



Measure Visual Acuity

Submitted in partial fulfillment of the requirements of the degree of
Bachelor of Engineering in Computer Engineering

By

NAYAN BHATIA (05)
DHARMIN CHOTHANI (11)

SWATI SAHA (47)

KASHISH WADHWA (80)

SUPERVISOR

Dr. Sarita Ambadekar



Department of Computer Engineering

K. J. Somaiya Institute of Engineering and Information Technology,

Ayurvihar, Sion, Mumbai-22

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CERTIFICATE

*This is to certify that the project entitled “**Measure Visual Acuity**” is a bonafide work of **Nayan Bhatia, Dharmin Chothani, Swati Saha and Kashish Wadhwa** submitted to the University of Mumbai in partial fulfillment of the requirement in Project, for the award of the degree of “**Bachelor of Engineering**” in “**Computer Engineering**”.*

Dr. Sarita Ambadekar
Project Guide
Dept. of Computer Engineering

Dr. Sarita Ambadekar
HOD Dept. of Computer Engg.
Place: Sion, Mumbai-400022

Date:

Dr. Suresh K. Ukarande
Principal

PROJECT APPROVAL FOR B. E.

This project report entitled “**Measure Visual Acuity**” by **NAYAN BHATIA (Roll No. 05) DHARMIN CHOTHANI (Roll No. 11) SWATI SAHA (Roll No. 47) KASHISH WADHWA (Roll No. 80)** is approved for the degree of **Bachelor of Engineering in Computer Engineering.**

Examiners

1. _____

2. _____

Place: Sion, Mumbai-400022

Date:

DECLARATION

We declare that this written submission represents our ideas in our own words and where other ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

NAYAN BHATIA_____

DHARMIN CHOTHANI_____

SWATI SAHA_____

KASHISH WADHWA

Date:

ACKNOWLEDGEMENT

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NAYAN BHATIA (05)

DHARMIN CHOTHANI (11)

SWATI SAHA (47)

KASHISH WADHWA (80)

Place: Sion, Mumbai-400022.

Date:

ABSTRACT

Visual acuity (clearness of vision), usually measured by an eye doctor using a Snellen's chart, is one of the most commonly applied clinical tests in the world. With the patient's participation, it measures the smallest letters that can be reliably identified at a specified distance, and thereby test the resolving power of our eyes. The traditional test for acuity requires the patient to look and report which letters they see. Currently visual acuity tests are performed in a room having an ample amount of space where the distance between the patient and standard Snellen chart is 6 meters. Also enough light ambience is required to perform this test. But in rural areas these eye check-up camps are organized in small rooms such as in primary schools without proper light ambience available. This lack of space and light ambience makes it difficult to perform eye tests. So to overcome these problems of space and light ambience, we have proposed a solution which uses a periscope. At one end of the periscope a digital Snellen chart is displayed on a digital display. The chart on this display is controlled by the volunteer by using another remote application. Patient will be seeing the chart from the other end and will speak what he/she sees. Based on the response by the patient the volunteer will give the input in the application. Using a periscope will solve the problem of space and the external ambience.

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LIST OF ABBREVIATION

MVA	Measure Visual Acuity
ETDRS	Early Treatment Diabetic Retinopathy Study
ML	Machine Learning
IDE	Integrated Development Environment
WA	Wavefront Aberration
IEEE	Institute of Electrical and Electronics Engineers.

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION:

Visual Acuity is what a person sees & is measured by what they read of a chart. Typically, practitioners use a Snellen chart which is read at a distance of 20 feet. Ideal chart for use would be the ETDRS chart. This is one of the most important outcomes measured following cataract surgery. Typically, a patient is asked to cover each eye and thereafter responds (reads of or points) to symbols from a chart at a distance. This is thus dependent on – Human Response, Light (ambient) and attention of the patient and the person recording. The current method of measurement involves the use of Snellen's chart and the involvement of skilled technicians for measuring visual acuity.

1.2 AIM AND OBJECTIVE:

Aim: To develop a solution which can be used to conduct eye tests in regions with lack of space and ambience issues especially rural areas.

Objective: The main objectives of this project are:

1. To come up with a visual acuity measurement app or solution which can give consistent and accurate readings.
2. To develop a cost effective and easy to use solution which can be used in rural areas.
3. To develop a solution which can be used by a non-medical field (social) worker.

1.3 PROBLEM STATEMENT:

To measure visual acuity of the patients accurately with a cost-effective and easy to use solution. The solution should be such that it can be used by a non-medical field (social) worker. Visual acuity needs to be measured accurately in field settings (Field settings mean that the solution should work in a room where ambient light should not be a hindrance as opposed to Clinics where ambient light can be controlled, field settings mean Classroom, camp settings in villages).

CHAPTER 2

REVIEW OF LITERATURE

Literature survey consisted of study of several papers published in reputed journals related to the topic as well as some peripheral topics to give us better knowledge and clarity of the domain. A lot of informative material was found on the internet which helped us learn more about object tracking.

2.1 OVERVIEW OF THEORETICAL STUDY:

Visual acuity is the most widely used measure of visual function. In fact, visual function is often equated with visual acuity, thereby ignoring other important dimensions of visual stimuli, such as color and contrast. Visual acuity tests have proven to be useful for assessment of refractive error, screening for ocular health, following the course of eye disease, evaluating the effectiveness of medical and surgical treatment, prescribing aids for the visually impaired, and setting vision standards for employment and driving.

Given the variety of its applications, it is not surprising that many different types of visual acuity tests have evolved. Generally, these tests were developed with little concern for standardization. Since the 1980s, several attempts have been made to formulate standards for test design and administration. The Committee on Vision of the National Academy of Sciences-National Research Council (NAS-NRC)¹ has published standards for clinical testing of visual acuity that are widely adopted in the USA, and the British Standards Institution has published similar standards for the UK.

2.2 Distance Vision

The most familiar test of visual acuity is the Snellen chart. This has a series of letters of graduated size, each subtending an angle of 5 minutes of arc at a specific distance. The top letter on the chart subtends this angle at 60 metres while the smallest letters subtend the angle at 5 metres. The test is conducted at a distance of 6 metres (20 feet) which is optically equivalent to infinity. A patient who can only see the top letter has a visual acuity of 6/60, while a patient who can read

down to those letters subtending an angle of 5 minutes of arc at 12 metres has a visual acuity of 6/12. Visual acuity of 6/6 is the accepted normal (in America, expressed as 20/20).

2.3 Types of Charts

The Snellen Eye Chart: The original eye chart designed in the 1860's by the Dutch eye doctor Hermann Snellen. The first line on this chart is a giant letter E. You read the chart from top to bottom, left to right covering one eye at a time.

Tumbling E Charts: This type of eye chart is used for children that are too small to read or adults with reading or speaking difficulties. The patient is asked to lift their hand up, down, to the left or right depending on the image orientation of the letter E they see on the chart.

Jaeger Eye Charts: The Jaeger eye chart (or Jaeger card) is used to test and document near visual acuity at a normal reading distance. Refractive errors and conditions that cause blurry reading vision include astigmatism, hyperopia (farsightedness) and presbyopia (loss of near focusing ability after age 40).

ETDRS: The Early Treatment Diabetic Retinopathy Study helped develop standardization for both visual acuity testing and eye chart design. The ETDRS is accepted by The National Eye Institute and the Food and Drug Administration as the mandated standard for clinical eye test trials worldwide.

Landolt C: Edmund Landolt, a Swiss ophthalmologist, created this visual acuity chart. This eye chart, which is similar to the Tumbling E chart, uses a Landolt's broken ring symbol in various orientations. The Landolt C chart is a way to check vision for illiterate or mute patients.

CHAPTER 3

REQUIREMENT SPECIFICATION

3.1 INTRODUCTION:

To be used efficiently, all software needs certain hardware components or the other software resources to be present on a device. These prerequisites are known as system requirements and are often used as a guideline as opposed to an absolute rule. Most software defines two sets of system requirements: minimum and recommended. With increasing demand for higher processing power and resources in newer versions of software, system requirements tend to increase over time.

3.2 HARDWARE REQUIREMENTS:

The most common set of requirements defined by any operating system or software application is the physical computer resources known as hardware.

The following are the hardware requirements of our solution:

Android Device Requirements:

- 1) ROM: 1GB
- 2) RAM: 512MB

3.3 SOFTWARE REQUIREMENTS:

Role of SRS

The purpose of the software requirement specification is to reduce the communication gap between the clients and the developers. Software Requirement Specification is the medium through which the client and user needs are accurately specified. It forms the basis of software development. A good SRS should satisfy all the parties involved in the system.

Purpose and scope

The SRS phase consists of two basic activities:

- **Problem/Requirement Analysis:** The process is orderly and more nebulous of the two, deals with understanding the problem, the goal and constraints.

- **Requirement Specification:** Here, the focus is on specifying what has been found giving analysis such as representation, specification languages and tools, and checking the specifications are addressed during this activity. The requirement phase terminates with the production of the validate SRS document. Producing the SRS document is the basic goal of this phase.

Software Requirement

ANDROID API LEVEL: minimum 15(Ice Cream Sandwich)

OPERATING SYSTEM: Windows XP and above, Ubuntu v12.04 and above.

FRONTEND: HTML, CSS, Javascript

BACKEND: PHP, Python, Flask

DATABASE: MongoDB

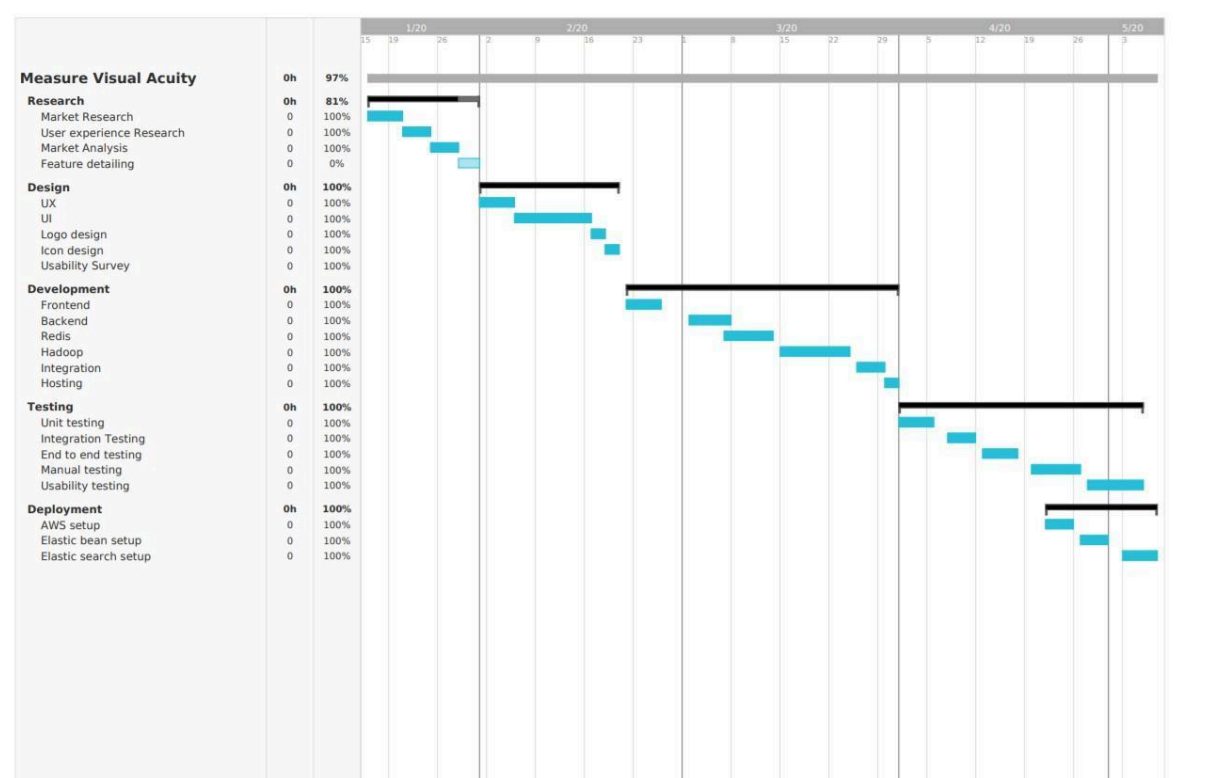
CHAPTER 4

ANALYSIS

4.1 PROJECT TIMELINES AND TASK DISTRIBUTION:

A timeline represents the flow of the working of the project with its list of events in chronological order, also known as a project artifact. It is a graphical design that shows the dates with the tasks completed on their sides. The highlighted areas indicate the period wherein they were completed.

Table 4.1: Project Timeline



4.2 EXISTING SYSTEM:

Visual acuity (clearness of vision), usually measured by an eye doctor using a Snellen's chart, is one of the most commonly applied clinical tests in the world. With the patient's participation, it measures the smallest letters that can be reliably identified at a specified distance, and thereby test the resolving power of our eyes. The traditional test for acuity requires the patient to look and report which letters they see. Currently visual acuity tests are performed in a room having an ample amount of space where the distance between the patient and standard Snellen chart is 6 metres. Also enough light ambience is required to perform this test. But in rural areas these eye check-up camps are organized in small rooms such as in primary schools without proper light ambience available. This lack of space and light ambience makes it difficult to perform eye tests.

4.3 PROPOSED SYSTEM:

4.3.1 ASSUMPTIONS:

A volunteer is required which will be using the remote application.

4.3.2 REQUIREMENTS:

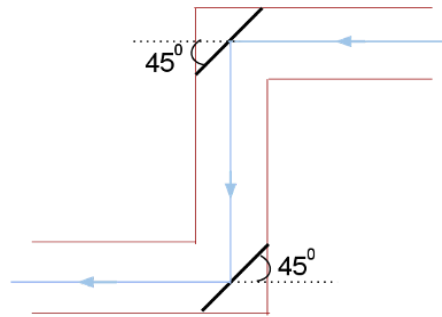
- 1) Two devices (a mobile and tablet/laptop/mobile)
- 2) Measuring Tape
- 3) Periscope (optional)
- 4) Pinhole Occluder (To check for refractive and non-refractive error)

4.3.3 COST:

- 1) Periscope (Optional): Rs.150 /-
- 2) Pinhole Occluder (Optional): Rs. 300 /-
- 3) Measuring Tape: Rs. 40/-

4.3.4 WORKING:

So to overcome the problems of space and light ambience, we have proposed a solution which uses a periscope. At one end of the periscope a digital Snellen chart is displayed on a digital display. The chart on this display is controlled by the volunteer by using another remote application. Patient will be seeing the chart from the other end and will speak what he/she sees. Based on the response by the patient the volunteer will give the input in the application. To solve the problem of space instead of increasing the distance between the chart and patient, we have made the light travel a fixed amount of distance greater than 25 cm to avoid strain in the eye, which is the length of the periscope.



At both the ends of the periscope there is a thin mirror placed at an angle of 45 degrees to reflect the light from the chart to the patient's eye. As we are using the periscope, there will be no effect of external light ambience on the test. This solution can be used to conduct eye tests anywhere especially in rural areas where there are very small rooms and ambience issues.

4.3.5 FEATURES:

- 1) Variety of charts like Snellen Chart, Landolt C, etc. So this solution is applicable to all the age groups, all types of patients whether literate or illiterate.
- 2) Solution is simple to use by the Non-medical workers.
- 3) Random letter generation so that if the patient has memorized the chart then it would not affect the chart.
- 4) The system works in two modes:
 - With Periscope
 1. This mode uses a periscope so that the effect of external light ambience is eliminated.
 2. In this mode, the distance between the chart and the patient is fixed.
 - Without Periscope
 1. This mode does not use periscope. It is used where ambience is not an issue.
 2. Here chart size is dynamically decided based on the input distance.

4.4 FEASIBILITY STUDY:

Feasibility study is an important phase in the software development process. It enables the developer to have an assessment of the product being developed. It refers to the feasibility study of the product in terms of outcomes of the product, operational use and technical support required for implementing it. Feasibility study should be performed based on various criteria and parameters. The various feasibility studies are:

- Economic Feasibility
- Operational Feasibility
- Technical Feasibility

Economic Feasibility:

It refers to the benefits or outcomes that are deriving from the product as compared to the total cost that is spent for developing the product. In the case of this project, using a simple android and flask application, so there will not be any economic cost associated with it.

Operational Feasibility:

It refers to the feasibility of the product to be operational. In the case of this project, it has been developed in such a way that even a non-technical or non-medical person can operate it. Thus, in this way this project is operationally feasible.

Technical Feasibility:

It refers to whether the software that is available in the market fully supports the present application. Technical feasibility deals with the technology used in the system. It studies the pros and cons of using software for the development and its feasibility. In the case of this project, it can be handled by any of the users who is technically sound. Hence this project is technically feasible.

CHAPTER 5

DESIGN

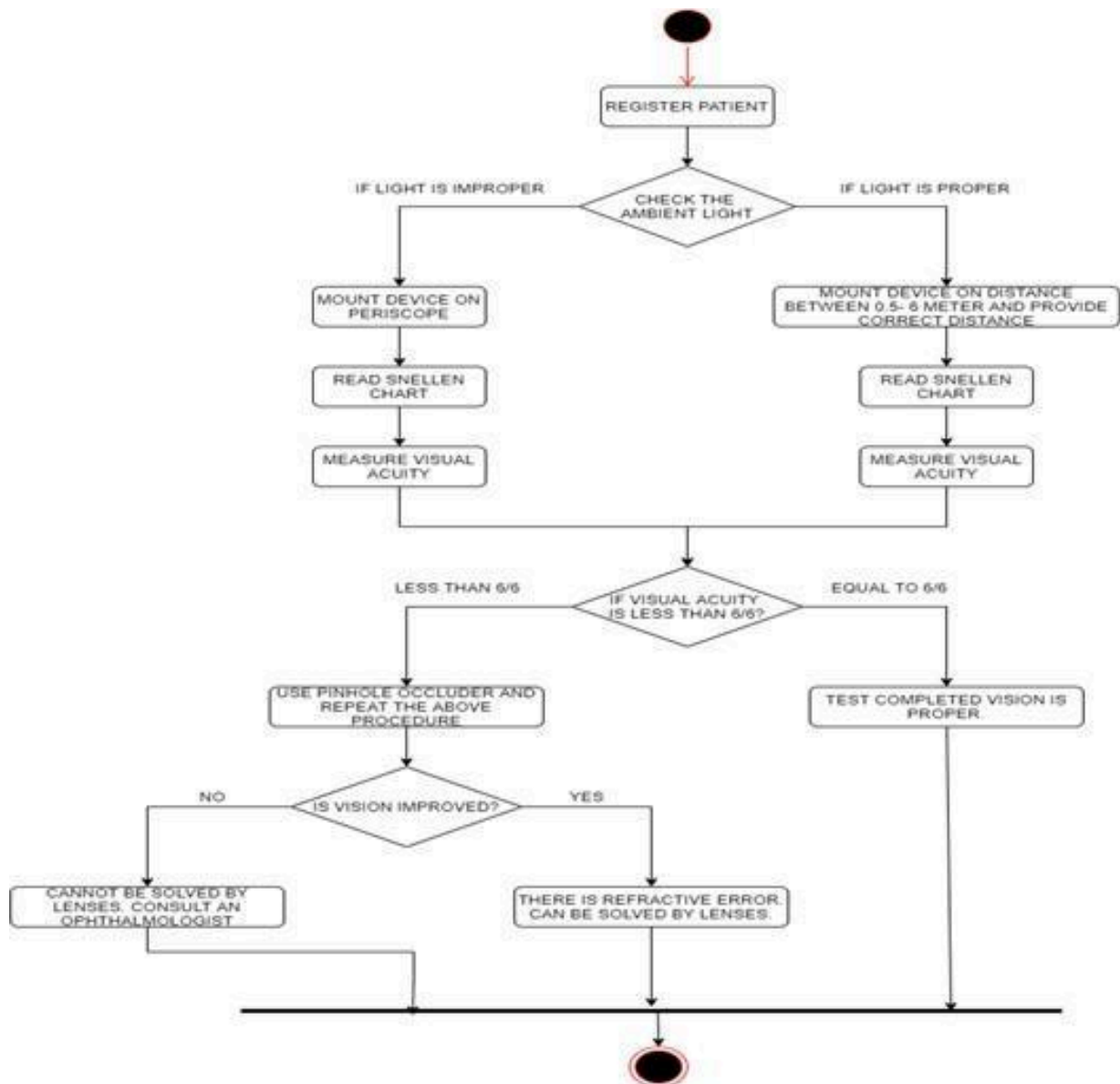
The flow of the project needs to be decided in advance because of the obstacles which need to be taken care of. The main aim is to make sure that all the disabilities which are categorized should be taken care of and need to be handled correctly. Categorized learning disabilities can be classified into five categories.

UML is a standard language for specifying, visualizing, constructing, and documenting the artifacts of software systems. There are several goals for developing UML but the most important is to define some general-purpose modeling language, which all modelers can use, and it also needs to be made simple to understand and use. The biggest problem is how to share knowledge among end users, developers and managers. In order to upgrade the quality of software development, this paper aims to present a novel operational process model that assists to share or reuse the knowledge through different stages of software engineering. The operational process model is the knowledge transformation and computing model and it will prompt the automation of software design; also enhance the standardization of knowledge representation.

5.1 SYSTEM FLOW:

Flow of the system goes as follows:

- 1) The patient registers on the application.
- 2) Field settings are checked. If there is no proper light ambience available in the surrounding, then the digital chart is mounted on the periscope otherwise the device can be mounted between 0.5 to 6 meters and input the distance in the app.
- 3) Then the Snellen chart is read by the patient and accordingly the volunteer inputs the response of the patient in the remote application. Accordingly, the visual acuity is calculated by the app.
- 4) If the visual acuity is less than 6/6 then a pinhole Occluder is used and the same test is performed again.
- 5) If the vision is improved by using the pinhole Occluder then the patient may have a refractive error in the eyes which can be solved by using lenses.
- 6) But if the vision is not improved by using the pinhole Occluder then the patient may need to consult an ophthalmologist.



CHAPTER 6

IMPLEMENTATION AND TESTING

6.1 IMPLEMENTATION:

Implementation is the stage of the project when the theoretical design is turned out into a working system. Thus it can be considered to be the most critical stage in achieving a successful new system and in giving the user, confidence that the new system will work and be effective.

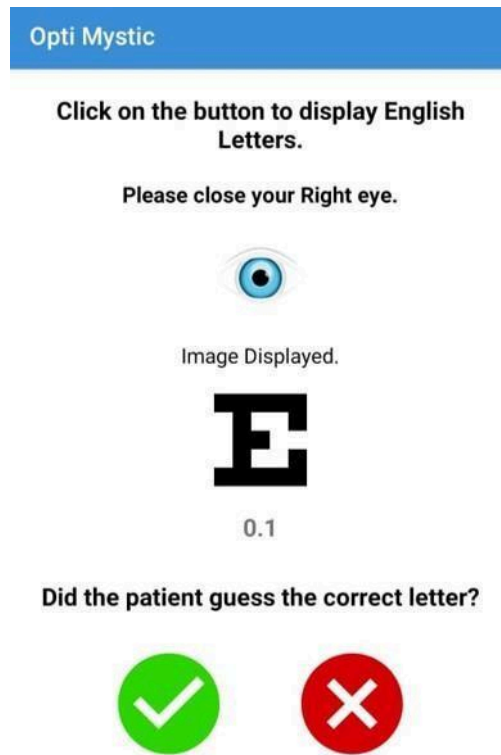
To develop an android application which will calculate the visual acuity of the patient by recording the response of the patient of what he/she sees of the digital chart.

The patient registers on the application. The data is stored in the database. Field settings are checked. If there is no proper light ambience available in the surrounding, then the digital display device is mounted on the periscope otherwise the device can be mounted between 0.5 to 6 meters and input the distance in the app. Then the Snellen chart is read by the patient and accordingly the volunteer inputs the response of the patient in the remote application. Accordingly, the visual acuity is calculated by the app. If the visual acuity is less than 6/6 then a pinhole Occluder is used and the same test is performed again. If the vision is improved by using the pinhole Occluder then the patient may have a refractive error in the eyes which can be solved by using lenses. But if the vision is not improved by using the pinhole Occluder then the patient may need to consult an ophthalmologist. The results of the visual acuity test are sent to the patient through SMS and E-mail.

6.2 TECHNOLOGY USED:

This project is developed in Android. The Android Studio Framework will be used for the same. Android Studio is the official integrated development environment (IDE) for Google's Android operating system built on JetBrains IntelliJ IDEA software and designed specifically for Android development. It is available for download on Windows, macOS and Linux based operating systems. It is a replacement for the Eclipse Android Development Tools (ADT) as primary IDE for native Android application development.

6.3 SCREENSHOTS OF THE IMPLEMENTATION:



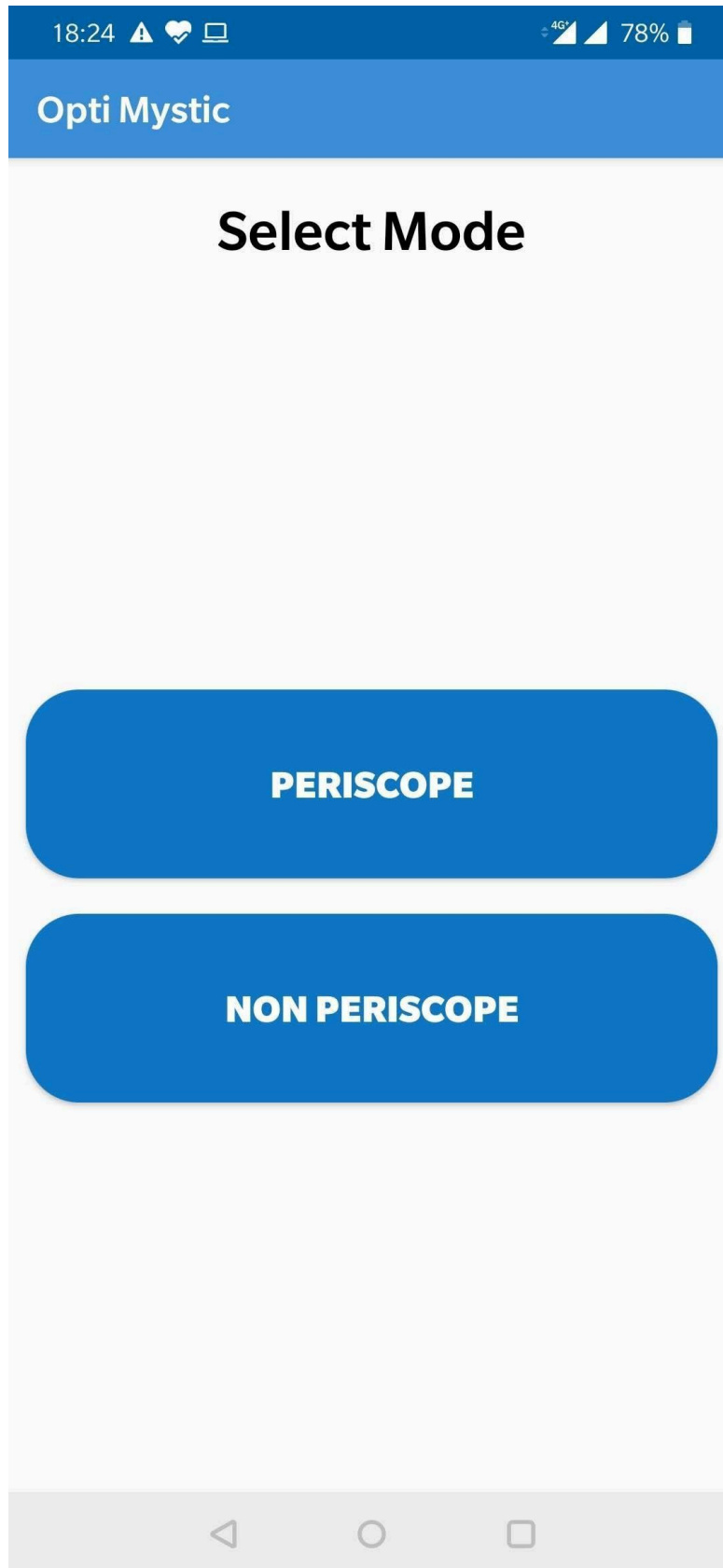
(The screen as seen by the volunteer: The image displayed to the patient is also displayed on the app accessed by the volunteer, where he/she is supposed to input whether the patient identified the correct letter or not.)



Enter Ip Address

OPEN CONNECTION

(For establishing the socket connection between the app and the remote the IP address is to be entered)



(Volunteers can select the mode- whether periscope will be used or not, on the screen based on the availability of external environmental conditions such as space, light etc.)



Select Chart type

ENGLISH

LANDLOT C



(Volunteers can select from the various types of charts available on the app according to age group, literacy level etc. of the patient)



Enter Distance between 1-6 meters

SUBMIT DISTANCE



(The volunteers will enter the distance between the eye of the patient and the chart manually for rendering the optotypes with accurate measurements)



(Periscope structure to be used by the v for places where actual clinical setup/proper ambience is not possible/available)

6.4: TESTING:

The testing phase of the software development lifecycle (SDLC) is where you focus on investigation and discovery. During the testing phase, developers find out whether their code and programming work according to customer requirements. And while it's not possible to solve all the failures you might find during the testing phase; it is possible to use the results from this phase to reduce the number of errors within the software program. Before testing can begin, the project team develops a test plan. The test plan includes the types of testing you will be using, resources for testing, how the software will be tested, who should be the testers during each phase, and test scripts, which are instructions each tester uses to test the software. Test scripts ensure consistency while testing. There are several types of testing during the test phase, including quality assurance testing (QA), system integration testing (SIT), and user acceptance testing (UAT).

CHAPTER 7

7.1 CONCLUSION:

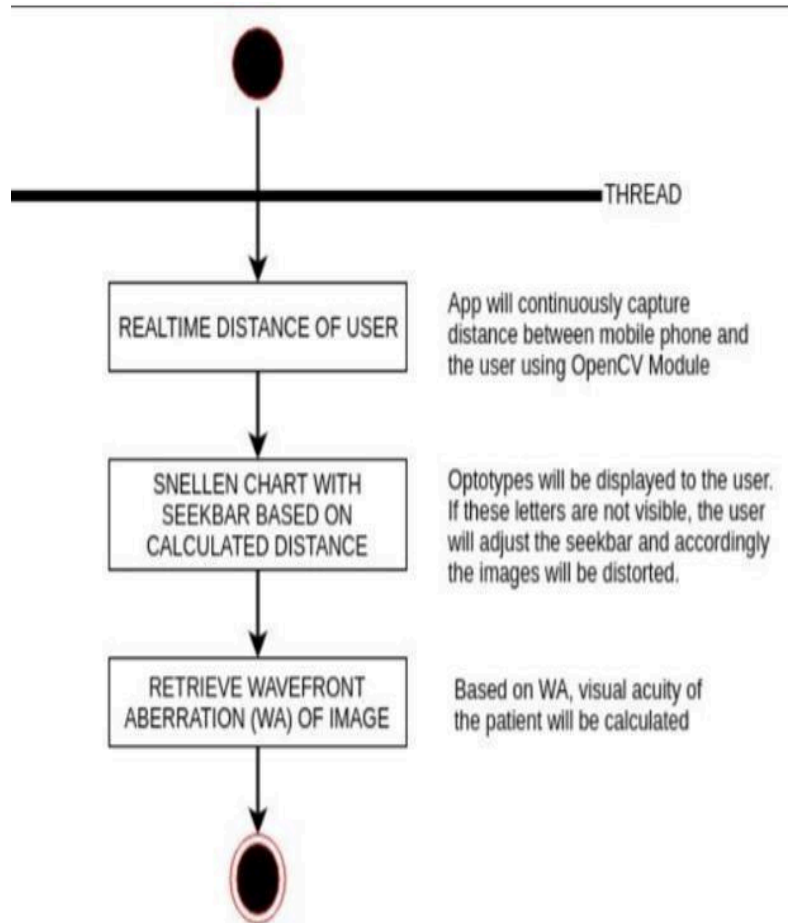
A software for conveniently, accurately and portably visual tests was designed and implemented. Size design of the visual optotype based on number of pixels solved the key problem of limited measurement accuracy and measurement range. The software could present optotypes accurately and control the appearance order effectively. The software could be used by a tablet computer for home use and the data collection methods met the scientific use of large numbers of people.

7.2 FUTURE SCOPE:

It is possible to relate the visual acuity to the physical health of the eye. So for this there is an abstract solution proposed by us which can be implemented in future. To simulate the effect of lenses, we will be using the concept of wave front aberration(WA).

- Our solution is to simulate the observer performing the acuity task with an eye possessing a particular set of WA.
- When a letter is presented, we first distort a digital image of the letter by the specified WA, and add noise to mimic the noisiness of the visual system.
- We then attempt to match the blurred noisy image to similarly blurred candidate letter images, and select the closest match.
- We repeat this for many trials at many letter sizes, and thereby determine the smallest letter that can be reliably identified: the visual acuity and the lens number. We will be incorporating optical and neural filtering, neural noise, and an ideal decision rule.
- This approach provides an automated system to estimate visual acuity based on objective measurements of the eye optics and wave front aberrations (WA).
- Wavefront aberrations are represented in a particular form known as the Zernike Polynomials.

- A typical measurement on the eye of a patient will consist of a list of approximately 16 numbers that constitute the coefficients of the polynomials.
- The WFA Metric is an algorithm that converts the list of numbers into an estimate of the visual acuity of the patient. If changes are planned to the WA of the patient (through surgery or optical aids) the predicted change in acuity can be calculated.



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