is also working to take a fundus image from the normal iPhone camera with which an hand held ophthalmoscope will be attached. The ophthalmoscope will be placed in a plastic box made to be easily attached to the iPhone and from it the doctor can then take a picture of the fundus image which was previously not done.

[2] It refers to a TED talk which talks about turning a cellphone into a device which can examine your eyesight without the need of going anywhere.

[3] The following research paper talks about the visual acuity test in comparison with ETDRS The purpose of this study was twofold: first, to prospectively compare visual acuity (VA) scores obtained with Snellen charts versus Early Treatment Diabetic Retinopathy Study (ETDRS) charts in a "real world" retinal practice, and second, to see if there was a difference in visual acuity measurements obtained with ETDRS charts starting at 4 or 2 meters. The result of the comparison was Visual acuity scores were significantly better on ETDRS charts compared to Snellen charts. The difference was greatest with poor visual acuity (<20/200) and in patients with exudative AMD. Thus, caution should be exercised when comparing data using the different charts.

[4] The research paper talks about the standards used for the Visual Acuity Test using the Snell's chart. Proper measurement have been given for every degree to which the eye sight number can go and all the related calculations are included.

[5] The results obtained from the artilcle "Evaluation of acquired colour defects by F.M. 10O hue test" supports the fact that,F.M. 100 Hue test, though time consuming, provides both qualitative and quantitative information indicating by how much and in what manner the patient's colour vision de-parts from normal. The study was aimed at assessing the officacy and clinical usefulness of F.M. 100 Hue test in detection of colour defects frequently encountered in various ocular and systemic diseases.

[6] In case of manual testing of FM 100 test, the technique of calculating the total error score (TES) is detailed in the article. Errors are made whenever caps are misplaced from the correct order. Error scores are calculated according to the distance between any two caps. Score of a cap is the sum of the differences between the number of that cap and the numbers of the caps adjacent to it on either side, e.g., if cap number 50 is wrongly positioned say between 55 and 56, then the score of this cap is 55-50 + 56 - 50 = 5 + 6 = 11. The score of each cap is plotted on a circular graph provided. The error score is the score with 2 subtracted -i.e., 11 - 2 = 9. [If this cap no. 50 had been correctly positioned, then the score of that cap would have been 50 - 49 + 51 - -50 = 2: and with 2 subtracted, its error score would have been zero]. Sum of the error scores of the entire set of caps goes to make the total error score (TES). By plotting the scores graphically, characteristic patterns are obtained in specific defects. Manual scoring of error scores and plotting graphs are of course extremely time consuming and very tedious. To overcome this, various computer-based [but expensive] methods have been developed.

In hospitals, there are manual systems for eye tests such as Snell's chart- placed at a distance of 6m from the patient and is used for visual acuity testing. In case of color vision deficiency testing there are a set of 24 Ishihara plates (printed images) available to the ophthalmologists.

For distant vision testing presently there are systems available in a few hospitals which include hardware such as monitor screens and a remote control to increase or decrease the text size of alphabets/images.

In addition, there are online tests available for FM 100 color deficiency testing.

The matter is all the existing solutions are not available at one place and there is no Smartphone based solution covering such a wide range of eye tests.

2.4 Proposed Project

The Eye Diagnosis Suite shall provide a mobile/tablet application that would run on top of an Android operating system. It has four modules covering four eye tests. Three of the modules (Visual Acuity, Ishihara test, FM100) shall be available for use to the general public (any Smartphone user) whereas

the last module (Fundus imagery) shall be specific to use for ophthalmologists or health workers. It shall be a mobile/tablet based solution satisfying objectives such as:

1. Mechanism for testing color blindness
2. Display Ishihara 24 -plate images for automating color blindness test
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4. Separate modules/interfaces for general public and ophthalmologists
5. Display of guidelines for performing eye tests accurately
6. Automation of Visual Acuity test
7. Take multiple images of the eye through an ophthalmoscope attached to camera of mobile/tablet
8. Show a complete image of the eye fundus
9. Email option for eye images

The solution to the last module i.e. fundus imagery, lies in Digital Image Processing. To see inside an eye is called Fundoscopy. This is done usually by an equipment called Ophthalmoscope. Ophthalmoscopes are possessed by every Ophthalmologist but computerized ophthalmoscopes are too costly to be bought by a normal doctor and normal ophthalmoscopes show only a very small area inside eye so the image has to be constructed in mind by the doctors which is a difficult task. But here comes our application, all a doctor needs is a smartphone/tablet having Android O.S and by placing the camera of the android device on the ophthalmoscopes' lens, we can see on the screen of smartphone and capture the pictures easily and then can stitch them together to make a complete picture of eye ball from inside which will solve the problem of the Ophthalmologists.

2.5 Summary

There hasn't been a single application, till date that incorporates most of the common eye tests together in one suite. We intend to develop an application that will cater most of the common eye tests so that maximum people can make use of it. In addition to this, FM-100 Test and Fundus Test has never been implemented before on a computerized device (mobile, tablet) and we are intending to automate the tests.

Chapter 3: Software Requirement Specification

This section details software requirements specification for the Eye Diagnosis Suite, an Android based software application that would be built for Smart phones /tablets.

This section describes the requirements for version-1 of Eye Diagnosis Suite. The main purpose of this project is the development of a mobile/tablet application that would allow both general population and ophthalmologists to perform certain eye tests through an interactive mobile interface that incorporates functionality of manual systems used in hospitals.

3.1 Overall Description

3.1.1 Product Functions

The main features of the Eye Diagnosis Suite are highlighted below:

1. A main menu - for navigation
2. Automated eye vision test - to check visual acuity
3. Color vision deficiency tests which includes Ishihara and FM 100 tests
4. Allow user to perform fundoscopy- an infected eye test, through portable device attached to a Smartphone camera (ophthalmoscopes)

3.1.2 User Classes and Characteristics

The application can be accessed by every Android phone/Tablet user.

Though the app allows access to everyone there is a significant risk involved in performing specialized tests (Fundus eye infection test), by a normal user. To tackle this problem we suggest a modular structure in the proposed android app and a complete isolation of the doctor's modules-the **specific modules**, from the general eye tests -the **public modules** (the remaining three modules) - that would be available for use to any Smartphone user.

Public module is for the general population of all ages. Whereas specific module is only for doctors/health workers in addition to the public modules which are accessible to all users.

The different types of users are:

Health workers (frequent user) in camps would be able to take photographs of infected eye and email it from the remotest setting and ask for further opinion from ophthalmologists sitting at a far off land miles away from camp thus promoting telemedicine.

1. They would be able to access the visual acuity test for distant vision

2. They would have access to Ishihara color vision and FM 100 tests

3. They would be able to take images for fundus eye infection test

Ophthalmologists (frequent user) would be able to use this app for their own convenience as the app will save their and the patient's time

1. They would be able to perform all the above mentioned tests which would be available for health workers

Students (occasional user) in possession of android smart phones would be able to perform color vision and eye acuity tests easily at home

Teachers (occasional user) in kindergarten schools could use this app to identify children at an early stage with eye related disabilities such as color blindness, distant vision.

3.1.3 Operating Environment

The product shall be operating in an android environment. It shall be compatible with version 4.3 (Jelly Bean) and all the higher versions of android.

Internet connection shall only be required for the last module (Fundus eye infection test) in which the user shall be able to email the eye image.

3.1.4 Design and Implementation Constraints

1. The application will run on devices having a minimum of total 1 GB RAM (200 required maximum for the application itself).
2. Limited memory of the cell-phone device
3. The forth module of the application i.e. fundus eye test will require OPENCV drivers in the device to function.
4. Android devices vary in capabilities / technology supported, and thus we cannot guarantee universal access to our application across all Android platforms.

3.1.5 User Documentation

A user manual will be provided to the users in which separate instructions will be given according to the particular user i.e. students, teachers, ophthalmologists etc.

3.1.6 Assumptions and Dependencies

Open-CV is presumed to be installed prior to installing the application.

3.2 External Interface Requirements

3.2.1 User Interfaces

1. Swipe views of android will be used as the main screen.
2. Tabs will be provided in the main screen.
3. Individual test screens will open up after following the instructions on the relevant tab views.

3.2.2 Hardware Interfaces

1. Camera with minimum 8.0 mega pixels and 306 pixel density.
2. Camera will interact with the software through imaging APIs.

3.2.3 Software Interfaces

1. This is an android based application which specifically will run on android 4.3 and higher.
2. Android support library will be needed for the swipe and tab views.
3. Open CV for the imaging modules.

3.2.4 Communication Interfaces

N/A- No communication interfaces are required in our system.

3.3 System Features

1. The application shall be available for use in offline mode.
2. Instructions for using the app shall be provided before the start of each test.
3. The instructions shall be audio-visual

3.3.1 Accessing the Main Menu

3.3.1.1 Description and Priority

After starting the application the categories will be displayed as a main menu.
Its priority will be high as without this feature the application will not be navigable and the user will not be able to perform any action.

3.3.1.2 Stimulus/Response Sequences

1. Open the application.

2. Access main menu

3.3.1.3 Functional Requirements

REQ-1: The application must be properly installed on the device.

REQ-2: The main menu shall be used to check whether the user is a normal Smartphone user or a doctor (ophthalmologist)/health worker.

REQ-3: The different types of users shall be:

1. Doctors
2. Any literate Smartphone user

REQ-4: At any time the user shall be able to exit the test and move over to the main menu or exit the app completely

3.3.2 Vision Test

3.3.2.1 Description and Priority

The visual acuity tests holds a very high priority since it is a core feature of this application.

3.3.2.2 Stimulus/Response Sequences

1. The user selects a vision test.
2. The user sees the Snell's images (Figure 3-1) and press next to proceed.

3.3.2.3 Functional Requirements

REQ- 5: The app will implement distant vision tests.

REQ- 6: The app will implement Snell's chart used for manual testing of near sighted vision by providing three different categories of images

REQ-7: Images (in variable sizes) of objects/animals shall be provided for children and illiterates

REQ-8: Images (in variable sizes) of numbers shall be provided for numerical identification

REQ-9: Images of alphabets shall be provided for identification of variable sized alphabets from a fixed distance specified

REQ-10: The distance at which the mobile should be placed from the eye shall be specified to the user

REQ-11: The images used in Snell's chart implementation shall decrease in size consistently for each category of images used

REQ-12: Results that would give a conclusion to the eye test performed by the user shall be displayed on the screen

Figure 3-1 Vision Test Chart

3.3.3 Ishihara Color Blindness Test

3.3.3.1 Description and Priority

The Ishihara Color Blindness Test holds a very high priority since it is one of the core feature of this application.

3.3.3.2 Stimulus/Response Sequences

1. The user selects Ishihara Color Blindness Test
2. The user sees the Ishihara color plates (Figure 3-2) and inputs the seen number.
3. Clicks next to proceed on the next color plate

3.3.3.3 Functional Requirements

REQ-13: The app would display images of Ishihara color plates for color vision deficiency

REQ-14: A set of 24 plates shall be available

REQ-15: The user would opt out the number of plates to be identified. There can be 8, 16 or complete set of 24 plates

REQ-16: After displaying the images the user shall be prompted to identify numbers on the images

REQ-17: A dial pad shall be provided to enter number identified from the image

REQ-18: On the basis of correct and incorrect responses the system shall generate a result report

REQ-19: Detailed result shall display the images that were incorrectly identified

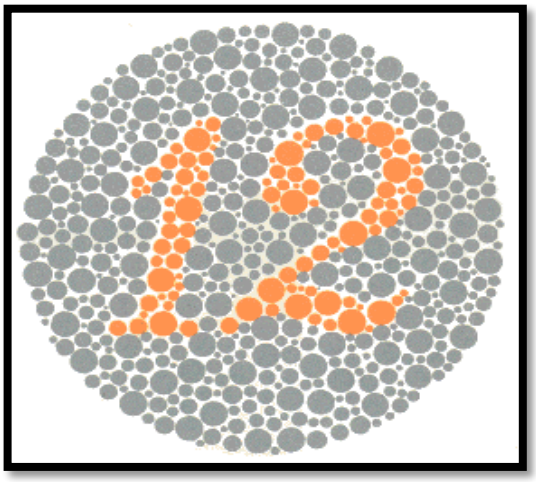


Figure 3-2 Ishihara Test Plate Sample

3.3.4 FM 100 Test

3.3.4.1 Description and Priority

The FM 100 tests holds a medium priority since we have two color blindness tests.

3.3.4.2 Stimulus/Response Sequences

1. The user selects a FM 100 test.
2. The user sees the plates (Figure 3-3) to reposition and press next to proceed to the next screen.

3.3.4.3 Functional Requirements

REQ-20: Starting from red to green, arrange 20 tiles in ascending order of their intensities. The first and last tile in a row shall be fixed

REQ-21: Each row contains 20 movable tiles

REQ-22: Drag and drop feature shall be provided to move the tiles

REQ-23: Results shall be indicated after the user completes test in the form of bar graph

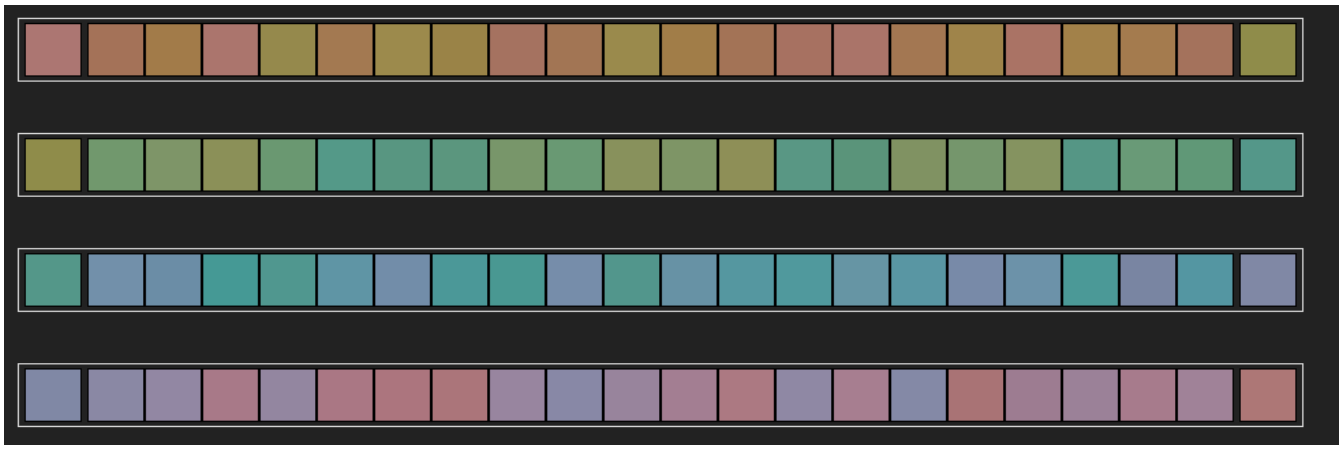


Figure 3-3 FM 100 Test tiled View

3.3.5 Fundus Eye Test

3.3.5.1 Description and Priority

The Fundus Eye Test holds a high priority since this is a core feature of this application.

3.3.5.2 Stimulus/Response Sequences

1. The user selects a Fundus Eye Test.
2. Camera opens.
3. The user captures multiple fundus images (Figure 3-4)
4. The complete image of the fundus is displayed.

3.3.5.3 Functional Requirements

REQ-24: Set of instructions is to be provided on how to perform the test

REQ-25: Take four images starting from the rightmost to the leftmost part of each eye

REQ-26: Option of discarding an image shall be available after capturing of each image

REQ-27: The user will have an option to save the images

REQ-28: Stitched image shall be shown to the user

REQ-29: Emailing option shall be provided to email the images

Figure 3-4 Image of Eye Fundus

3.4 Other Non-Functional Requirements

3.4.1 Performance Requirements

In case of FM 100 test for color vision deficiency, the tiles must be large enough to view and arrange easily by all types of users. This would reduce the time for performing the test.

3.4.2 Safety Requirements

The use of the software product has no harms whatsoever; nor does it have any possibility of loss or damage that might be inflicted however during the use of the application, users experiencing eye strain should take a break from using the device to avoid further strain and/or possible damage. If the app crashes during addition, deletion or editing there will be no change in the database.

3.4.3 Security Requirements

Application running on the Android device should not need any additional information other than the collected data from the user or already present data. There are no connections to other devices or severs so no data will be sent or received or used in any way. Otherwise, access to the user's personal information from other apps except for photos (which should not be done without the permission of the user,), including calendar information, email, contacts etc. is under no circumstance necessary and should be considered a breach of privacy in the event it occurs.

3.4.4 Software Quality Attributes

1. **Usability:**

   The graphical user interface of app is to be designed with usability as the first priority. The app will be presented and organized in a manner that is both visually appealing and easy for the user to navigate. There will be feedbacks and visual cues such as notifications to inform users of updates and pop-ups to provide users with instructions

2. **Accuracy:**

   To ensure reliability and correctness, there will be zero tolerance for errors in the algorithm that computes results.

3. **Portability:**

   In API, portability can be defined as "compatibility of application with platform (Android's version) upgraded or downgraded versions. In Android platform when an up-gradation is done the application will require some changes for compatibility with the new version. As android's OS is backward compatible so no changes will be required in down-gradation. The minimum requirement of operating system is Android 4.3.

4. **Availability:**

   The application will be available from boot to shutdown, provided mobile is in working state and the application is installed and configured properly.

5. **Flexibility:**

   The design and architecture of the application will be flexible enough for catering any new requirements, if any at some later stage or for the application enhancement.

6. **Data Integrity:**

   If the app crashes during addition, deletion or editing there will be no changes in the database.

7. **Scalability:**

   The application is expected to handle one user at a time. One instance of the application could be opened on a phone at a time.

8. **Confidentiality:**

   No user's data (pictures etc.) will be accessed without user's permission.

Chapter 4: Design and Development

4.1 Introduction

The purpose of this chapter is to give the user a clear and precise description of the functionality and design details of the Eye Diagnosis Suite, an Android based software application that would be built for Smart phones /tablets.

This chapter is organized in such a way that the detailed architecture of the system is provided initially. The design is further elaborated using diagrammatical representation of system components, classes, states, sequence of events, flow of events and their relationships. Furthermore user interface constraints have been discussed along with issues like product reuse, design decision and tradeoffs, pseudo code for components and appendices.

4.2 System architecture description

4.2.1 Architectural Pattern

We have chosen Call and Return as our architectural pattern (Figure 4-1); since in Call-and-return systems, there is a main program and it has subroutines. There is a hierarchical pattern that is seen in the Call and Return architecture. In our android application, Eye Diagnosis suite, there is a main menu that is in control of the entire program and it calls subroutines (namely Visual Acuity test, Ishihara test, FM 100 Test and Fundus Test) which then further have their own sub-sub routines. The sub-sub routines return their results to the layer routines above them.

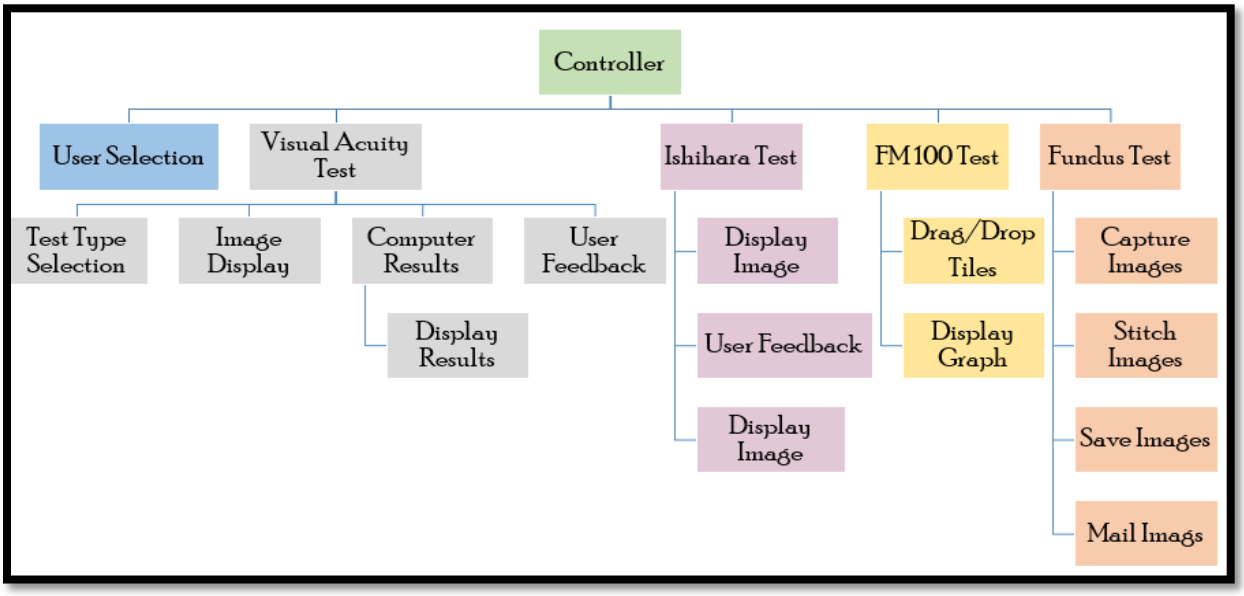


Figure 4-1 Architectural Diagram

4.2.2 Component Diagram of System

A component represents a modular part of the system. A component defines its behavior in terms of provided and required interfaces.

The "ball-and-socket" connection is used between a provided interface and a required interface as shown in Figure 4-2.

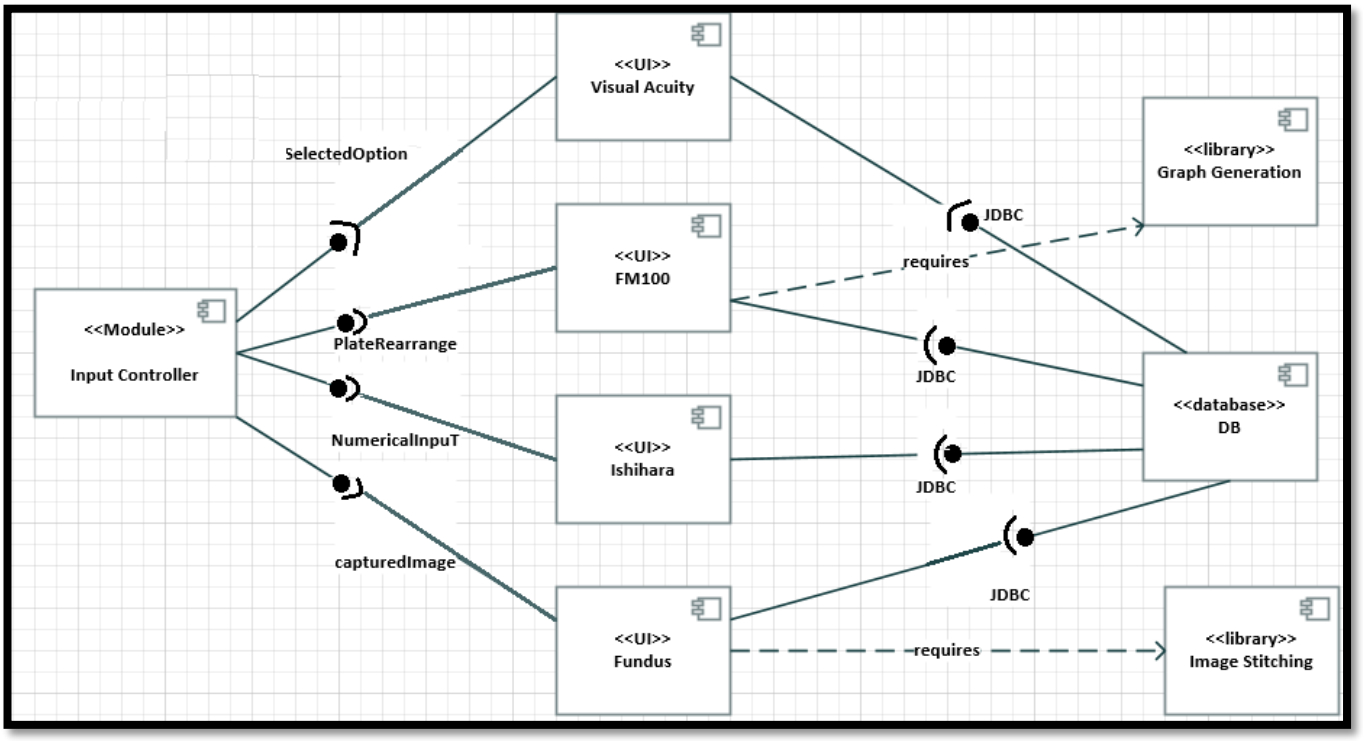


Figure 4-2 Component Diagram

4.2.3 User Interface of the Design

Each of the four components are related to the Input Controller as shown by the component diagram (Figure 4-1) in a way that every test (VAT, Ishihara Test, FM 100, Fundus Test) is called by the controller but other than this each component is independent of each other and have no relation amongst other.

The user interface screen samples are shown in (Figure 4-3 to 4-8).

Figure 4-3 Select User Type Screen

Figure 4-4 Main Menu Screen

Figure 4-5 VAT Directions Screen

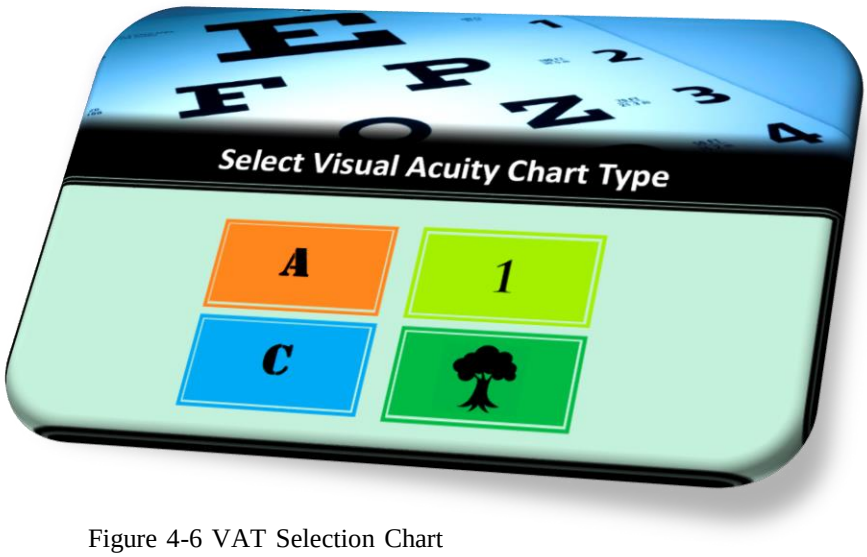


Figure 4-6 VAT Selection Chart

Figure 4-7 FM 100 Test Screen

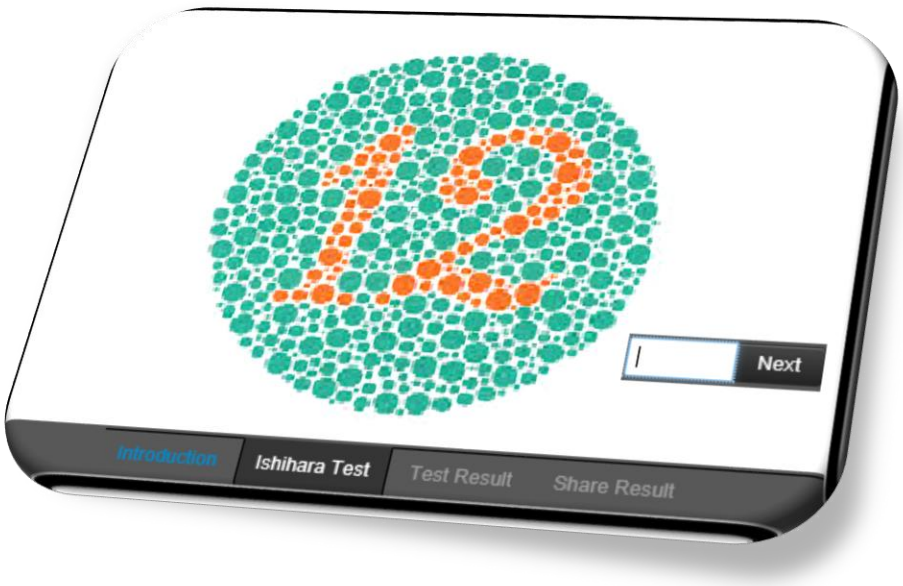


Figure 4-8 Ishihara Test Screen

4.3 Use case Diagrams

4.3.1 System Use Case Diagram

The graphic depiction of interactions among the elements of a system are shown in the system use case diagram (Figure 4-9)

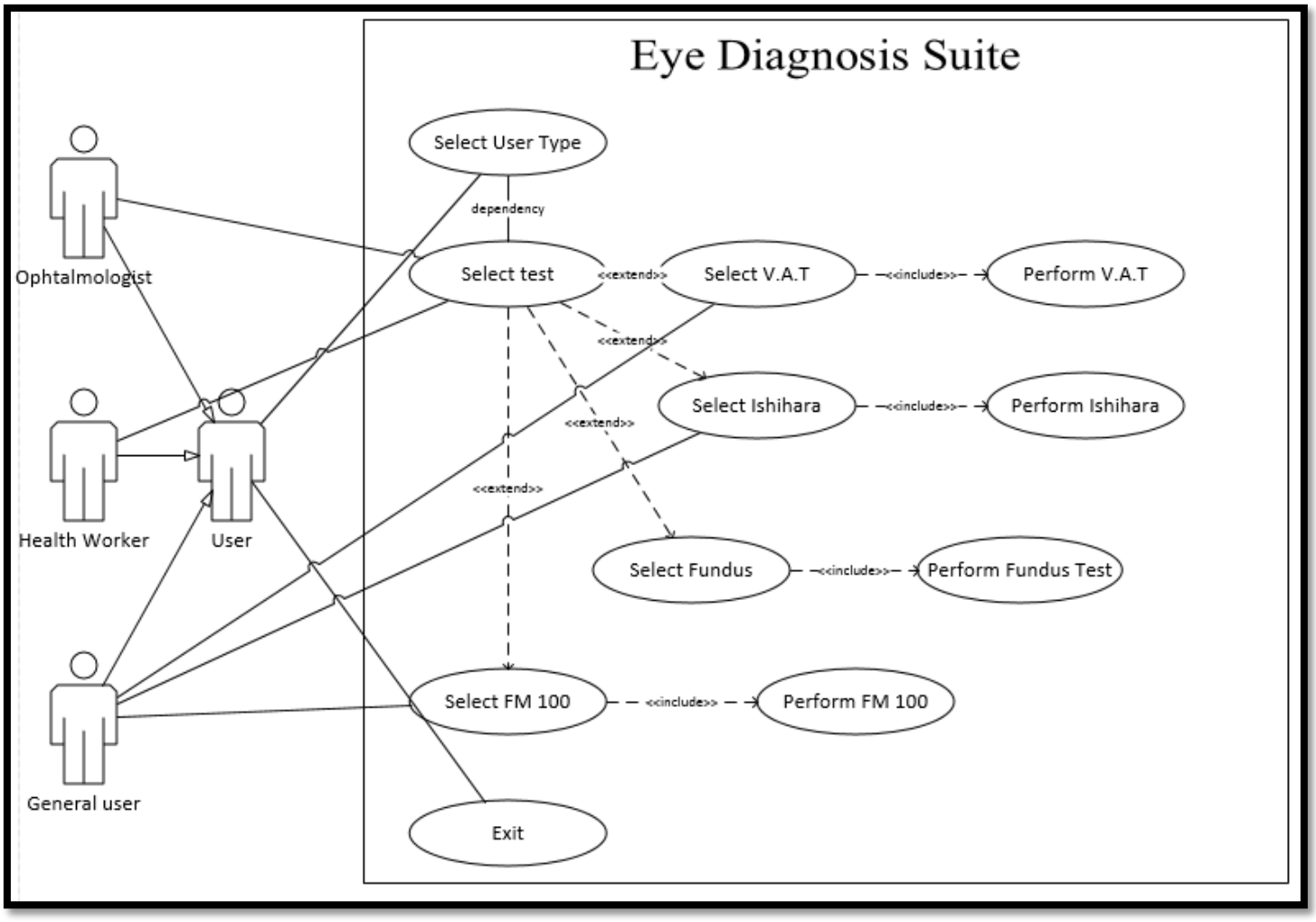


Figure 4-9 Use Case Diagram of Eye Diagnosis Suite

4.3.2 Use Case Diagram of the Modules

1. VAT Use Case Diagram

Figure 4-10 shows the Use Case of Visual Acuity sub module of the Eye Diagnosis Suite.

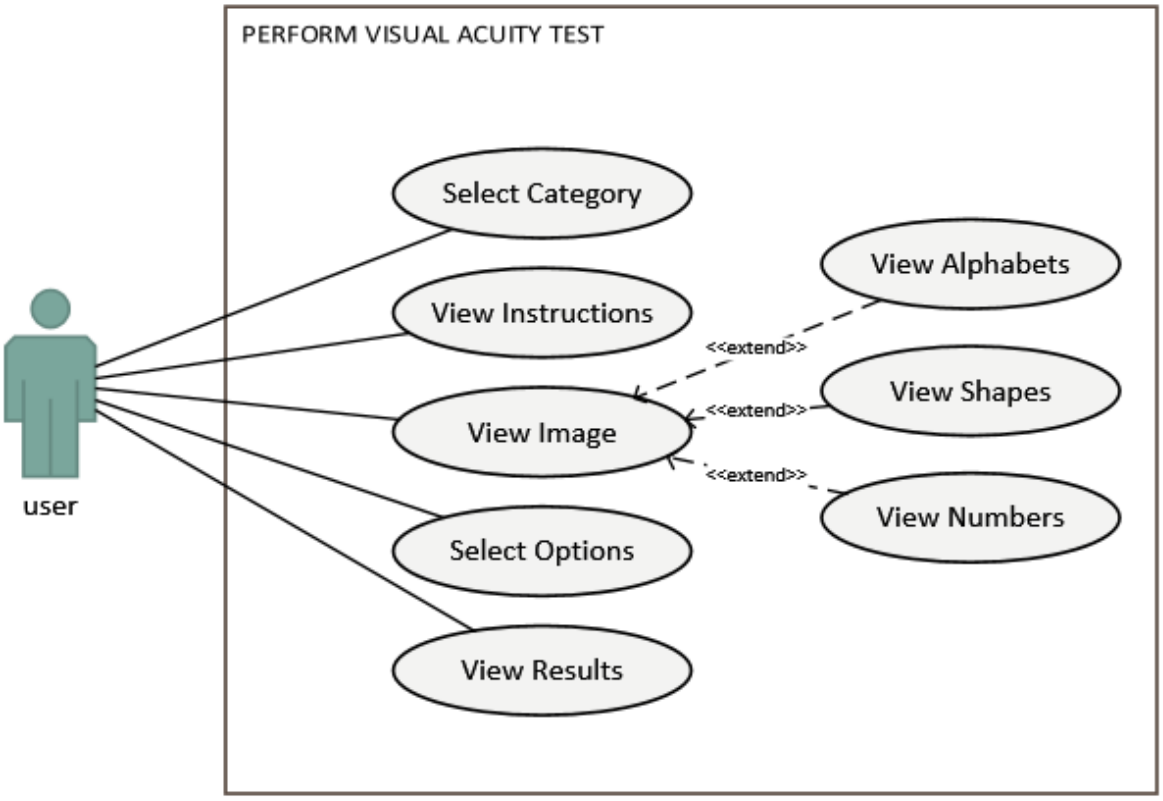


Figure 4-10 Use Case- Perform Visual Acuity

2. FM 100 Use Case Diagram

Figure 4-11 shows the Use Case of FM 100 sub module of the Eye Diagnosis Suite.

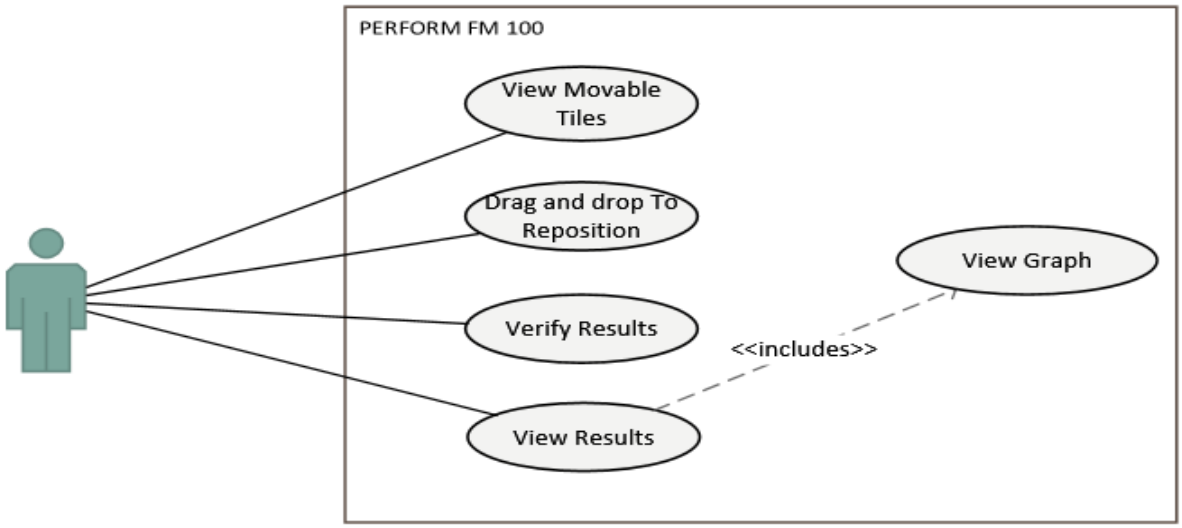


Figure 4-11 Use Case- Perform FM 100 Test

3. Ishihara Use Case Diagram

Figure 4-12 shows the Use Case of Ishihara sub module of the Eye Diagnosis Suite.

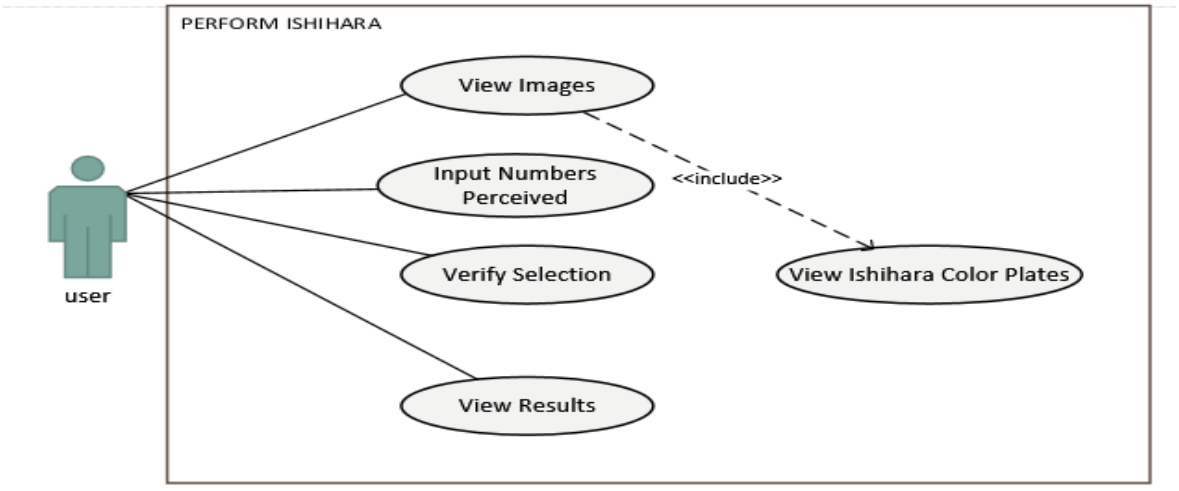


Figure 4-12 Use Case- Perform Ishihara Test

4. Fundus Use Case Diagram

Figure 4-13 shows the Use Case of Fundus sub module of the Eye Diagnosis Suite.

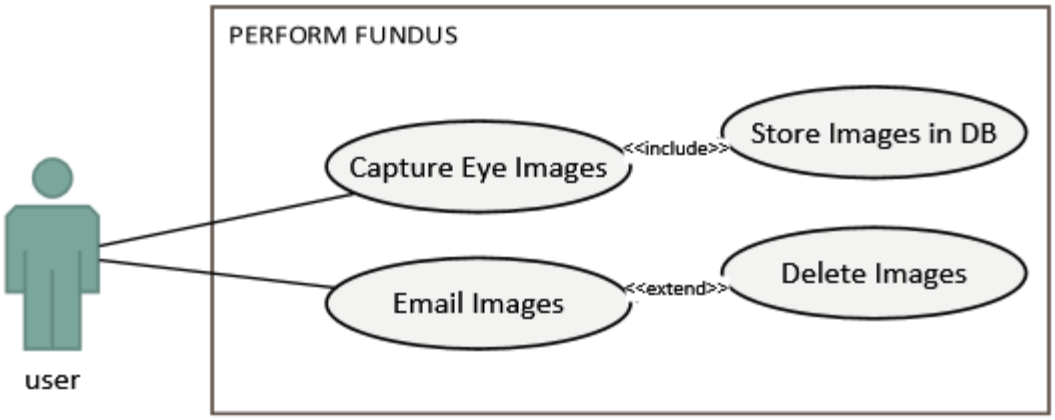


Figure 4-13 Use Case- Perform Fundus

4.3.3 Use Case Scenarios

The Scenario of the Use Case 'Select User Type' (Figure 4-9) is elaborated in the Table 4-1.

Table 4-1: Use Case: Select User Type

Use Case ID:	01
Use Case Name:	Select User Type
Actor:	Specialized User (Ophthalmologist, Health Worker), General User
Description:	This feature of Select User Type helps the user to select the type according to his level of knowledge. A novice user may select himself as a general user whereas a specialized user is to choose Specialized user to access extra features.
Pre-conditions:	The user must have switched on the application
Post-conditions:	The user will be asked to choose a specific test after he/she has chosen the 'Select User Type'
Priority:	This feature is given high priority as it is the base of choosing our main users
Frequency of Use:	Only one time at the beginning of the application
Normal Course of Events:	The user opens the application and chooses the user option for himself according to his/her need and knowledge
Alternative Courses:	The user chooses to exit the application in which case the application will close down.
Exceptions:	-
Includes:	-
Special Requirements:	-
Assumptions:	-
Notes and Issues:	-

The Scenario of the Use Case 'Select Test' (Figure 4-9) is elaborated in the Table 4-2.

Use Case ID:	02
Use Case Name:	Select Test
Actor:	Specialized user(Ophthalmologist, Health Worker), General User
Description:	This feature is used to select test type. There are four tests out of these three (Ishihara test, FM100 test, Visual Acuity) is accessible to all the three actors mentioned. The fourth test i.e. Fundus test is accessible to specialized user i.e. ophthalmologist or health worker.
Preconditions:	The user must have opened the application and selected user type.
Post conditions:	The user would be able to access specialized tests after selecting test.
Priority:	It has a high priority as without this we cannot proceed further
Frequency of Use:	In normal situation the user would select test once and perform only one test at a time. Furthermore, a user can take the test as many times as he wants.
Normal Course of Events:	1. The user selects the test 2. The system based on the user type displays the tests to be performed 3. If the user is an ophthalmologist/health worker the system shall provide four options: Select Visual Acuity test, Select Ishihara, Select FM100 test and Fundus test 4. If the user is a general user he would be provided with three options: Select Visual Acuity test, Select Ishihara and Select FM100 test
Alternative Courses:	The user chooses to exit the application in which case the application will shut down
Includes:	Select Visual Acuity test, Select Ishihara , Select FM100 test, Select Fundus test
Special Requirements:	-
Assumptions:	-
Notes and Issues:	-

Table 4-2: Use Case: Select Test

The Scenario of the Use Case ‘Selecting Visual Acuity Test (V.A.T)’ (Figure 4-9) is elaborated in the Table 4-3.

Table 4-3: Use Case: Selecting Visual Acuity Test (V.A.T)

Use Case ID:	03
Use Case Name:	Selecting Visual Acuity Test (V.A.T)
Actor:	Specialized user(Ophthalmologist, Health Worker), General User
Description:	This use case scenario enables the user to select the visual acuity test or the vision test which is aimed to check the eyesight of the user.
Pre-conditions:	The user must have selected the option of ‘Selecting Visual Acuity Test to perform this test and his/her application must be turned on.
Post-conditions:	The user will see his eye test results
Priority:	This use case holds high priority
Frequency of Use:	Generally, this test will be performed once when the application is turned on but it can be performed as many times as the user wishes as per his choice.
Normal Course of Events:	1. Turn on the application 2. Choose the user type 3. Choose the test type 4. Visual Acuity Test opens
Alternative Courses:	1. The user chooses to exit the application 2. The user chooses some other test out of the 4 tests
Exceptions:	-
.Includes:	Perform Visual Acuity Test
Special Requirements:	-
Assumptions:	-
Notes and Issues:	-

The Scenario of the Use Case 'Perform Visual Acuity Test' (Figure 4-9) is elaborated in the Table 4-4.

Table 4-4: Use Case: Perform Visual Acuity Test

Use Case ID:	04
Use Case Name:	Perform Visual Acuity Test
Actor:	Specialized user(Ophthalmologist, Health Worker), General User
Description:	This use case scenario enables the actor to take the test of Visual Acuity and check his/her eyesight or check someone else eyesight in the case of Ophthalmologist or Health Worker.
Pre-conditions:	The user must have selected the option of 'Selecting Visual Acuity Test' to perform this test and his/her application must be turned on.
Post-conditions:	The user will be able to check his eye sight
Priority:	High priority as this feature is one of the most important features of the application
Frequency of Use:	Generally, this test will be performed once when the application is turned on but it can be performed as many times as the user wishes as per his choice.
Normal Course of Events:	1. Turn on the application 2. Choose the user type 3. Choose the test type 4. Visual Acuity Test opens 5. Perform Visual Acuity test
Alternative Courses:	1. The user chooses to exit the application 2. The user chooses some other test out of the 4 tests
Exceptions:	-
Includes:	-
Special Requirements:	-
Assumptions:	-
Notes and Issues:	-

The Scenario of the Use Case ‘Select Ishihara’ (Figure 4-9) is elaborated in the Table 4-5.

Table 4-5: Use Case: Select Ishihara

Use Case ID:	05
Use Case Name:	Select Ishihara
Actor:	Specialized user (Ophthalmologist, Health Worker), General User
Description:	The user on selecting Ishihara test shall be displayed instructions and Ishihara -24 plate images with numbers hidden in patterns
Preconditions:	The user must have opened the application and should have been provided with an option to select the specific test out of the four tests (Fundus test, Ishihara test, FM100 test and Visual Acuity test)
Post conditions:	The user shall be displayed Ishihara color plates for identification of numbers on them
Priority:	It has a medium priority as it is an option for the user, he may or may not select Ishihara the test
Frequency of Use:	In normal situation the user would select test once and perform it only once. Furthermore, a user can take the test as many times as he wants.
Normal Course of Events:	1. The user selects the Ishihara test 2. The system will display instructions for performing test 3. The system shall display image plates
Alternative Courses:	
Includes:	Perform Ishihara
Special Requirements:	-
Assumptions:	-
Notes and Issues:	-

The Scenario of the Use Case ‘Perform Ishihara’ (Figure 4-9) is elaborated in the Table 4-6.

Table 4-6: Use Case: Perform Ishihara

Use Case ID:	06
Use Case Name:	Perform Ishihara
Actor:	Specialized user (Ophthalmologist, Health Worker), General User
Description:	The user after selecting Ishihara test will be given instructions to perform it. The user shall identify numbers on color image plates and move to next image to feed answers based on their perception.
Preconditions:	The user must have selected his type as either general user or ophthalmologist/health worker and test type as Ishihara test
Post conditions:	The user results shall be used to generate result report based on correct and incorrect responses
Priority:	It holds a high priority
Frequency of Use:	Generally, this test will be performed once when the application is turned on but it can be performed as many times as the user wishes as per his choice.
Normal Course of Events:	1. The user opens the application and select user type 2. The system displays the tests that can be performed 3. The user selects Ishihara color blindness test 4. The system displays images to identify numbers hidden in patterns 5. The user identifies the number and based on their perception feeds input to the system 6. The system continues to display more images for getting user responses
Alternative Courses:	-
Exceptions:	-
Includes:	-
Special Requirements:	-
Assumptions:	-
Notes and Issues:	-

The Scenario of the Use Case ‘Select FM-100’ (Figure 4-9) is elaborated in the Table 4-7.

Table 4-7: Use Case: Select FM-100

Use Case ID:	07
Use Case Name:	Select FM-100
Actor:	Specialized user (Ophthalmologist, Health Worker), General User
Description:	The user shall select test type as FM100 test. The system will display test instructions
Preconditions:	The user must have selected his type as either general user or ophthalmologist/health worker and test type as FM100 test
Post conditions:	The user shall be able to perform FM100 test after reading the instructions provided
Priority:	The test has a high priority
Frequency of Use:	Generally, this test will be performed once when the application is turned on but it can be performed as many times as the user wishes as per his choice.
Normal Course of Events:	1. The user selects the FM100 test 2. The system will display instructions for performing test 3. The user would be provided with movable tiles for rearranging in order to perform the color vision deficiency test.
Exceptions:	-
Includes:	Perform FM-100
Special Requirements:	-
Assumptions:	-
Notes and Issues:	-

The Scenario of the Use Case ‘Perform FM-100’ (Figure 4-9) is elaborated in the Table 4-8.

Table 4-8: Use Case: Perform FM-100

Use Case ID:	08
Use Case Name:	Perform FM-100
Actor:	Specialized user(Ophthalmologist, Health Worker), General User
Description:	The user after selecting test type as FM100 shall be provided with movable tiles on screen. The user shall rearrange tiles based on the intensity of the colors and at the completion of test shall have a result report in the form of a graph
Preconditions:	The user must have selected his type as either general user or ophthalmologist/health worker and test type as FM100 test
Post conditions:	The user arranged tiles shall be compared with the actual pattern of tiles and shall be used to generate result report in the form of a graph
Priority:	It has a high priority
Frequency of Use:	High
Normal Course of Events:	1. The user opens the application and select user type 2. The system displays the tests that can be performed 3. The user selects FM-100 color blindness test 4. The system displays movable tiles 5. The user rearranges tiles by drag and drop based on the intensity of colors on tiles 6. The system verifies results 7. The user views the test result in the form of a graph
Exceptions:	-
Includes:	-
Special Requirements:	-
Assumptions:	-
Notes and Issues:	-

The Scenario of the Use Case 'Select Fundus Eye' (Figure 4-9) is elaborated in the Table 4-9.

Table 4-9: Use Case: Select Fundus Eye

Use Case ID:	09
Use Case Name:	Select Fundus Eye
Actor:	Specialized user (Ophthalmologist, Health Worker), General User
Description:	This test is set to be used by the specialized user only which includes the ophthalmologist and the health worker. This feature is aimed to check the internal eye by using an additional hardware known as the ophthalmoscope
Pre-conditions:	The user must have selected the option of 'Selecting Fundus Test' to perform this test and his/her application must be turned on.
Post-conditions:	The application must be open. The user has declared himself as an ophthalmologist or health worker and has chosen Fundus Test.
Priority:	High
Frequency of Use:	Medium
Normal Course of Events:	1. Turn on the application 2. Choose the user type as ophthalmologist or health worker 3. Choose the test type as Fundus Test
Alternative Courses:	1. The user chooses to exit the application 2. The user chooses some other test out of the 4 tests
Exceptions:	-
Includes:	-
Special Requirements:	-
Assumptions:	Only specialized worker can perform this test, assuming he/she is in the possession of an ophthalmoscope.
Notes and Issues:	-

The Scenario of the Use Case ‘Perform Fundus Eye’ (Figure 4-9) is elaborated in the Table 4-10.

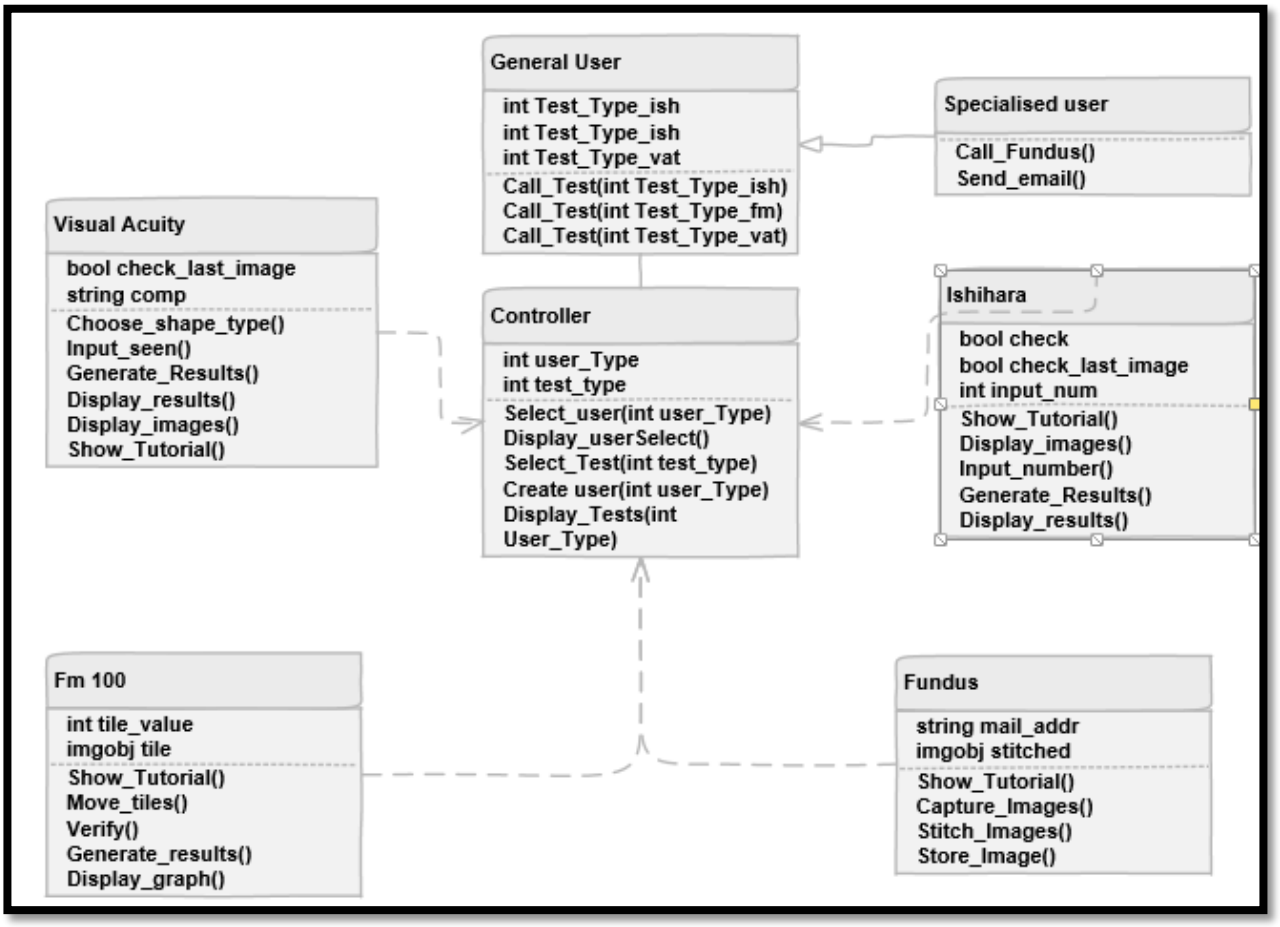
Table 4-10: Use Case: Perform Fundus Eye

Use Case ID:	10
Use Case Name:	Perform Fundus Eye
Actor:	Specialized user (Ophthalmologist, Health Worker), General User
Description:	This test is set to be used by the specialized user only which includes the ophthalmologist and the health worker. This feature is aimed to check the internal eye by using an additional hardware known as the ophthalmoscope
Pre-conditions:	The user must have selected the option of ‘Selecting Fundus Test’ to perform this test and his/her application must be turned on.
Post-conditions:	The application must be open. The user has declared himself as an ophthalmologist or health worker and has chosen Fundus Test.
Priority:	High
Frequency of Use:	Medium
Normal Course of Events:	1. Turn on the application 2. Choose the user type as ophthalmologist or health worker 3. Choose the test type as Fundus Test
Alternative Courses:	1. The user chooses to exit the application 2. The user chooses some other test out of the 4 tests
Exceptions:	-
Includes:	-
Special Requirements:	-
Assumptions:	Only specialized worker can perform this test, assuming he/she is in the-possession of an ophthalmoscope.
Notes and Issues:	

4.4 Class Diagram of the System

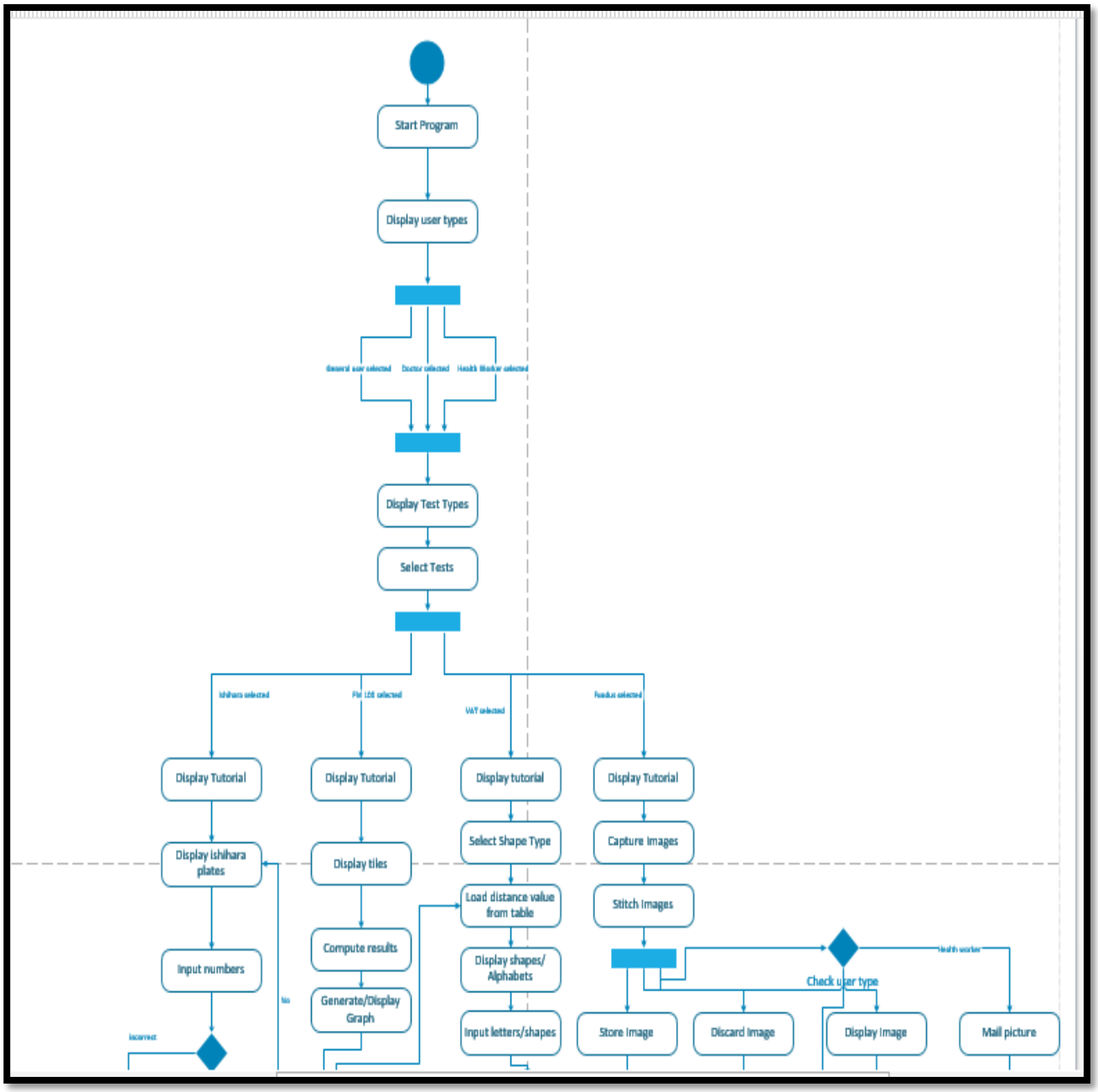
The following **Figure 4-14** Class Diagram of System. The four tests (VAT, FM-100, Ishihara, and Fundus) are all related to the controller class which is linked to the General user and gives the result back to the user. Each class has 3 parts as shown in the figure. The first shows the name of the class. Then the data type and the variables used in the class are shown in the second part and the last part shows the functions that are incorporated in the class.

Figure 4-14 Class Diagram of System



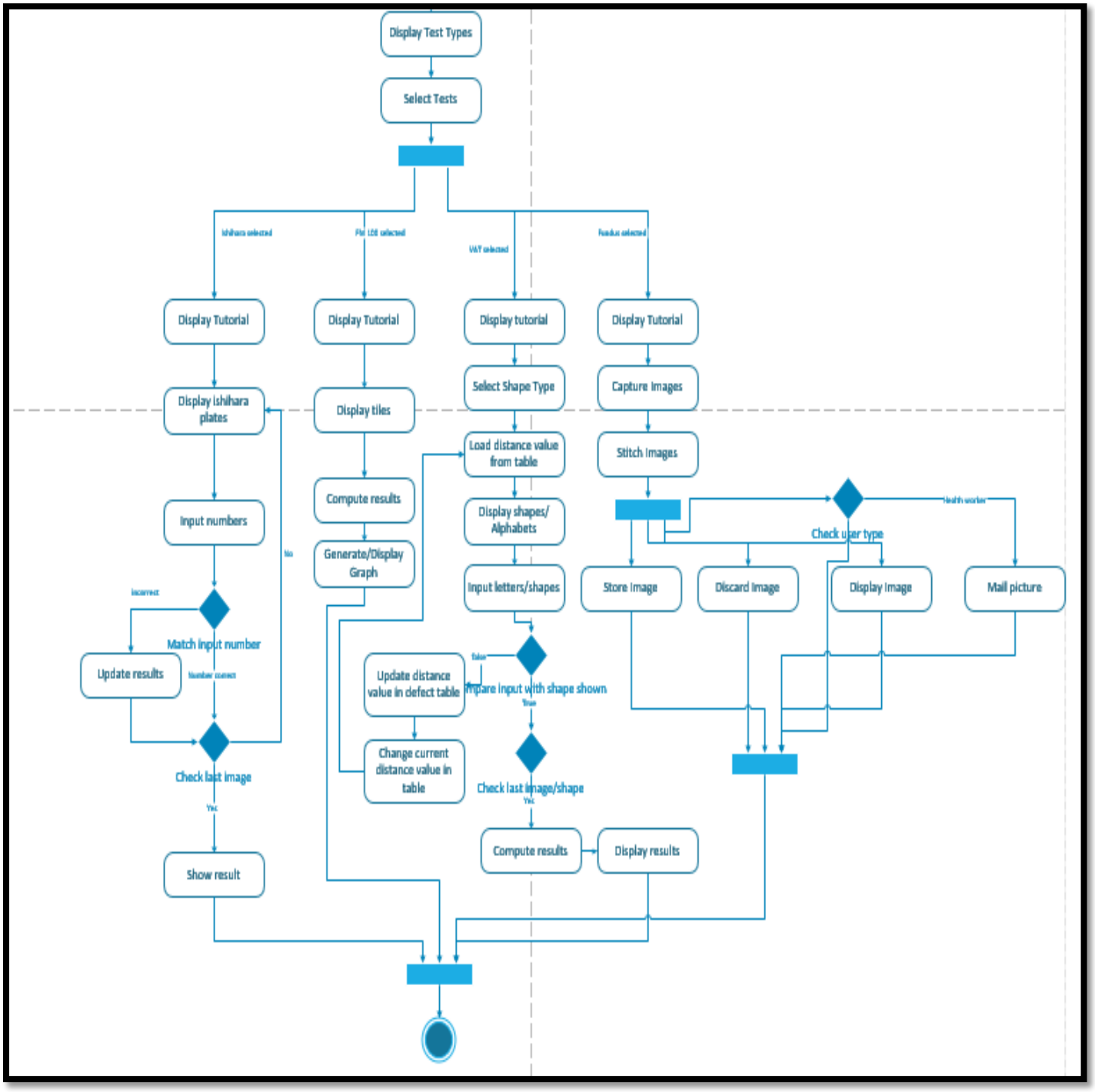
4.5 Activity Diagram

Activity diagrams are graphical representations of workflows of stepwise activities and actions with support for choice, iteration and concurrency. In the Unified Modeling Language, activity diagrams are intended to model both computational and organizational processes (i.e. workflows). Activity diagrams show the overall flow of control.



*Continuation of the Activity Diagram

Figure 4-15 Activity Diagram

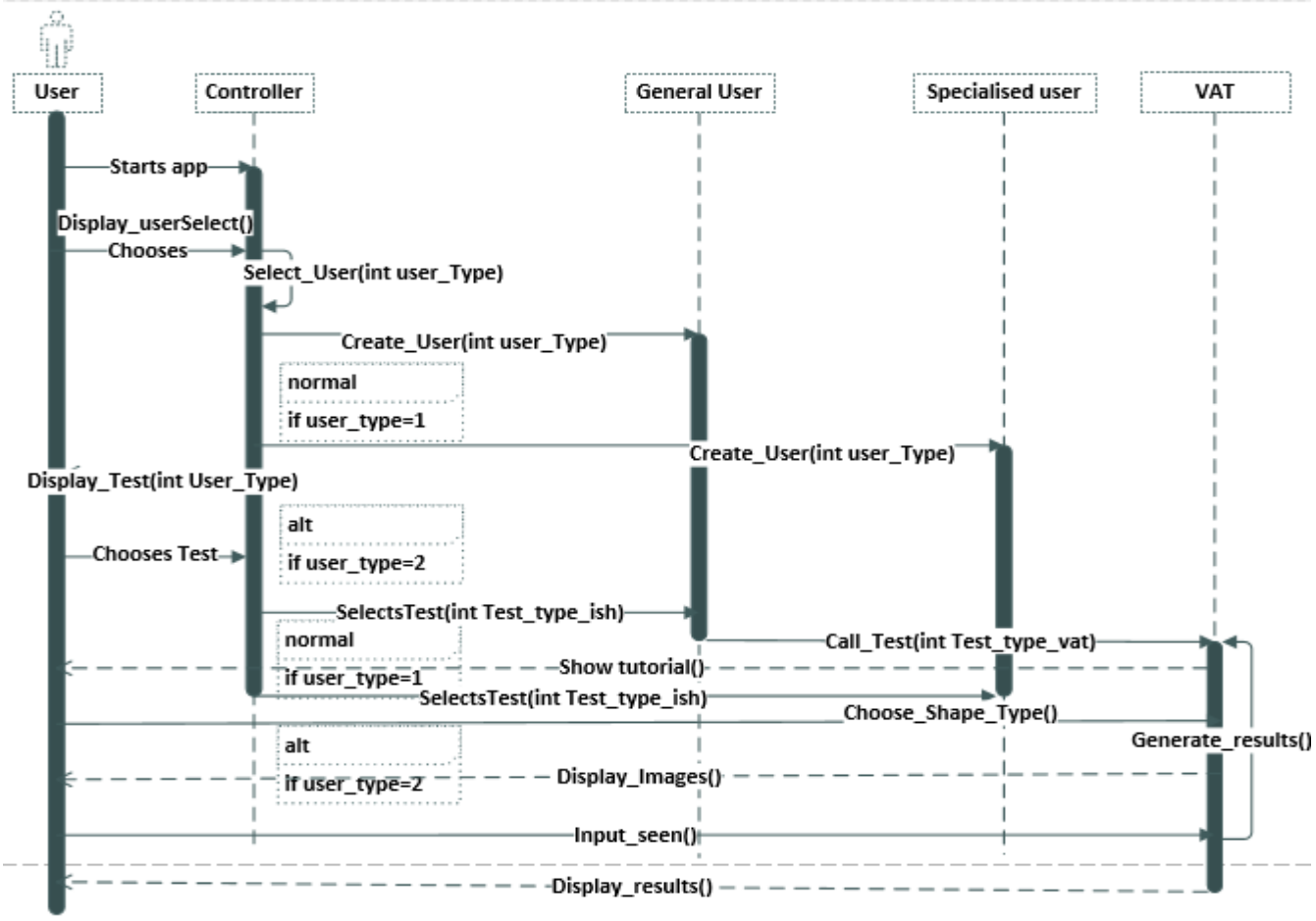


4.6 Sequence Diagram

A Sequence diagram is an interaction diagram that shows how processes operate with one another and what is their order. It is a construct of a Message Sequence Chart. 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.

The sequence diagram below shows the sequence of actions that take place during the Visual Acuity Test. The user prompts the controller to open the test. The user selects the type of test he wants to take. Then the images appear and the user enters the correct input according to what he sees. In the end the results are generated.

Figure 4-16 Sequence Diagram- Visual Acuity Test



The sequence diagram below shows the sequence of actions that take place during the FM-100 Test. The user prompts the controller to open the test. The user is supposed to drag and drop the titles according to the intensity. In the end the results are generated accordingly.

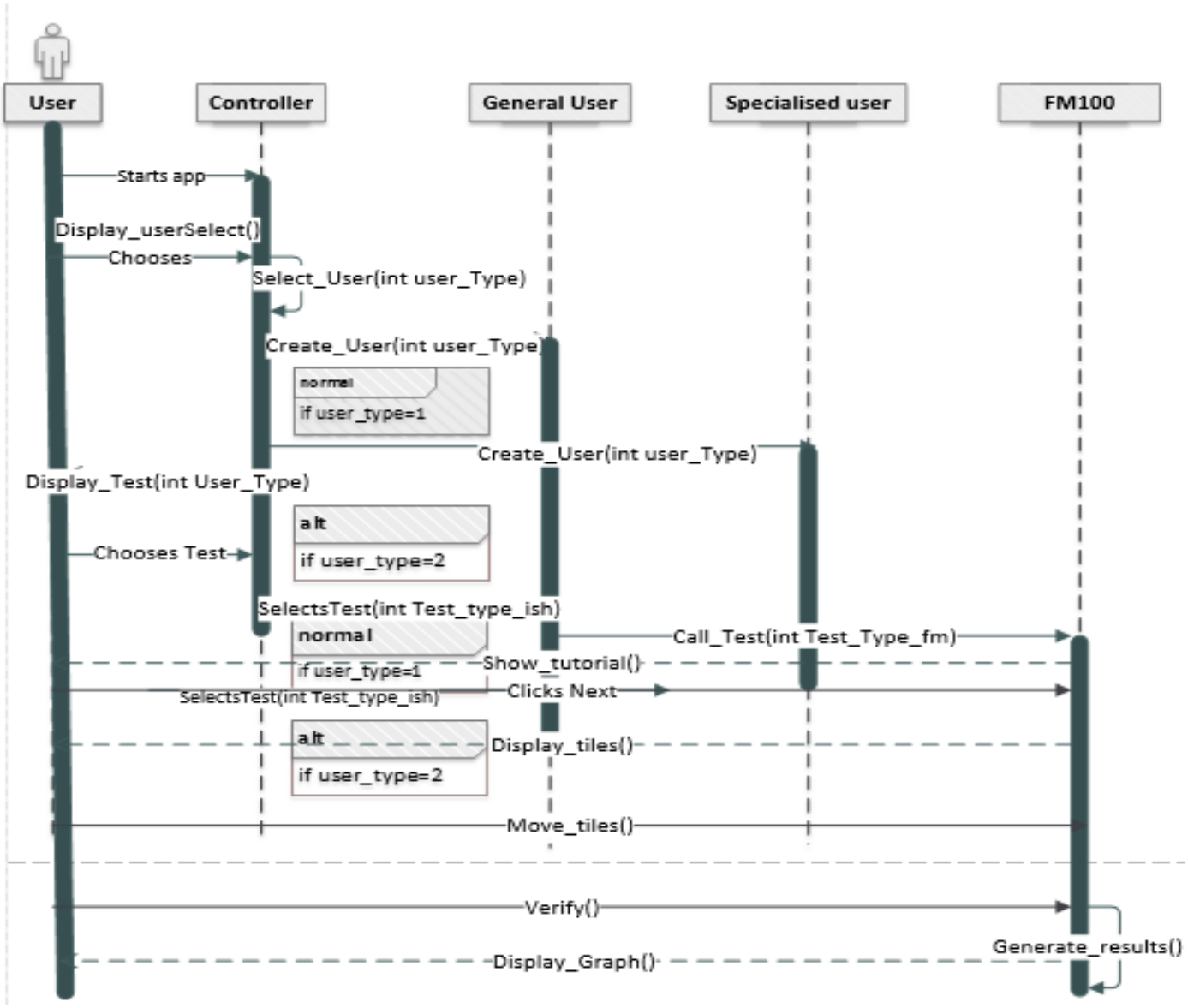


Figure 4-17 Sequence Diagram- FM 100 Test

The sequence diagram below shows the sequence of actions that take place during the FM-100 Test. The user prompts the controller to open the test. The user is supposed to drag and drop the titles according to the intensity. In the end the results are generated accordingly.

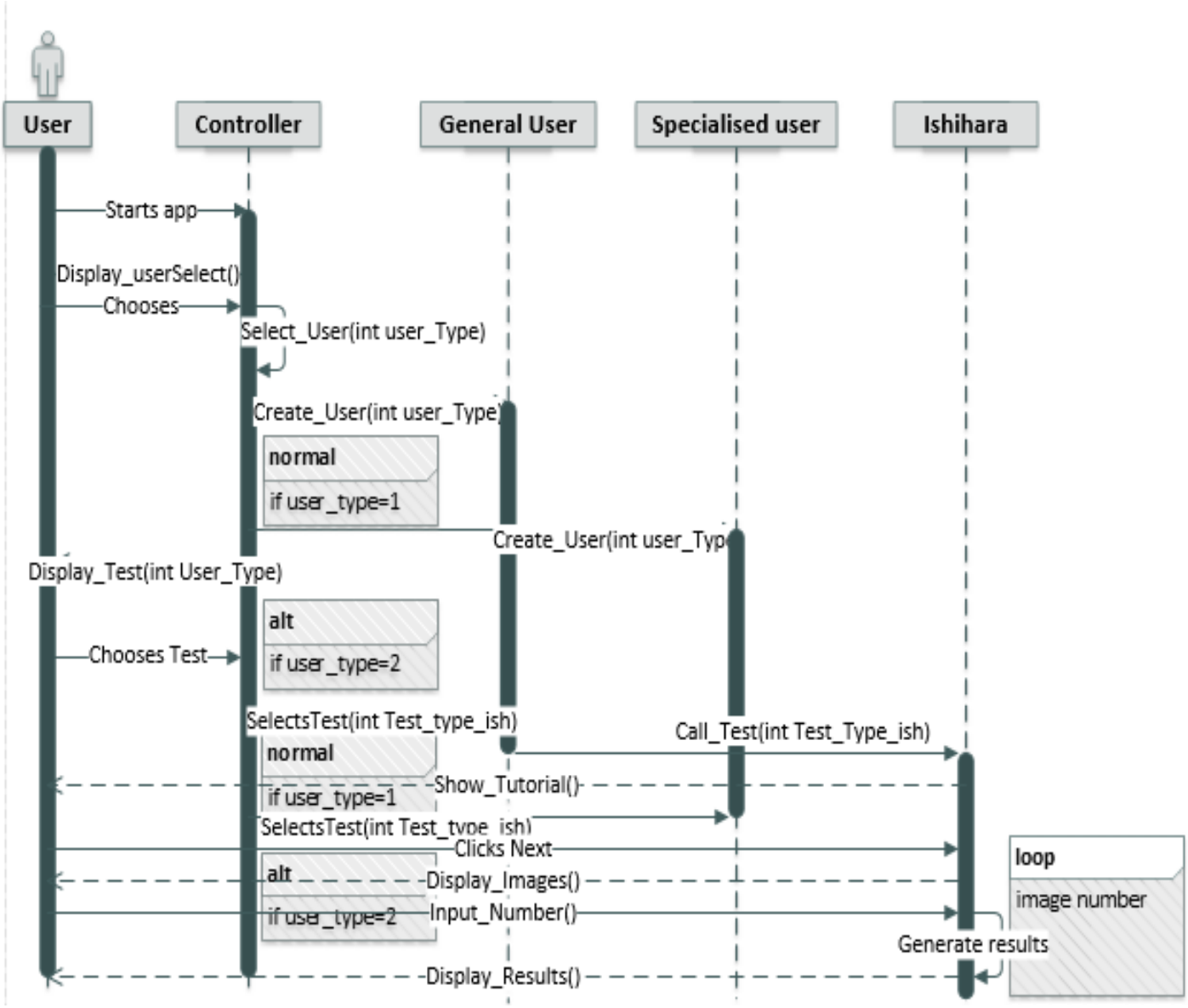


Figure 4-18 Sequence Diagram- Ishihara Test

The sequence diagram below shows the sequence of actions that take place during the Ishihara Test. The user prompts the controller to open the test. The user enters the image number as he sees . In the end the results are generated accordingly.

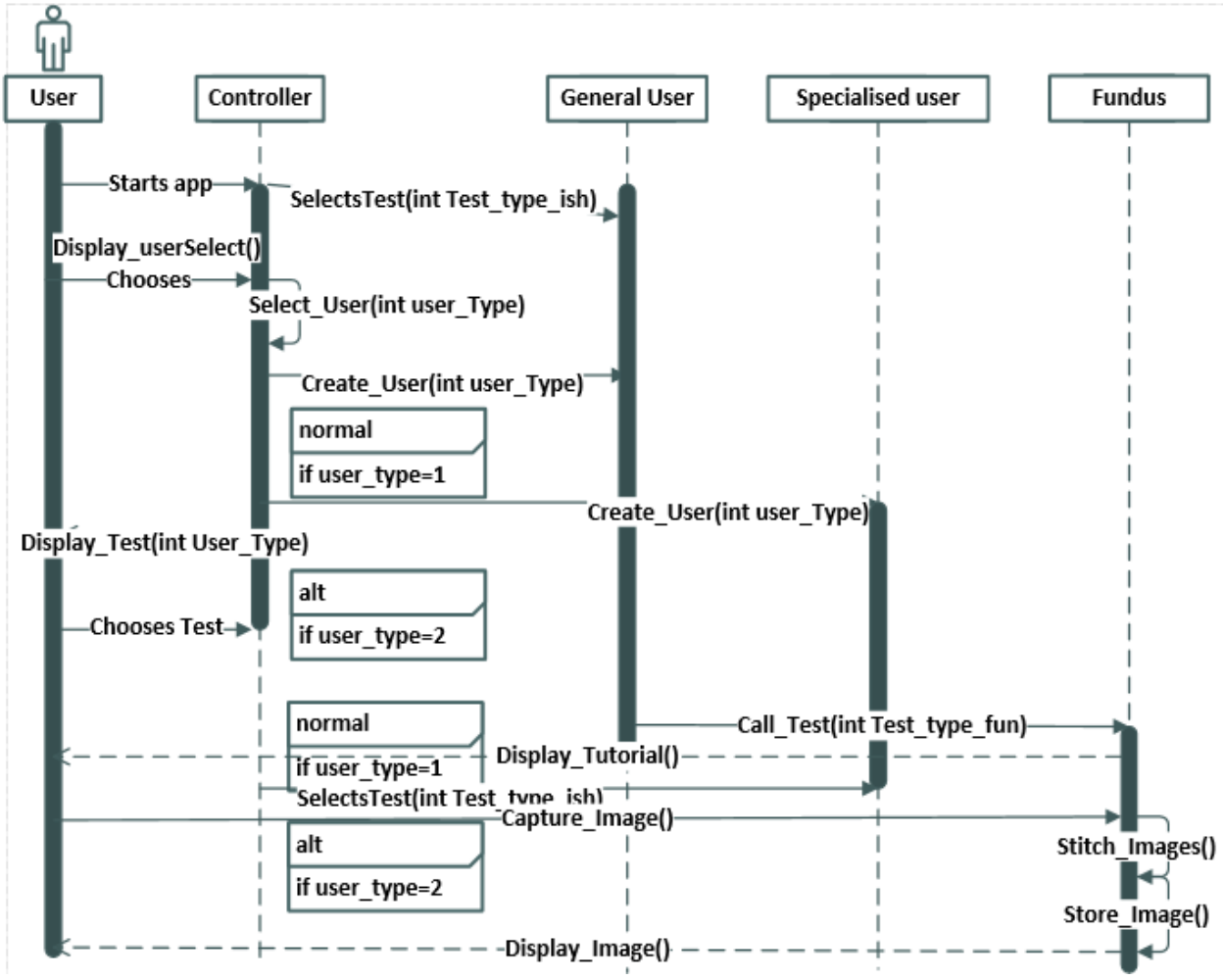
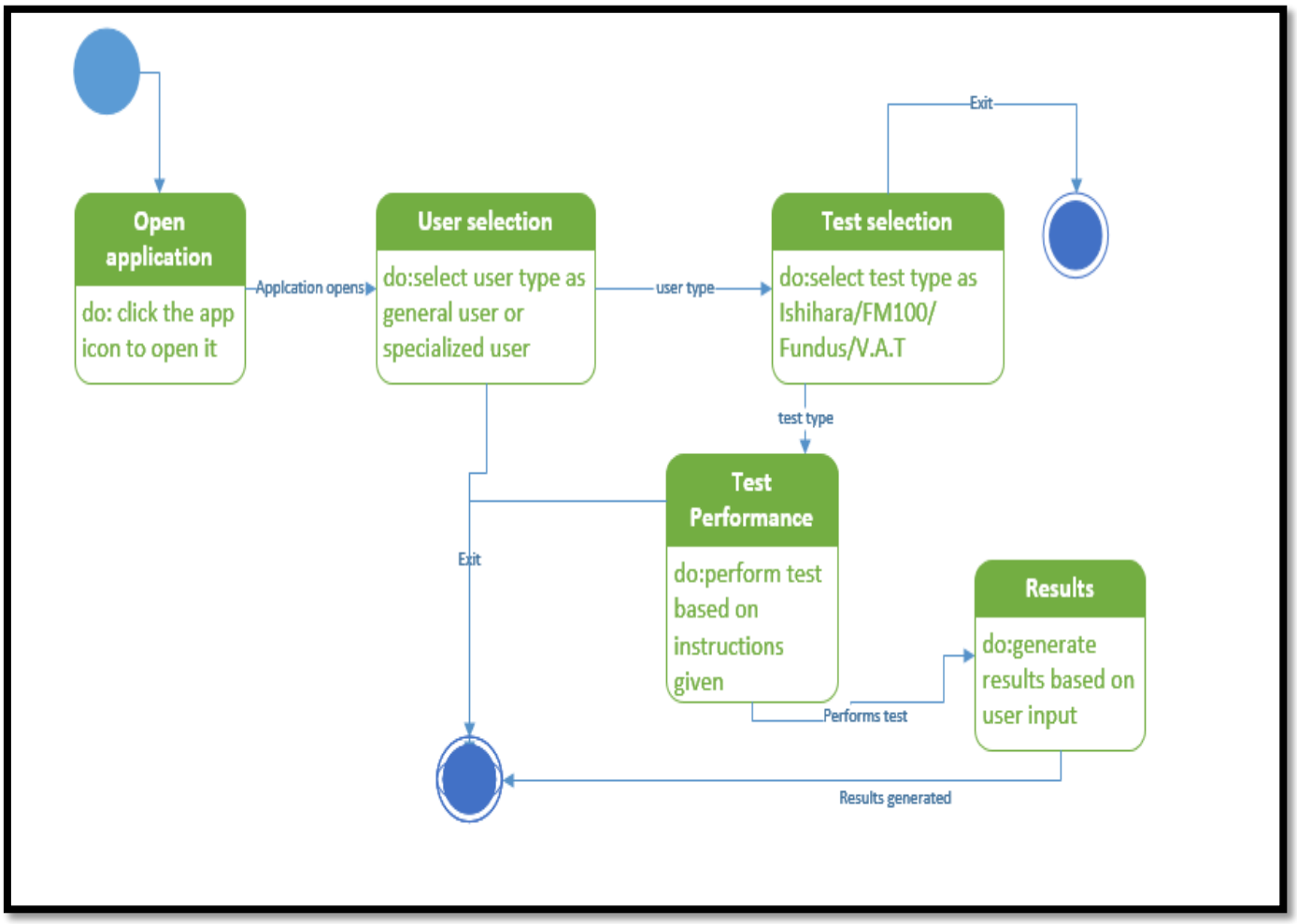


Figure 4-19 Sequence Diagram- Fundus Test

4.7 State Machine Diagram

The state machine diagram of the system is meant to indicate the different states that the system goes through while it does a certain function or task. The state diagram of our application shows the 5 possible states that the application goes through. The arrow indicates the flow of the system and it starts with the open application state and as follows, as shown in the Figure 4-20 below

Figure 4-20 State Machine Diagram



4.8 Detailed Description of Components

The purpose of the Input Controller Module (Table 4-11) is to control the four classes i.e. VAT, FM 100 Test, Ishihara Test and Fundus Test.

Table 4-11: Input Controller Module

Identification	Input_Controller
Type	Module
Purpose	The purpose of this module is that it controls the four classes (VAT, FM 100 Test, Ishihara Test, and Fundus Test). It is responsible to select user, display test and select test.
Subordinates	1. Select User 2. Display Tests 3. Select Tests
Dependencies	This is an independent component.
Interfaces	The user will enter the input values here of which user it has to select. What tests are chosen and displayed.
Resources	None
Processing	The only type of processing required is inputting information into the text boxes and navigating to other forms using links in the bottom half of the screen. Each link directs the user to a different screen that corresponds to the link that the user selects.
Data	The data entered by the user for this screen is the type of user it wants to select along with the test type, from the 4 tests provided.

The purpose of the Visual Acuity Class (Table 4-12) is to provide a user interface for distant vision test.

Table 4-12: Visual Acuity Class

Identification	VisualAcuity
Type	Class
Purpose	Its main purpose is to provide a user interface for distant vision test. The functional requirements that would be implemented using this design component are as below: 1. Snell's chart automation 2. Images (in variable sizes) of objects/animals/numbers/alphabets shall be provided 3. The distance at which the mobile should be placed from the eye shall be specified to the user 4. Results that would give a conclusion to the eye test performed by the user shall be displayed on the screen
Subordinates	Functional requirements satisfied using this component are: 1. Choose Shape type 2. Display Images 3. Input seen Options 4. Generate Results 5. Display Results
Dependencies	The VisualAcuity component is dependent on the controller component of the application.
Interfaces	The links to other screens are contained at the bottom of the screens. This component is designed to make UI easy to view. The component would provide audio visual cues to user to perform Visual Acuity Test
Resources	It requires database to store Snell chart images and user responses in order to generate result
Processing	The only type of processing required is comparing input with data stored and navigating to other screens using links in the bottom of the screen. Each link directs the user to a different screen that corresponds to the link that the user selects.

Data	The data is the user choice out of the multiple choices provided for identification of images shown.

The purpose of the FM100 Test Class (Table 4-13) component is to check the color blindness of the user by rearranging the color plates.

Table 4-13: FM100 Test Class

Identification	FM100_Test
Type	Class
Purpose	The purpose of this component is to check the color blindness of the user by rearranging the color plates. This component aims to identify which color of the user lacks to see.
Subordinates	1. Verify 2. Generate Results 3. Display Graph
Dependencies	The FM 100 test is dependent on the user input that comes from controller and the database from where the colors are taken.
Interfaces	The links are contained in the bottom of the screen. The screen is designed to be easy to view using the resolution standard on the PDA.
Resources	Database is being used to fetch the color tiles. Graph generation library is also being used here.
Processing	The only type of processing required is inputting information by moving the tiles and navigating to other forms using links in the bottom of the screen. Each link directs the user to a different screen that corresponds to the link that the user selects.
Data	The data is entered in the form of moving the color tiles and then selecting the ok button to confirm the selection.

The purpose of the Ishihara Class (Table 4-14) component is to implement color blindness test.

Table 4-14: Ishihara Class

Identification	Ishihara
Type	Class
Purpose	This component is used to implement color blindness test. This component provides user with Ishihara image plates for identification of numbers on image plates. The user result is then compared with predefined values stored with the images.
Subordinates	1. Functional requirements satisfied by this component are: 2. Display Images 3. Input numbers 4. Generate results 5. Display results
Dependencies	This component is dependent on the database (DB) and the controller components. The controller takes user input and provides to this module. The database is used to fetch images used by this components and store user responses.
Interfaces	The links to other screens are contained at the bottom of the screens. This component is designed to make UI easy to view. The component would provide audio visual cues to user to perform test.
Resources	Database is being used to fetch colour plate images.
Processing	The only type of processing required is comparing input with data stored and navigating to other screens using links in the bottom of the screen. Each link directs the user to a different screen that corresponds to the link that the user selects.
Data	The data is in the form of numerical user input

The purpose of Fundus Test (Table 4-15) is to perform fundoscopy through an ophthalmoscopes' images.

Table 4-15: Fundus_Test

Identification	Fundus_Test
Type	Class
Purpose	The purpose of Fundus Test is to perform fundoscopy through an ophthalmoscope which can be performed by an ophthalmologist or a health worker.

Subordinates	1. Stitch Images 2. Store Images
Dependencies	The Fundus test is dependent on the user input that comes from controller for selecting the test and the database to store the images captured by an ophthalmoscope.
Interfaces	The buttons are contained in the bottom of the screen to capture the image, save the image for further use or discard the image. The screen is designed to be easy to view using the resolution standard on the PDA
Resources	Ophthalmoscope which is an hardware is used to capture the images of the internal eye.
Processing	The image is taken in this component which is the only processing done in this fundus test.
Data	The data is entered by taking the images of the eye using an ophthalmoscope.

The purpose of Image Stitching (Table 4-16) component is to stich multiple images taken by the ophthalmoscope to generate one image as a whole.

Table 4-16: Image_Stitching

Identification	Image_Stitching
Type	Library
Purpose	The purpose of this component is to stich multiple images taken by the ophthalmoscope to generate one image as a whole.
Subordinates	Not Applicable. (either write N/A or Not Applicable complete)
Dependencies	Not Applicable
Interfaces	Not Applicable
Resources	A system controller required to include this library.
Processing	Not Applicable
Data	Not Applicable

The purpose of GraphGeneration (Table 4-17) library is that it is required by the FM100 component in order to generate graphical output to user input

Table 4-17: GraphGeneration

Identification	GraphGeneration
Type	library
Purpose	This component is required by the FM100 component in order to generate graphical output to user input
Subordinates	N/A
Dependencies	N/A
Interfaces	N/A
Resources	A system controller program needs to include this library for it to be used
Processing	N/A
Data	N/A

4.9 Pseudo Code for Components

```
Start
```

SELECT TYPE:

```
Display_User_Type();
startLoop{          //loop startsSelect_User_Type();
Display_test_types();
tag m;
Select_Test();
```

FM 100 TEST:

```
runparallel{
fm100 obj;
obj.display_tutorial();
obj.display_tiles();
```

```
obj.move_tiles();
obj.compute_results();
obj.generate_graph();
}endparallel;
```

FUNDUS TEST:

```
runparallel{
if(current_user==general_user)
then {jump(m);}
fundus obj;
obj.display_tutorial();
obj.capture_images();
obj.stitch_images();
   runparallel{
   obj.store_image();
    }endparallel;
   runparallel{
   obj.discard_image();
    }endparallel;
   runparallel{
   obj.display_image();
    }endparallel;
   runparallel{
   obj.mail_image();
    }endparallel;
```

ISHIHARA TEST:

```
run parallel{
ishihara obj;
 obj.display_tutorial();
tag i;
startLoop{
obj.display_ishihara_plates();
obj.input();
obj.compare(int inputNum);
   if (bool check=obj.compare(int inputNum) == false)
   then obj.update_results();
   if(bool check_last_image==true)
   then obj.show_result();
   else jump(i);
}endloop;
}endParallel;
```

VISUAL ACUITY:

```
runparallel{
vat obj;
obj.display_tutorial();
obj.select_shape_type();
tag j;
obj.load_dist_val();
tag k;
obj.display_shape_choice();
string comp=obj.input();
  if( obj.compare(comp)==false)
```

```
  then{obj.update_distance(current_dist);
  obj.change_distance(current_dist);
  jump(j);}
if(check_last_image()==false)
{jump(k);}
obj.compute_results();
obj.display_results();
}endparallel;
}endparallel;
```

```
}loopTill(start_again=true);        //end loop
```

Chapter 5: Project Analysis and Evaluation

The following table 5-1 below checks if the General User button (as shown in of the Figure 4-3 Select User Type Screen) works accordingly and takes the user to the three eye test screen as it was expected as an outcome of the test.

Table 5-1: Test Case: Testing User Type for General User Button

Test Case Number	1
Description	Testing User Type Menu for General User Button
Preconditions	Application should be open
Input	Click on General User Button
Steps	Select the General User button from the user type menu
Expected output	Three Tests for General User opens
Results	Three Tests for General User opens

The following table 5-2 below checks if the Doctor User button (as shown in of the Figure 4-3 Select User Type Screen) works accordingly and takes the Doctor or a health worker to the four eye test screen as it was expected as an outcome of the test.

Table 5-2: Test Case: Testing User Type Menu for Doctor User Button

Test Case Number	2
Description	Testing User Type Menu for Doctor User Button
Preconditions	Application should be open
Input	Click on Doctor Button
Steps	Select the Doctor button from the user type menu
Expected output	Four Tests for General User opens
Results	Four Tests for General User opens

The table 5-3 and Table 5-4 below are the two similar tests applied to the Visual Acuity Test button (as shown in Figure 4-4 Main Menu Screen) to check whether it opens the VAT test on clicking the VAT Button. Table 5-3 checks the same test for the general user first and Table 5-4 then checks it for the Specialized User (Doctor).

Table 5-3: Test Case: Testing the General Users for Visual Acuity

Test Case Number	3
Description	Testing the General Users for Visual Acuity
Preconditions	The user must have selected the general user option from the main user type screen
Input	Click in the Visual Acuity button
Steps	First Select General user from the main user type and then click on Visual Acuity Test
Expected output	The Visual Acuity test should open
Results	Visual Acuity Test opens

Table 5-4: Testing the Doctor for Visual Acuity

Test Case Number	4
Description	Testing the Doctor for Visual Acuity
Preconditions	The user must have selected the Doctor option from the main user type screen
Input	Click in the Visual Acuity button
Steps	First Select Doctor from the main user type and then click on Visual Acuity Test
Expected output	The Visual Acuity test should open
Results	Visual Acuity Test opens

The table 5-5 and Table 5-6 below are the two similar tests applied to the FM-100 Test button (as shown in Figure 4-4 Main Menu Screen) to check whether it opens the FM-100 test on clicking the FM-100 Button. Table 5-5 checks the same test for the general user first and Table 5-6 then checks it for the Specialized User (Doctor)

Table 5-5: Test Case: Testing the General user for FM-100 Test

Test Case Number	5
Description	Testing the General user for FM-100 Test
Preconditions	The user must have selected the General user option from the main user type screen
Input	Click in the FM-100 Test button
Steps	First Select General user from the main user type and then click on FM-100 Test
Expected output	The FM-100 test should open
Results	FM-100 Test opens

Table 5-6: Test Case: Testing the Doctor for FM-100 Test

Test Case Number	6
Description	Testing the Doctor for FM-100 Test
Preconditions	The user must have selected the Doctor option from the main user type screen
Input	Click in the FM-100 Test button
Steps	First Select Doctor from the main user type and then click on FM-100 Test
Expected output	The FM-100 test should open
Results	FM-100 Test opens

The table 5-7 and Table 5-8 as shown below, are the two tests applied to the Ishihara Test button (as shown in Figure 4-4 Main Menu Screen) to check whether it opens the Ishihara test on clicking the Ishihara Button. Table 5-3 checks the same test for the general user first and Table 5-4 then checks it for the Specialized User (Doctor).

Table 5-7: Test Case: Testing the General User for Ishihara Test

Test Case Number	7
Description	Performing the Ishihara Test in General User's menu
Preconditions	The user must have selected the General User option from the main user type screen
Input	Click in the Ishihara Test button
Steps	First Select General User option from the main user type and then click on Ishihara Test
Expected output	The Ishihara Test should open
Results	Ishihara Test opens

Table 5-8: Test Case: Testing the Doctor for Ishihara Test

Test Case Number	8
Description	Performing the Ishihara Test in Doctor's menu
Preconditions	The user must have selected the Doctor option from the main user type screen
Input	Click in the Ishihara Test button
Steps	First Select Doctor button from the main user type and then click on Ishihara Test
Expected output	The Ishihara Test should open
Results	Ishihara Test opens

The table 5-9 as shown below, is the test applied to the Fundus Imagery Test button (as shown in Figure 4-4 Main Menu Screen) to check whether it opens the Fundus test on clicking the Fundus Button. This test is exclusively for specialized health worker and eye doctors (ophthalmologists).

Table 5-9: Test Case: Testing the Doctor for Fundus Imagery Test

Test Case Number	9
Description	Performing the Fundus Test in Doctor's menu
Preconditions	The user must have selected the Doctor option from the main user type screen
Input	Click in the Fundus Test button
Steps	First Select Doctor button from the main user type and then click on Fundus Imagery Test
Expected output	The Fundus Imagery Test should open
Results	Fundus Imagery Test opens

Visual Acuity Test

The test case 10 as shown in Table 5-10 tests the proceed button (as shown in Figure 4-5 VAT Directions Screen). The button is intended to take the user from the tutorial screen to the actual visual acuity test.

Table 5-10: Test Case: Testing the proceed to test button in Visual Acuity Test

Test Case Number	10
Description	Testing the proceed to test button in Visual Acuity Test
Preconditions	The application must be open and the user must have either chosen a particular user type. After this, the user must have selected the Visual Acuity Test from the main test option screen.
Input	Click on 'Proceed to Test' Button
Steps	Click on 'Proceed to Test' Button
Expected output	The Visual Acuity Test screen should open
Results	The test screen for Visual Acuity opens

The table 5-11 is meant to assess the timing functionality of the VAT. The timer is set on 3 seconds and it is intended that the image is only flashed for 3 seconds. The Expected output and the results are as follows:

Table 5-11: Test Case: Testing the 3 second timer in Visual Acuity Test

Test Case Number	11
Description	Testing the 3 second timer in Visual Acuity Test
Preconditions	Visual Acuity Test must be open
Input	-
Steps	Click on proceed on proceed to test button
Expected output	An image will be shown for three seconds and after that the screen will disappear.
Results	The image was to be seen for 3 seconds and after that another screen opened in which we have to choose from the options provided, what we saw on the previous screen

The table 5-12 is included because the user needs to select from the 4 options that will be shown to him against one image. From these only one will be correct and three will be incorrect. The record of correct and incorrect answers will be kept later and will be used to determine the eyesight of the user.

Table 5-12: Test Case: Testing the four option screen Visual Acuity Test

Test Case Number	12
Description	Testing the four option screen Visual Acuity Test
Preconditions	Visual Acuity Test must be open
Input	-
Steps	Click on proceed on proceed to test button in Visual Acuity Test. See the image for 3 seconds and after that choose from the options provided on the screen for the right answer.
Expected output	4 options will be displayed from which one will be the right answer.
Results	4 options were be displayed from which one was the right answer.

The Table 5-13 tests one of the most essential features of the Visual Acuity Test and that is the size reduction of the images as the test proceeds further on. The idea is that, the first image shown to the user will be the largest, the second will be smaller in size compared to the first one and third will be smaller than the second and so on till the test finishes.

Table 5-13: Test Case: Testing the reduction in picture size as the Visual Acuity Test proceeds forward

Test Case Number	13
Description	Testing the reduction in picture size as the Visual Acuity Test proceeds forward
Preconditions	Visual Acuity Test must be open

Input	Choose the correct image option from the 4 options provided
Steps	Open the test and see the image. Then choose the correct answer of the image as he saw previously from the four provided options. Repeat the same procedure until the time when he is unable to see the images correctly because of reduced size.
Expected output	The size of the images reduce as the test proceeds
Results	The size of the images reduce as the test proceeds

Table 5-14 is created to check whether or not the results appear in the VAT and if they are shown than are they even correct. The table below show the results when feature went under testing.

Table 5-14: Test Case: Testing the results displayed at the end of Visual Acuity Test

Test Case Number	14
Description	Testing the results displayed at the end of Visual Acuity Test
Preconditions	Visual Acuity Test must be open
Input	The user must have chosen the supposedly correct answers just like he saw it on the image
Steps	Open the test and see the image. Then choose the correct answer of the image as he saw previously from the four provided options. Repeat the same procedure until the time when he is unable to see the images correctly because of reduced size.
Expected output	Correct result to be displayed.
Results	A correct result was calculated based on how many wrong answers were given out of the total questions answered.

Color Blindness

The test case 15 as shown in Table 5-15 tests the test button. The button is intended to show a detailed tutorial as in how to use the color blindness test to get the best possible results. The findings of it are as follows:

Table 5-15: Test Case: Testing Ishihara test tutorial button

Test case number	15
Description	Testing Ishihara test tutorial button
Preconditions	The user selects the Ishihara Test icon
Input	Click the Show Tutorial image button
Steps	The user after selecting the test will be provided with ‘Show tutorial’ image button
Expected output	The tutorial screen with steps for performing test is displayed

Results	Pass

The test case 16 as shown in Table 5-16 tests the proceed button. The button is intended to take the user from the tutorial screen to the actual Ishihara Test.

Table 5-16: Test Case: Testing Proceed to test button

Test case number	16
Description	Testing Proceed to test button
Preconditions	The user must be on the tutorial screen
Input	Click the Proceed to test button
Steps	The user after selecting Proceed to test button will be provided with screen showing an Ishihara plate image and a dial pad with numbers will pop up.
Expected output	A screen with a single Ishihara plate image appears on screen and a dial pad to enter number seen shall be provided to user
Results	Pass

The table 5-17 is included to test the dial pad of the Ishihara test.

Table 5-17: Test Case: Testing the dial pad

Test case number	17
Description	Testing the dial pad
Preconditions	The user must be on the screen with the Ishihara plate image and dial pad must have appeared on screen
Input	The user enters the digits on dial pad
Steps	The user enters the number seen on the Ishihara plate through dial pad and press OK to proceed or clears if he wants to re-enter number and then clicks OK to proceed
Expected output	The dial pad allows user to enter digits and erase incorrect input before clicking OK
Results	Pass

Table 5-18, checking the new image feature has been incorporated to test if multiple images of Ishihara plates are shown are not. The intension is to show multiple images to the user, but one picture at a time so that he can be checked from multiple sides, since each picture holds different color combinations of red and green.

Table 5-18: Test Case: Checking the new image feature

Test case number	18
Description	Checking the new image feature
Preconditions	The user must have identified the number on the first Ishihara plate and clicked OK
Input	Click OK on dial pad after identifying number on image button displayed
Steps	The screen should appear with a new image
Expected output	A new image appears on screen
Results	Pass

The test case 19 as shown in Table 5-19 tests the test button. The button is intended to show a detailed tutorial as in how to use the color blindness FM-100 test to get the best possible results. The findings of it are as follows:

Table 5-19: Test Case: Testing FM100 test tutorial button

Test case number	19
Description	Testing FM100 test tutorial button
Preconditions	The user selects the FM100 Test icon
Input	Click the Show Tutorial image button
Steps	The user after selecting the test will be provided with 'Show tutorial' image button
Expected output	The tutorial screen with steps for performing test is displayed
Results	Pass

Table 5-20 checks the 20th test case. It has been included to access the fixation of the first and last tile of the first row as shown in Figure 3-3 FM 100 Test tiled View. The idea behind the fixation is to accommodate the user so that he knows from which color to start and from which color to end and then he sets the remaining tiles according to the increasing intensity.

Table 5-20: Test Case: Check first and last tile is fixed in each row

Test case number	20
Description	Check first and last tile is fixed in each row (FM100 test)
Preconditions	The user must be on the FM100 test screen
Input	Drag and drop tiles
Steps	The user tries to drag the first and last tile in a row.
Expected output	The user should not be able to move the first and last tile
Results	Pass

Test case 21 as depicted in Table 5-21 tests one of the most important features of the FM-100 test. The tiles are arranged in the uneven and incorrect order and for the user to place them correctly according to the increasing intensity, it is essential the tiles can be dragged and dropped accordingly. The table 5-12 shows the results of the testing this feature.

Table 5-21: Test Case: Drag and drop tiles in a row

Test case number	21
Description	Drag and drop tiles in a row (except first and last tile)
Preconditions	The user must be on the FM100 test screen
Input	Drag and drop
Steps	The user re-arranges tiles according to a gradient based on the first and last tiles by using the drag and drop feature provided
Expected output	The user should be able to move tiles by using drag and drop functionality provided
Results	Pass

The results of the FM-100 test are intended to be shown as a graph which shows the areas of color deficiency. The Table 5-22 shows the following graph feature being tested and its results are as follows

Table 5-22: Test Case: Display output of FM100 test in form of graph

Test case number	22
Description	Display output of FM100 test in form of graph
Preconditions	The user must have completed FM100 test
Input	Click Done
Steps	The user performs the FM100 test and clicks done to get results of test in the form of a graph
Expected output	The user sees a graph showing errors in performing test
Results	Pass

Fundus Test

The test case 23 as shown in Table 5-23 tests the proceed button. The button is intended to take the user from the tutorial screen to the actual Fundus Imagery Test.

Table 5-23: Test Case: Testing the Proceed to Test Button for Fundus Imagery Test

Test Case Number	23
Description	Testing the Proceed to Test Button for Fundus Imagery Test
Preconditions	Click on ‘Proceed to Test’ Button
Input	Click on ‘Proceed to Test’ Button
Steps	The Fundus Test screen should open
Expected output	The test screen for Fundus Test opens

Results	The application must be open and the user must have either chosen a particular user type. After this, the user must have selected the Fundus Test from the main test option screen.

The images taken from the ophthalmoscope by the doctor are selected and inserted into the Fundus Image Test and it is expected from the 'Stitch Button' that it will stitch all those pictures to make one flat square picture which is easier to see and easy to observe. Table 5-24 depicts the test and it's testing results are as follows:

Table 5-24: Test Case: Testing the stitch button for fundus imagery test

Test Case Number	24
Description	Testing the stitch button for fundus imagery test
Preconditions	The Fundus Test should be selected first by the Doctor
Input	Click on the stitch button
Steps	Choose fundus test and click on stitch button
Expected output	The single images will be stitched into one big picture
Results	All the pictures are stitched correctly

Table 5-25: Test Case: Testing email button for Fundus Imagery Test

Test Case Number	25
Description	Testing email button for Fundus Imagery Test
Preconditions	The Fundus Test should be selected first by the Doctor
Input	Click on the email button
Steps	Choose fundus test and stitch the image. Then click on the email button to email the picture
Expected output	The email application of the phone/tablet opens
Results	The email application of the phone/tablet opens

User Acceptance Testing

Test No.	Test Name	Expected Results	Observed Results	Evaluation by doctor/users
1	Visual Acuity Test	Images were to be shown will the 3 second timer. The images had to decrease in size as the test proceeded. On the incorrect answer the application had to stop and give the results of the user eyesight.	The results were according to the expectations. The visual acuity test stops when the incorrect answer is entered. The user is told he needs to consult the ophthalmologist on a poor vision result	The doctor/users found the test accurate and results were accordingly
2.	FM-100 Test	The FM 100 test should allow user to drag and drop colored tiles based on intensity and provide result in the form of a graph indicating severity of color vision defect by comparing user's TES (total error score) from a range of standard values.	Once the user finishes performing test the graph showing result in the form of graph is displayed and user's score is mapped on the graph.	The doctor/users evaluated the test and found it satisfactory.
3.	Ishihara Test	The quality of the Ishihara plate images should be such that the user should be able to identify hidden numbers and give correct responses based on their color perception and not get distracted due to poor image quality.	The Ishihara image plates were clearly visible to users who tested the application and did not complain about distorted image quality or difficulty in image visualization.	The users found the test accurate and were satisfied with the results generated.
4.	Fundus Test	The fundus test is supposed to stitch the pictures. The pictures are saved in the camera through a hand held ophthalmoscope and they are inserted to stitch them into one picture.	The pictures which are saved in the tablet are inserted into the test and they are stitched into one picture.	The ophthalmologists found the test satisfactory.

Chapter 6: Future work

The tests developed can be re used in the future to proceed with evolution. The separate tests can even be extended in the next versions of this eye suite. The new section in this project shall be the addition of a Cataract test of the eye which shall test the intensity of the clouding of the lens inside the eye which leads to a decrease in vision. It is the most common cause of blindness and is conventionally treated with surgery. The intensity would be based on the colors of cataract starting from white to yellow, brown and then black.

Chapter 7: Conclusion

Eye diagnosis suite is a complete package comprising of multiple eye tests that are beneficial for normal people as well as ophthalmologists. Not only the people's time and cost would be saved but with the introduction of this application ophthalmologists will have less work load as well cost effective alternative to the expensive test machines will be available in hands.

In addition to this, this automated procedure can also be used to increase the precision of clinical testing of eye related diseases and would reduce eye problems

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USER'S MANUAL

Android Application for Eye Diagnosis Suite

Military College of Signals NUST

May, 2015

USER'S MANUAL

TABLE OF CONTENTS

1.0 GENERAL INFORMATION

1.0 GENERAL INFORMATION

1.1 System Overview

The Eye Diagnosis Suite provides a collaboration of four eye tests i.e. Visual Acuity test, Color blindness tests (FM 100 and Ishihara test) and Fundus Test that are commonly needed by the general public and the doctors. The user can choose different eye tests anytime through touch gestures. It is a free application that operates on the android operating system.

Operational status of Application: Operational.

This documentation concerns Eye Diagnosis Suite's version 1.0.0.0.

1.2 Project References

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1.3 Organization of Manual

The user's manual consists of the following sections:

1. General Information
2. System Summary
3. Getting Started

General Information section explains the purpose of the intended system, in general terms.

System Summary section contains a general overview of the system. It outlines the uses of the system's requirements including software, hardware, user access levels and system's behaviour.

Getting Started section describes how to get the application and install it on the device. It contains explanation in detail about the system functions.

1.4 Acronyms and Abbreviations

FM 100 test - The Farnsworth-Munsell 100 Hue Color Vision Test

VAT- Visual Acuity Test

2.0 SYSTEM SUMMARY

2.0 SYSTEM SUMMARY

This section outlines the outline the uses of the system in supporting the activities of the user.

2.1 System Configuration

Eye Diagnosis Suite operates on mobile devices with Android operating system. It is compatible with Android 4.3 (Jellybean) and higher versions. The application requires connection to Internet in order to email the images (Fundus images of eye).
After installation on the device, Eye Diagnosis Suite can be used immediately without any further configuration.

2.2 User Access Levels

Everyone having an android tablet/smartphone can use the application.

2.3 Contingencies

Application running on the Android device will not need any additional information other than the collected data from the user or already present data. There are no connections to other devices or severs so no data will be sent or received or used in any way, hence no data loss or security related issue exists.

3.0 USING THE SYSTEM

3.0 USING THE SYSTEM

This section contains the logical arrangement of information that would help the user of the application to understand the sequence of flow of system- from initiation through exit.

3.1 Logging On

Prerequisites:

Before installing Eye Diagnosis Suite to your mobile phone, make sure you have checked the following:

1. Your mobile platform is Android.
2. Mobile Internet services are subscribed and available to use for your mobile phone.

To install the app, launch Play Store, then search for "Eye Diagnosis Suite". Once on the app page, click on the install button.

Log On:

Once the installation is complete the user would be automatically logged in.

.

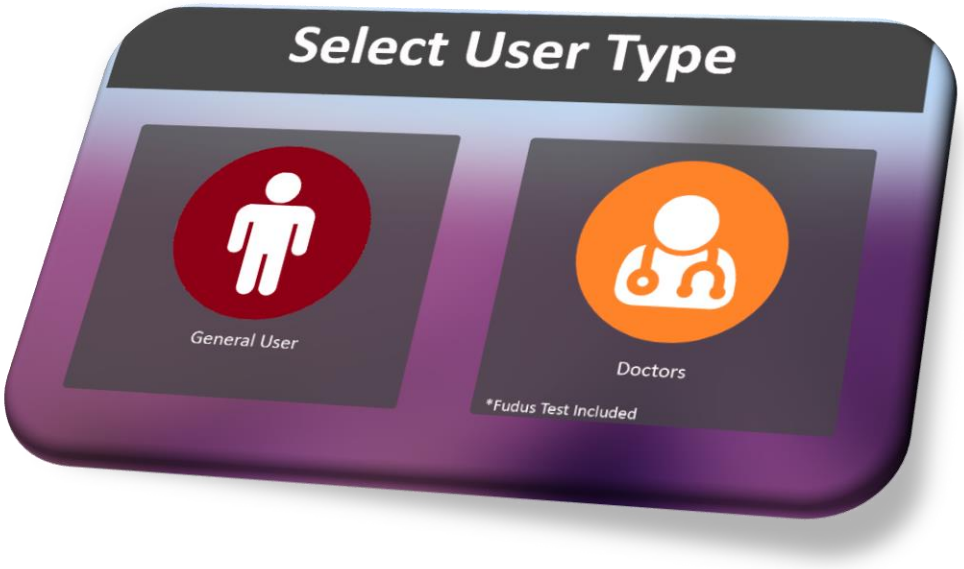
3.2 System Main Menu

After starting the application the categories will be displayed as a main menu. The sequence of actions followed are:

1. Open the application.
2. Access main menu

The main menu shall be used to check whether the user is a normal Smartphone user or a doctor.

Main Menu



Selection Screen

3.3 Visual Acuity Test Screen

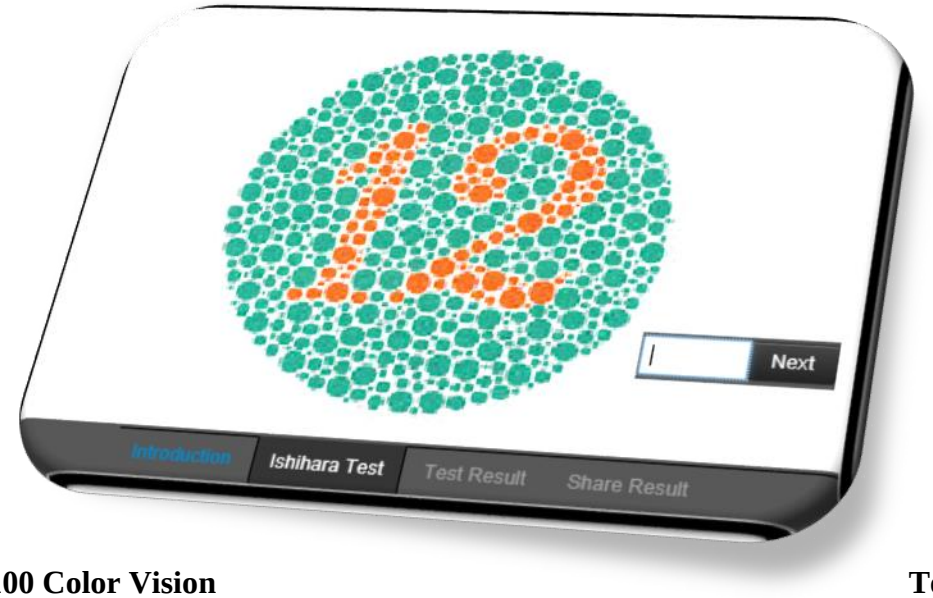
The course of actions followed for visual acuity test or Vision test is as described below:

1. The user selects a Visual Acuity test.
2. The user sees the Snell's images and press next to proceed.
3. Results that would give a conclusion to the eye test performed by the user shall be displayed on the screen.

3.4 Ishihara Color Vision Test Screen

To perform Ishihara test the user must perform the following sequence of steps

1. The user should select Ishihara Color Blindness Test
2. The user sees the Ishihara color plates and inputs the seen number.
3. Clicks next to proceed on the next color plate.



3.5 FM 100 Color Vision Test Screen

1. The user selects a FM 100 test.
2. The user sees the plates to reposition and press next to proceed to the next screen.
3. Starting from red to green, arrange 20 tiles in ascending order of their intensities. The first and last tile in a row shall be fixed.
4. Each row contains 20 movable tiles.
5. Drag and drop to move the tiles.
6. Results are indicated after the user completes test in the form of a graph

3.6 Fundus Image Stitching

1. The user selects a Fundus Eye Test.
2. The user gets multiple fundus images from different directions.
3. The complete image of the fundus is displayed to the user.

3.7 Exit System

At any time the user shall be able to exit the test and move over to the main menu or exit the app completely by using the exit/back button