DESIGN OF LOW COST, EASY TO USE AND PORTABLE VISION TEST TOOL FOR RURAL POPULATIONS

By

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13885

FINAL PROJECT REPORT

Submitted to the Electrical & Electronics Engineering Programme

in Partial Fulfillment of the Requirements

for the Degree

Bachelor of Engineering (Hons) Electrical & Electronics Engineering

Universiti Teknologi PETRONAS
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CERTIFICATION OF APPROVAL

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Approved by,

_____

AP DR. FAWNIZU AZMADI BIN HUSSIN
PROJECT SUPERVISOR

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK
MAY 2014

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

YEE ZEN MING

ABSTRACT

This report describes the design and implementation of a vision screening system dedicated for android based devices. It is used as a vision test tool for the rural population especially the senior citizens. The senior citizens in the rural areas do not have the means to regularly visit clinics or hospital to undergo eye check-up as it is inconvenient for them to travel far. Hence, this project is aimed to design a user-friendly eye test application that comes with multi-lingual language option. With this application, the senior citizens can run the eye test at the comfort of their home. The designed application is portable and simple for the user to run without any prior experiences. It comes with the visual acuity eye test. Input from the user will be analysed and the eye score will be displayed at the end of the test with an appropriate recommendation to the user. Experiments have been conducted on 15 university students. Those with vision problems are taken as samples to measure the sensitivity of the application. The results obtained show that the application has constantly achieved more than 80% of accuracy in terms of specificity and sensitivity.

ACKNOWLEDGEMENT

First and foremost, I would like to express my gratitude and thankful to God for His kind blessing by giving me the strength and determination to complete my Final Year Project (FYP) in good condition, health and well-being. Next, I would like to take this opportunity to express my greatest gratitude to my supervisor, AP Dr. Fawnizu Azmadi Bin Hussin for his valuable guidance and advice throughout the project. His willingness to motivate, coach and guide me contributed tremendously to my project.

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LIST OF ABBREVIATIONS

AMD	Age Related Macular Degeneration
WHO	World Health Organization
LDPI	Low Dot Per Inch
MDPI	Medium Dot Per Inch
HDPI	High Dot Per Inch
XHDPI	Extra High Dot Per Inch
LOGMAR	Logarithm of Minimum Angle of Resolution
GUI	Graphical User Interface
SDK	Software Development Kit
XML	Extensible Markup Language
CSR	Corporate Social Responsibility

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CHAPTER 1:

INTRODUCTION

1.1 Background

Malaysia is facing the increasing rate of senior citizens. According to the Department of Statistics Malaysia, the percentage of senior citizens with 60 years old and above has increased from 6.3 percent in 2000 to 8.2 percent in 2010 [1]. This percentage is expected to rise up to 9.9 percent in the year of 2020. With the rapid growth of the number of senior citizens, health issue has become one of the most important issue that the government and the society must not overlook.

There is no doubt that aging will bring up different kinds of physical impairment or diseases. For instance, eye vision is one of the critical functionality that will generally cease with aging. Eye impairment may change one's life since it is the most important sensory organ inside the human body. Human rely on the eyes to capture up to 80 percent of the information and impressions in the daily life. Without a good pair of eyes, one may face a lot of difficulties in carrying out their daily task.

In Malaysia, there is a large number of senior citizens in the rural areas. Many of them do not have the means to regularly visit medical facilities to undergo eye check-up. The only place such a test can be conducted is either at the clinics, hospitals or through private optometrists. Unfortunately, these are not viable options for the senior citizens in the rural areas as the hospitals are generally located far away from their home land. Mini clinics in the remote areas usually do not equip with a full set of eye check-up instruments. It is important for the senior citizens to regularly run through the eye check-up for an early detection of eye disease as well as to ensure their vision quality is maintain at an acceptable level at all the times in order for them to carry on with their normal life.

1.2 Problem Statement

It would be inconvenient for the senior citizens in the rural areas to go for regular eye check-ups particularly given that many of the elderly folk live on their own and have no means of transport. Hence, there is a need to design a vision test tool so they can perform the eye test at the comfort of their home. The option of developing a physical eye test tool such as a low cost eye chart is omitted as it would require some training to the end user before they can perform the self-eye test. Thus, an intelligent Android based eye test application is proposed to address the issue where the users do not need to go through training in order to perform the self-eye test. The application is proposed to run on touch-screen based devices. Several options have been taken into consideration, such as the use of joystick or keyboard to obtain the input from the user while running the eye test. However, touch-screen interfaces are often easier to learn to use compare to other hardware. Hence, it is proposed that the application will receive input directly from the touch screen. The designed application must fulfill the following criteria:

i. It must be simple to operate so that the users can perform self-test with the absence of an ophthalmologist.
ii. Proper and understandable instructions or guidance must be provided to the users.
iii. Appropriate type of eye test must be incorporated in order to identify eye pathology which causes eye diseases and visual reduction.
iv. The application should suggest the user to go for a thorough eye examination when he is suspected to have eye problems, i.e. when the user fail to answer the test questions and exceeded the specific rate of errors.

1.3 Objectives

The main objective of this project is to design an Android application that acts as a vision screening tool to grade the vision quality of a senior citizen. The designed application must achieve the following requirements:

i. Comes with a multi-lingual interface, namely the Bahasa Malaysia, Mandarin as well as the English language.
ii. The designed application must be portable. In other words, it must be able to run on all types of android devices regardless of the different sizes of the screen or screen resolution.
iii. The application should achieve high accuracy (> 80% as recommended by the doctor) as compared to the test conducted with the original eye chart.
iv. The designed application should be able to detect any abnormal types of input by the user and make a re-test when necessary.

1.4 Scope of Study

This project is primarily focus on the design of an Android application which is used as a vision test tool for the rural population especially the senior citizens. The scope includes the design of the graphical user interface, which is realized by using the android development tool from the web. The study also includes various types of eye diseases as well as the type of vision test that is appropriate to be used to grade the vision quality of a senior citizen. The designed application is validated through a number of experiments to ensure it achieves a high accuracy.

CHAPTER 2:

LITERATURE REVIEW

2.1 Common Eye Diseases in the Elderly

Aging are known to cause various kind of eye diseases to adults over 60 years old. Among various kind of eye diseases, cataract is classify as the main cause of vision impairment in elderly patients [2]. Cataract occurred at the lens of the eye where a cloudy area had blocked the clear vision of the eye. This can compromise the normal vision depending on how large is the size and its location. The eye with cataract will suffer from a decrease in contrast sensitivity, visual acuity and visual field as well as increase sensitivity to glare [2].

Age-related Macular Degeneration (AMD) is another leading cause of vision impairment in elderly patients [3]. An early detection of AMD is critical since the laser treatment is most successful when performed before the damage of the retina occurs. This disease is not curable at a later stage since it affects the important part of the retina, known as the macula, causing permanent loss of central vision [2], [3]. Central vision is important for human to carry out daily task such as reading or driving. Study has found that patients with AMD are having more difficulties in driving and hence they tend not to drive especially in the night time or in the areas that they are not familiar with [4]. Since AMD only affects the central vision, patients are likely to use the side vision to view objects and this results in a straight line being appeared as a bend or curve line.

Glaucoma is another disease that is defined as a group of eye diseases which will damage the optic nerve causes permanent loss of vision or blindness. This disease can be caused by heredity or with the increase of age [2]. Study shows that Glaucoma is more common among the older people with 60 years old and above. Patients with glaucoma will usually suffer from low contrast sensitivity and may have difficulties with night driving and their eyes are easily tire while reading or watching television.

Often, this is related to the increased pressure in the eye, known as "intraocular pressure". This pressure is increased due a blockage in the trabecular meshwork, which causes the build-up of aqueous humour without a proper drainage [5].

Diabetic retinopathy, on the other hand, is an eye disease that will likely occur in elderly patients if they are having diabetes, especially to those who had diabetes for more than 10 years [6]. This disease is caused by the damage of the blood vessels around the retina. The leakage of the blood vessels causes the swelling of the retinal tissue which may result in a blur or unclear vision, decrease in contrast sensitivity or blindness in a long term [2], [6].

2.2 Visual Acuity Eye Test

Visual acuity test is a common test used to detect the vision problems. It is a test used to check the clearness of the vision [4]. Studies have shown three types of commonly used method to test the visual acuity, namely the Snellen chart, EDRTS chart as well as LEA symbol acuity [7], [8]. Figure 1 shows the well-known Snellen chart used by the ophthalmologists worldwide.

Figure 1: Snellen Chart

Snellen, the creator of the Snellen chart, realized that the human eye has a vision capability that was slightly better than 1 arc minute [9]. Hence, the letters constructed in the Snellen chart are designed based on this theory where each letter subtends 5 arc minutes as shown in the following figure.

Figure 2: Size of Snellen Letter

The size of the 6/6 Snellen letter can be calculated based on the following formulae:

$$\tan\left(\frac{5}{60}\right) = \frac{letter\ size\ (mm)}{test\ distance\ (mm)}$$

where 5/60 means the letter subtends 5 arc minutes (in degree). If a patient could only identify the big E at 6 meters, the rating of his vision is 6/60 [9]. Table 1 shows the Snellen score and its equivalent score in decimal and logarithm as well as the corresponding letter size at a test distance of 6m.

Table 1: The Snellen Score and the Corresponding Letter Size

Snellen Score	**Decimal**	**Log Score**	**Letter Size (6m)**
6/60	0.1	0	87.27 mm
6/48	0.125	0.09691	69.81 mm
6/24	0.25	0.39794	34.91 mm
6/18	0.33	0.52288	26.18 mm
6/12	0.5	0.69897	17.45 mm
6/9	0.67	0.82391	13.09 mm
6/6	1.0	1.0	8.73 mm

In contrast to the Snellen chart, the lines and letters in the EDRTS chart are equally space with a smaller grading scale which contribute to a more accurate test result [10]. LEA symbols, on the other hand, is a better choice for testing the children's vision as it only made up of 4 types of symbols, namely, an apple, rectangle, circle and a pentagon. This is particularly useful to test children that do not have any knowledge on alphabet letters [8], [11].

2.3 Existing Eye Test Application

There are several windows and android applications that currently provide the vision test examination. Some applications are provided free of charge while some charges a fee for the software license. At the moment, there are 4 popular windows programs adopted and used by the ophthalmologists worldwide as shown below:

i. 20/20 Vision Acuity Software by Canela [12]
ii. Acuity Pro by Vision Science [13]
iii. iChartPlus [14]
iv. PVVAT Vision Acuity Software by Precision Vision [15]

All products above are windows-based software which can be run on all types of windows desktop or laptop. These products are intended for professional use by the clinics or eye care professionals. These applications do not focus on testing elderly patients specifically, even though they packed with all the necessary tools to test the eye vision such as visual acuity test, astigmatism test and etc. They can be run on either a computer monitor or an external projector. Consequently, these products are very costly in terms of software licensing. In addition, these applications do not run on a mobile device or a tablet.

With the increase popularity of smartphones and tablet, developers have started to come out with a series of vision test applications which allow the users to perform self-test on their eyes. These applications are specifically built to run in either the android or iOS platform.

The following shows some of the vision test applications which currently support the android platform [16]:

i. Visual Acuity (Healthcare4mobile)
ii. ICARE Vision Test (ICARE eye hospital)
iii. B2 Eye Test (Balint Farago)
iv. Advanced Vision Test (Kikapps)
v. Vision Test (3 Sided Cube)
vi. Vision Check Up (IINSPIN Technology)

Some of the listed applications have 2 different types of version for both smartphone and tablet due to the different screen sizes and screen resolution. The types of eye test available in the each application varies from one to another. For instance, the Advanced Vision Test application developed by Kikapps, comes with color blindness test only. Applications like this can hardly grade the vision quality of an elderly since there are many other aspects such as Visual Acuity and AMD that need to be taken into account while grading the vision quality.

Besides, some of the applications are running a fixed set of test questions, e.g. the Vision Test application created by the "3 Sided Cube". The user may unintentionally memorize the answer when repeated tests have been carried out with the same set of test questions. Applications developed with random test questions often results in a more accurate grading. On the other hand, certain application, such as ICARE vision test developed by the ICARE eye hospital, did not reveal the eye test result in the form of a total score. When the user attempt wrongly on one of the questions, the test stops instantaneously with an eye failed message displayed without giving an additional chance for the user to continue with the test. Application like this can barely provide any real implications to the user especially to the elderly. Thus far, none of the mobile applications are constructed based on the elders' requirements. Therefore, these applications are not able to provide a quality vision testing to the elderly.

CHAPTER 3:

METHODOLOGY

3.1 Research Methodology

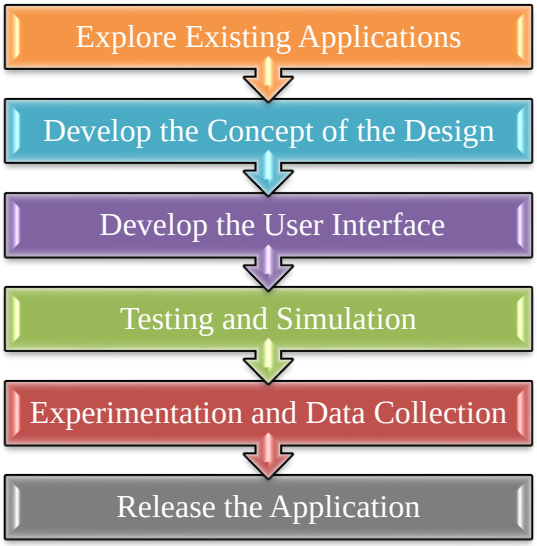

Figure 3: Project Methodology

1. **Explore Existing Applications**

   Existing applications in the market have been explored through several online app marketplace such as Google Play and Apple App Store. The design of the user interface for the existing apps have been analysed. Pros and cons for each application is studied based on the types of eye tests incorporated.

2. **Develop the Concept of the Design**

   The concept of the design is developed based on the advices received from the eye specialists from the Selayang Hospital. Dr Elias bin Hussein, an Opthalmologist and Ms Farah Wahidah binti Hashim, an Optometrist, both from the Selayang Hospital, have provided valuable suggestions and recommendations on the overall design of the eye test application.

The author has been presented with various types of technologies used to conduct the eye test such as the use of traditional Snellen Eye Chart as well as the newer technology known as Smart Chart with variable test distances varies from 3 meters to 6 meters. Moreover, the author has been presented with the procedure to conduct the eye test. According to the eye specialists, the near vision eye test does not bring significant relationship to the eye diseases of the elderly. Hence, only the distance visual acuity test is incorporated into the application since it is able to pick up eye pathology which causes eye diseases and visual reduction. The visual acuity eye test should run at a minimum test distance of 1 meter.

The symbols used for testing the eye vision are known as optotypes. There are many optotypes used in the visual acuity test. However, only Tumbling E is selected in the design of the visual acuity test as some senior citizens are illiterate and many are not familiar with the letters used in other standard vision charts. Furthermore, this optotype is highly recommended by the World Health Organization (WHO) as compared to other letters such as Landolt C rings. The Tumbling E is an optotype that is highly recognized as the standardized symbol for measuring visual acuity throughout the world. It is similar to the alphabet letter E used in the traditional Snellen chart. The limbs of the letter E can point at a number of positions (0°, 90°, 180°, and 270°). This is illustrated in Figure 4.

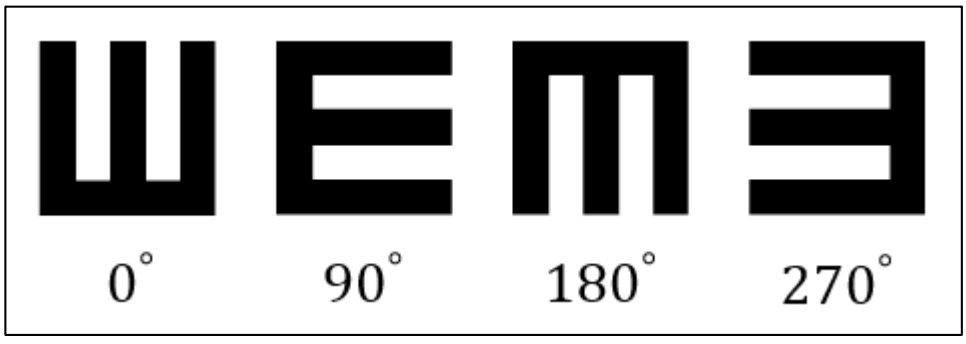

Figure 4: Orientation of the Letter E

The user is required to determine the direction of the limbs. The size of the letter E and its limbs are reduced according to the Snellen score. For a test distance of 1 meter, the sizes of the letter E are shown in Table 2.

Table 2: Letter Size for 1m Test Distance

Level	Snellen Score	Letter Size (Width and Height)
1	6/60	14.5444 mm
2	6/48	11.6355 mm
3	6/24	5.8178 mm
4	6/18	4.3633 mm
5	6/12	2.9089 mm
6	6/9	2.1817 mm
7	6/6	1.4544 mm

In order to maintain a fixed size of letter display across all types of android devices, the images of the letters are calculated in pixels based on the 4 categories set by Android, namely the Low Dot Per Inch (LDPI), Medium Dot Per Inch (MDPI), High Dot Per Inch (HDPI) and Extra High Dot Per Inch (XHDPI).

The Android system will automatically select the appropriate image file to be displayed on the screen based on the device's pixel density. Table 3 shows the corresponding image size in pixels for all the categories.

Table 3: Image Size for 1m Test Distance

Level	Snellen Score	160 PPI (LDPI)	240 PPI (MDPI)	320 PPI (HDPI)	480 PPI (XHDPI)
1	6/60	92px	137px	183px	275px
2	6/48	73px	110px	147px	220px
3	6/24	37px	55px	73px	110px
4	6/18	27px	41px	55px	82px
5	6/12	18px	27px	37px	55px
6	6/9	14px	21px	27px	41px
7	6/6	9px	14px	18px	27px

The letter size will decrease with the increase of the level. The visual acuity is measured based on how far the user can answer correctly from level to level. Users will be presented with various number of questions for each level to test the visual acuity of their eyes. The number of questions displayed per level changes based on the input from the user. The visual acuity scoring system is calculated based on the logarithm of minimum angle of resolution (LogMAR). The total cumulative score is 1 and the score assigned to each level is shown in Table 4.

Table 4: Visual Acuity Scoring System

Level	Snellen Score	Full Log Score	Half Log Score
1	6/60	0	0
2	6/48	0.097	0.048
3	6/24	0.301	0.151
4	6/18	0.125	0.062
5	6/12	0.176	0.088
6	6/9	0.125	0.062
7	6/6	0.176	0.088

Often, the physical visual acuity eye test conducted at the hospital do not start at 6/60 (Level 1) and some levels are skipped. Hence, this application has been pre-programed to form an intelligent guidance system in which the eye test will begin at Level 4 and progress up or down based on the input from the user. There is no fixed number of questions per level. However, the minimum number of questions per level are 2 questions (except Level 1) while the maximum number of questions per level are 8 questions. Similar to the eye test procedure conducted at the hospital, it is assumed that the user is able to recognize the larger words when he is able to identify the smaller words. Hence, as the level progresses downward, i.e. from Level 4 to Level 5, it is assumed that the user is able to answer correctly for all the letters from Level 1 to Level 3 and full score will be automatically awarded for these levels. The level 4 scoring system is indicated in Figure 5.

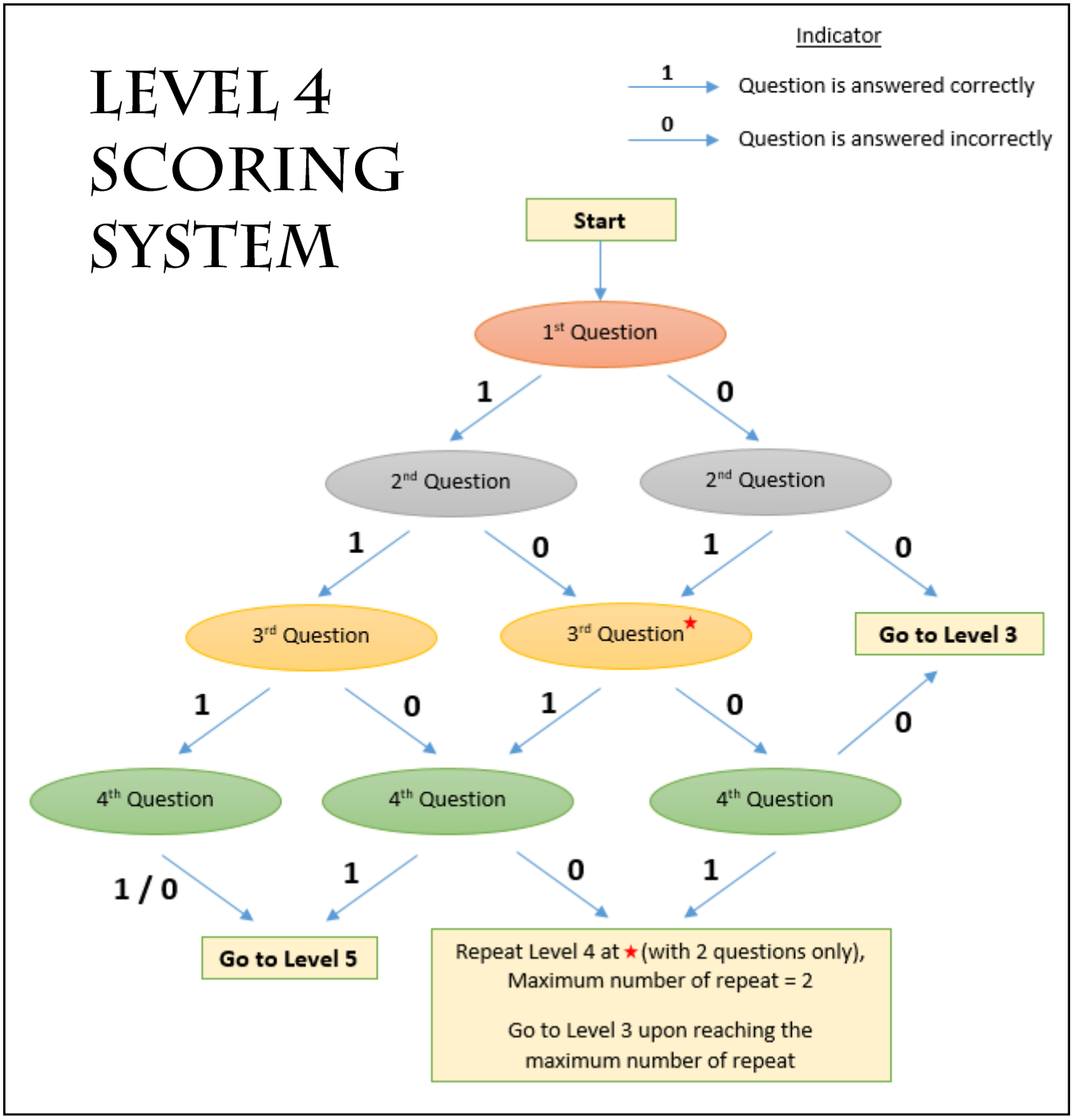

Figure 5: Level 4 Scoring System

The user will progress down to the Level 5 if the number of questions answered incorrectly does not exceed 1. When the user makes a specified rate of errors, he will progress up to Level 3 instead.

In some rare conditions, re-test of existing level is required to verify the results. This happens if the number of questions answered correctly are equivalent to the number of questions answered incorrectly in the existing level. Figure 6, Figure 7, Figure 8, Figure 9, Figure 10 and Figure 11 show the scoring system for the rest of the levels.

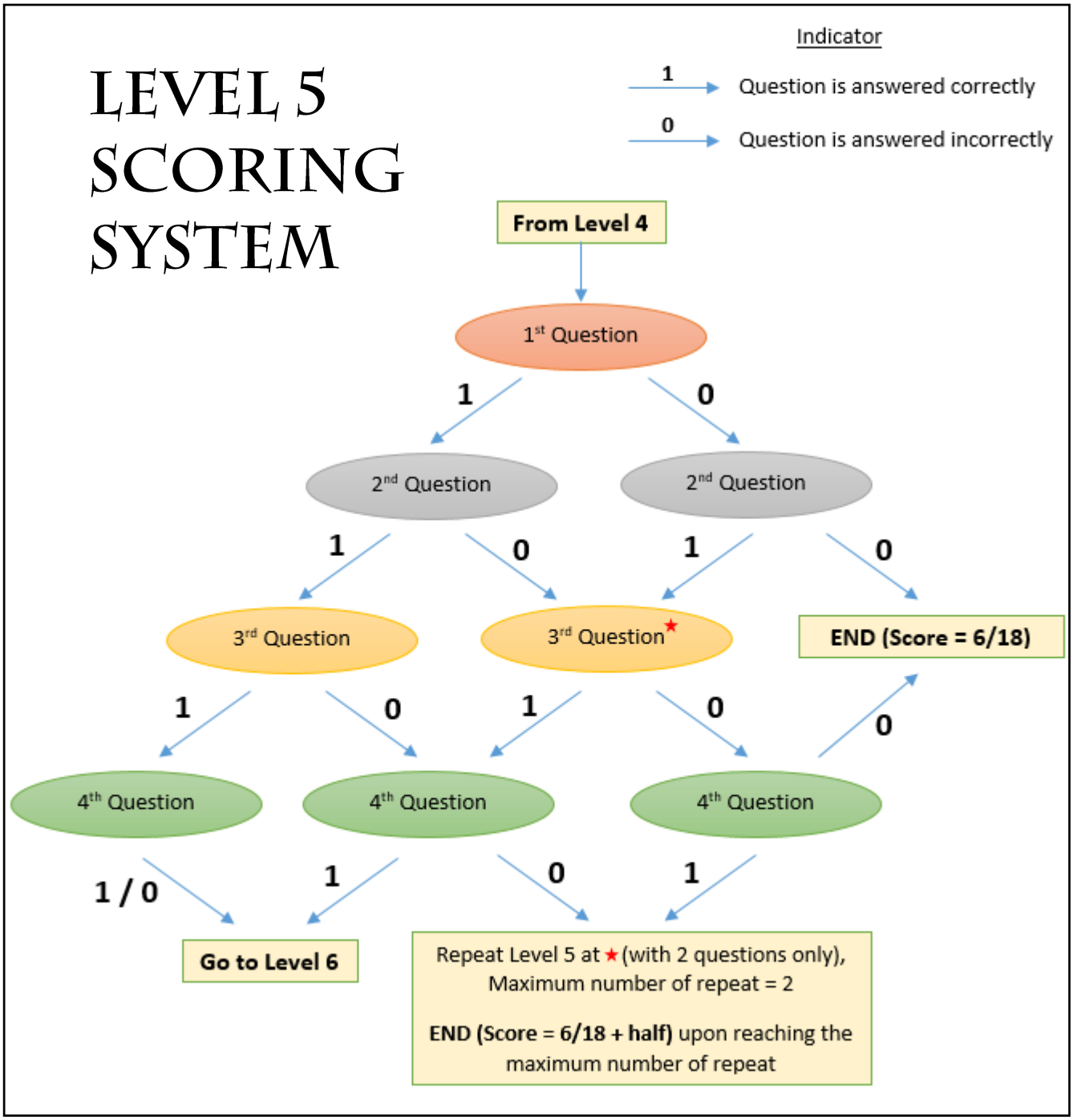

Figure 6: Level 5 Scoring System

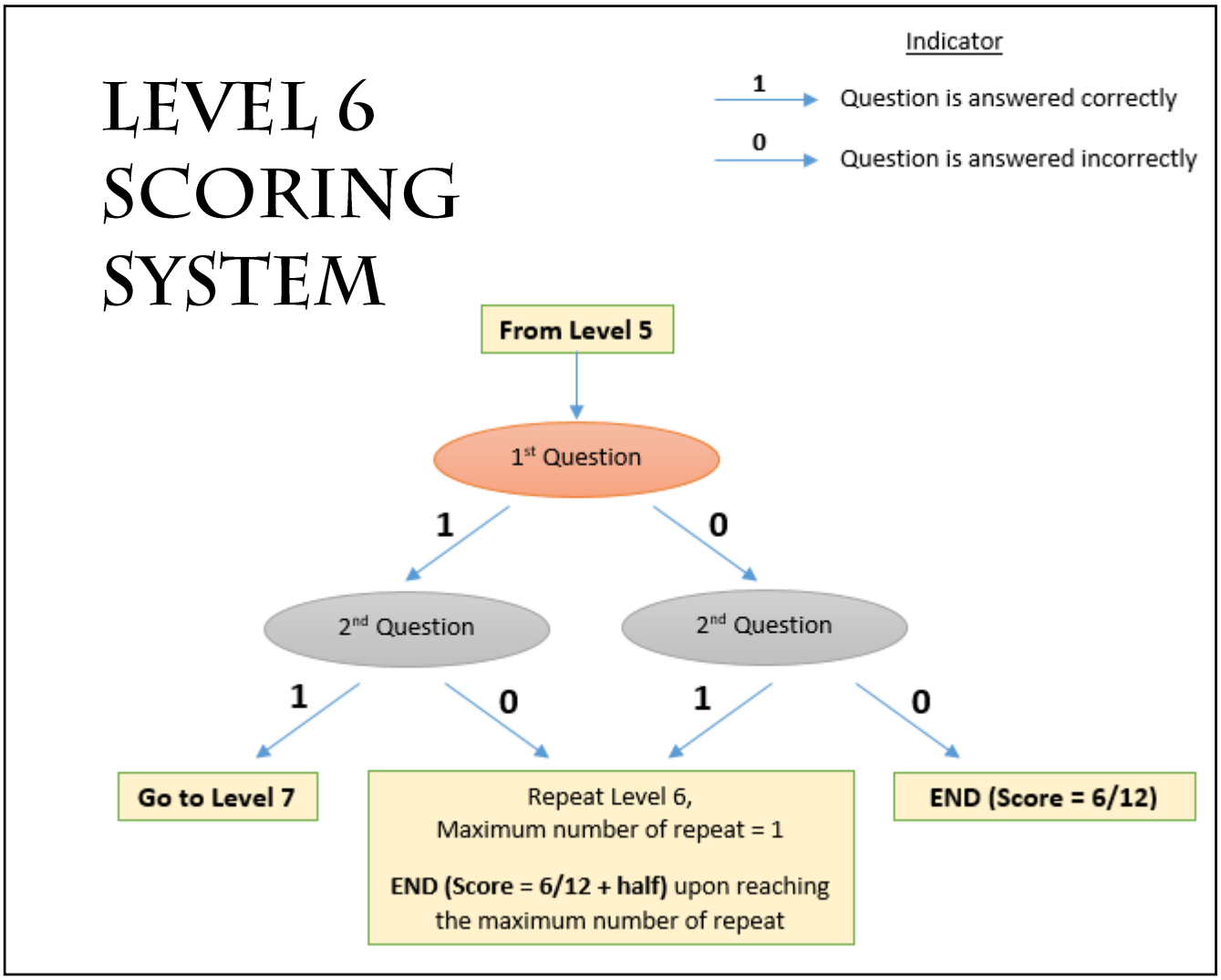

Figure 7: Level 6 Scoring System

For visual acuity eye test, the "pass" line is set by scoring at least 6/12 based on the recommendation from the eye specialists. Users who score 6/12 or better do not require to go for a full eye examination at the hospital. Hospital can concentrate on the core patients with major vision problem. Hence, Level 6 and Level 7 are designed with lesser number of questions since the users who manage to enter these levels had achieved an eye score of at least 6/12.

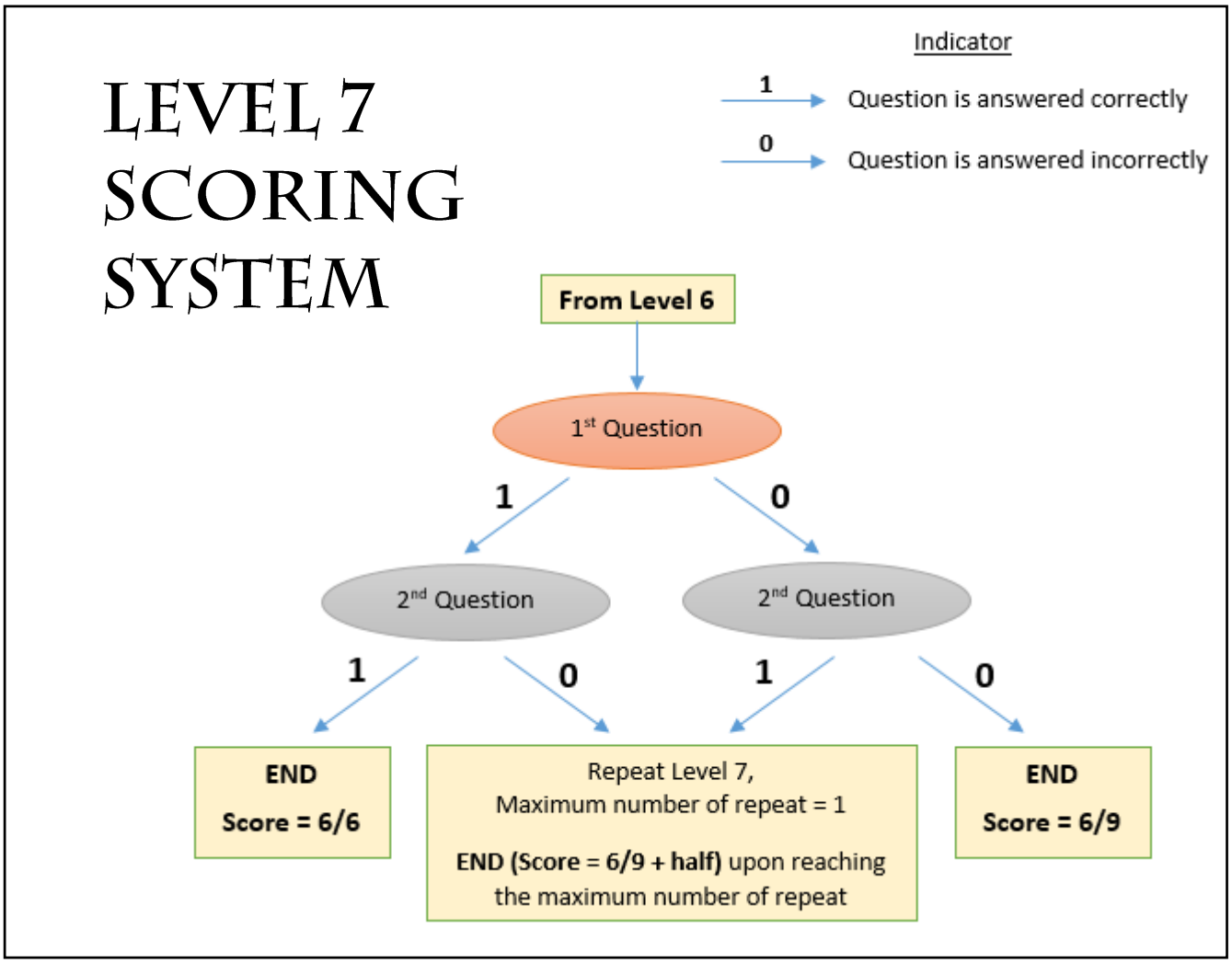

Figure 8: Level 7 Scoring System

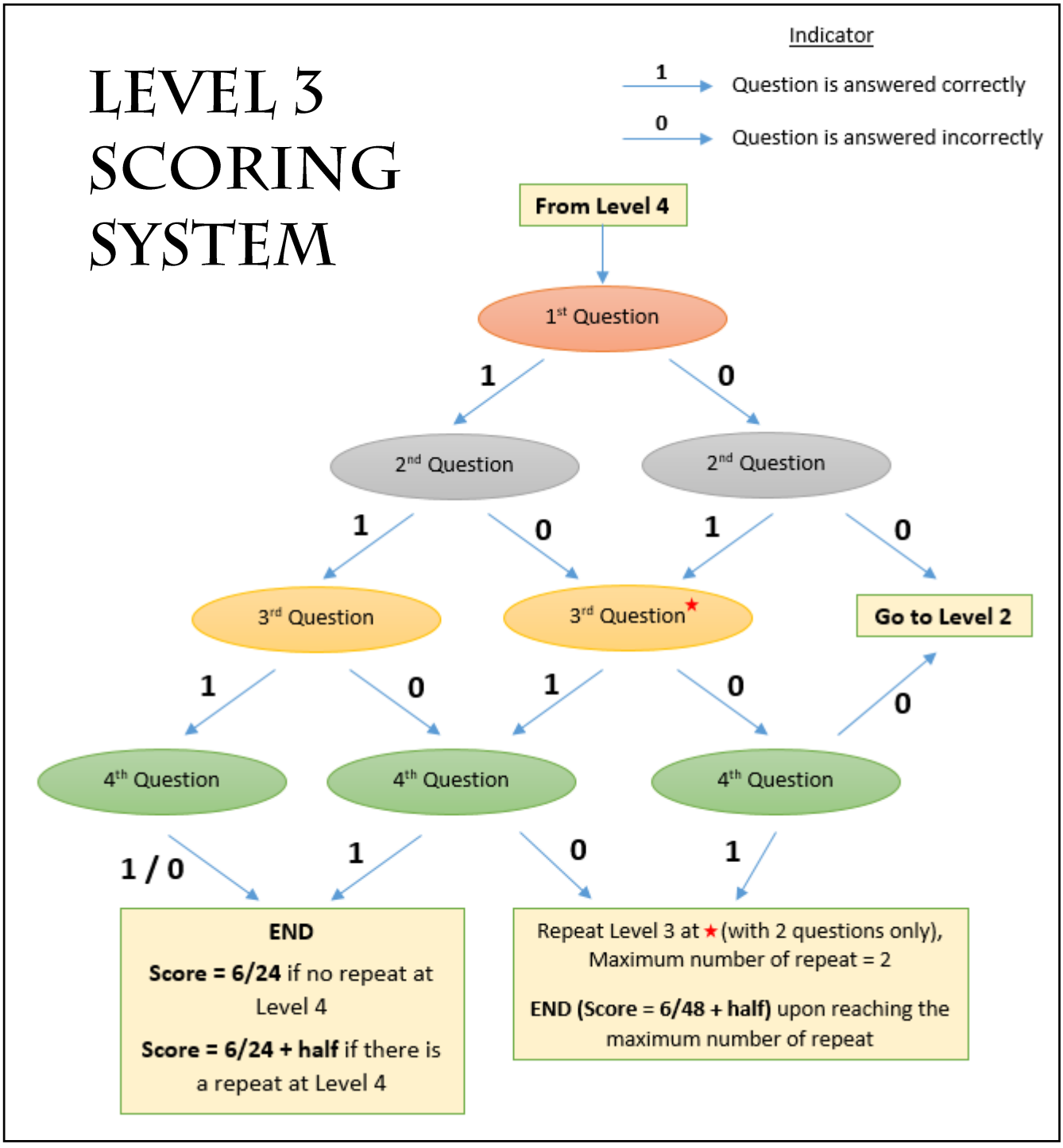

Figure 9: Level 3 Scoring System

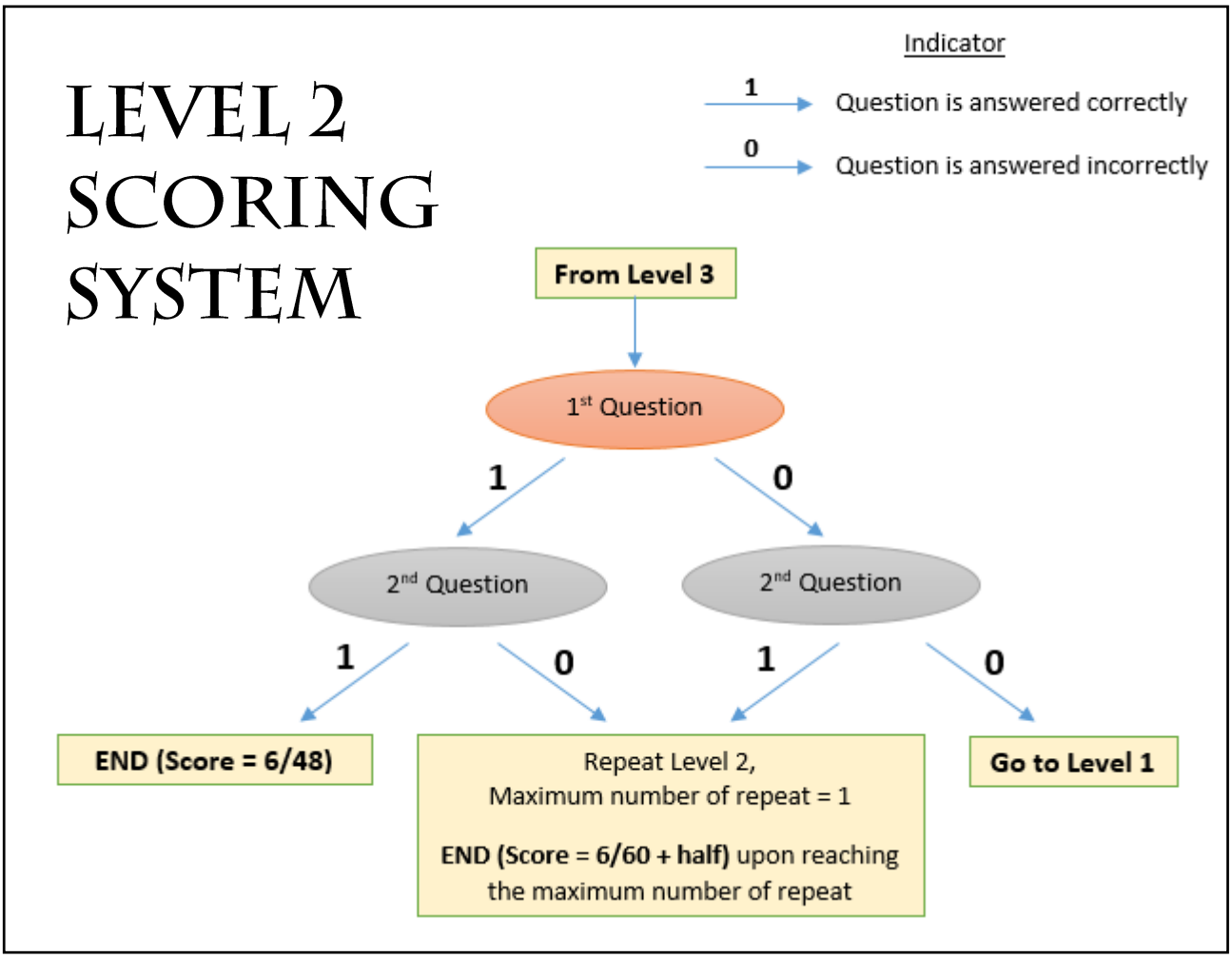

Figure 10: Level 2 Scoring System

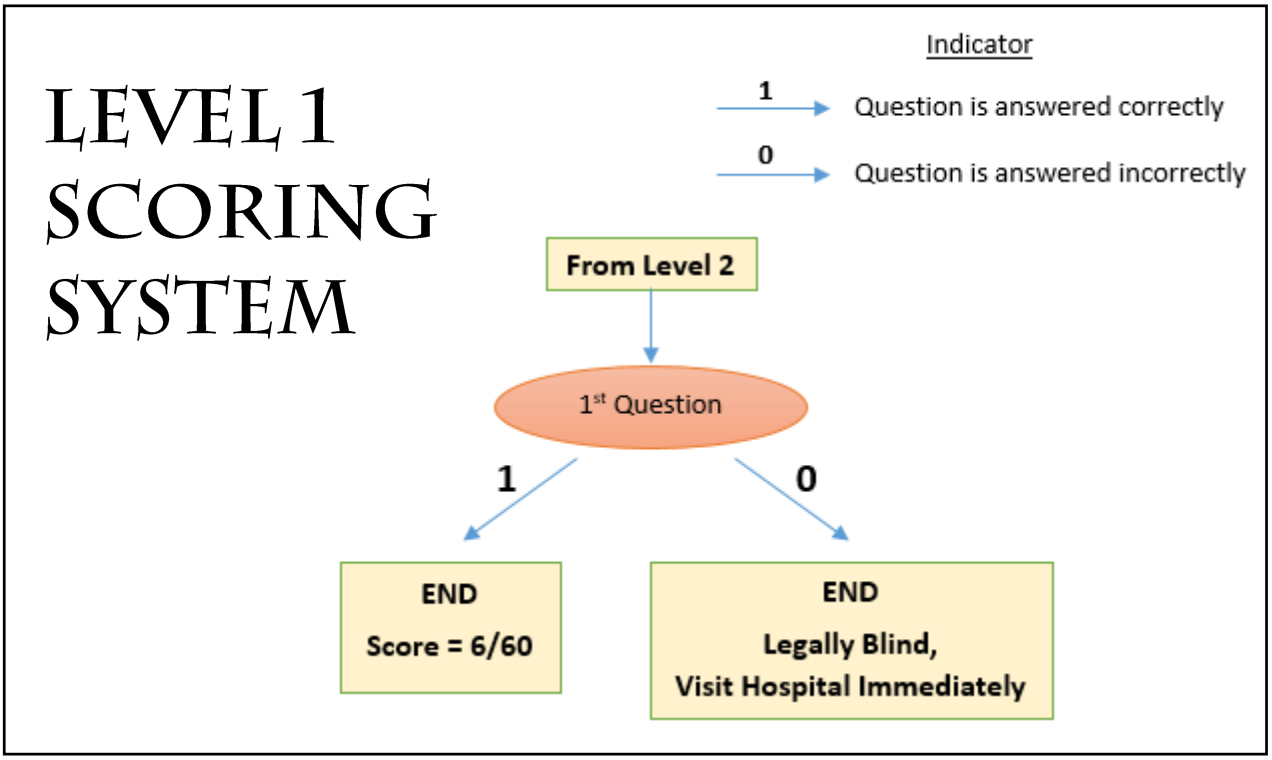

Figure 11: Level 1 Scoring System

Level 1 is the base level and all users are expected to have the ability to answer the question in level 1 correctly. Users who fail to give a correct answer for level 1 question is considered to be legally blind and it is highly recommended for the user to carry out a full eye examination at the hospital.

The total score for each level will be sum up and the percentage of the eye score can be calculated using the inverse of logarithm as shown below:

$$10^{[Total\ Score-1]} \times 100 = \%\ of\ eye\ score$$

Generally, users with 50% of eye score and above are able to continue with their daily routine with minimal impact. For less than 50% of eye score, users are recommended to see a doctor for a thorough eye examination.

3. **Develop the User Interface**

The Graphical User Interface (GUI) of the application is developed using Android Software Development Kit (SDK) through the use of Java programming language as well as the Extensible Markup Language (XML). Icons and other image files used in the application are designed using Adobe Photoshop. Since many old folks require large text with high contrast sensitivity due to declining vision, the overall user interface are designed with large text and the buttons are enlarged to ensure they can easily press on it. The application is designed to enhance its overall usability so that user with low vision can easily operate the application without difficulties. The background colour of the user interface is carefully selected in order to form high contrast sensitivity with the content to ease the user while reading the text display on the screen. The touch of the buttons will trigger the onClick, onTouch as well as the onFocus event. These events will then trigger the change of a button's colour which clearly indicates that the user has pressed on the button.

On top of that, the application also comes with multi-lingual options to assist the user with low literacy. This is designed to allow the user to operate the application using their preferred language. The user interface is simplified to ensure the user can follow the flow of the eye test without having complex navigation buttons or harder-to-read pages.

4. **Testing and Simulation**

The constructed application had run through several simulation on the Android SDK. Bugs discovered are fixed and the application has been installed and tested on Android powered smartphone and tablet.

5. **Experimentation and Data Collection**

   The constructed application has run through several experiments with 15 university students to test the overall accuracy, functionality and its user friendliness. The accuracy of the application is measured based on its specificity and sensitivity. The specificity measures the proportion who are properly classified as having a pair of healthy eyes while the sensitivity measures the proportion who are correctly classified as having vision deficiencies, which is sometimes referred to as true positive rate. Results obtained are recorded and compared with the eye test result conducted using an original eye chart. On top of that, the application will also be tested through the Corporate Social Responsibility (CSR) activities at the remote areas of Perak state. Senior citizens will participate in testing the application. Feedbacks and data collected will be analysed for further improvement on the application.

6. **Release the application**

   Outstanding problems found from the experiments are fixed and the final version will be released to the public via Google Play store.

3.2 Gantt Chart and Project Milestones

Table 5 shows the Gantt chart of the project as well as the overall project milestones.

Table 5: Gantt chart and Project Milestones

Detail / Week	FYP I (January 2014)														FYP II (May 2014)												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Selection of project topic	■	■																										
Literature Review		■	■	■	■	■	■																					
Preparation for proposal defence							■	■	■																			
Learn the Java programming language										■	■	■	■	■	■													
Develop GUI using Android SDK										■	■	■	■	■	■	■												
User Interface Test Evaluation															■	■												
Alpha Version Release																	◆											
Consultation with Eye Specialist														■			■			■								
Fix Outstanding Problems from Alpha																	■	■	■									
Beta Version Release																				◆								
Experimentation and Data Collection																				■	■	■	■	■	■	■		
Fix Outstanding Problems from Beta																										■	■	
Quality Assurance Testing																											■	
Final Version Release																												◆

◆ Milestones

CHAPTER 4:

RESULTS AND DISCUSSION

4.1 The Eye Test Application

The application is built to run on multiple Android platforms. It is compatible with Android 2.3 Gingerbread up to the latest version of Android 4.4 KitKat. Figure 12 shows the application running in the Google Nexus 10 powered by Android 4.4 KitKat.

Figure 12: Main User Interface of the Application

The application also comes with multi-lingual options as shown in Figure 13. This is designed to allow the user to operate the application using their preferred language. The language option page will pop up automatically during the first-run of the application. The preferred language will be saved and the application will automatically run in the preferred language at the next start-up. Language option can always be changed via the main user interface.

Figure 13: Multi-Lingual Options for the User

Simple instructions are provided to the user before they begin with the eye test. This is illustrated in Figure 14. Since this is a distance visual acuity eye test with a test distance of 1 meter, a minimum of two persons are required to carry out the eye test. Instructions are provided to both the user as well as the operator.

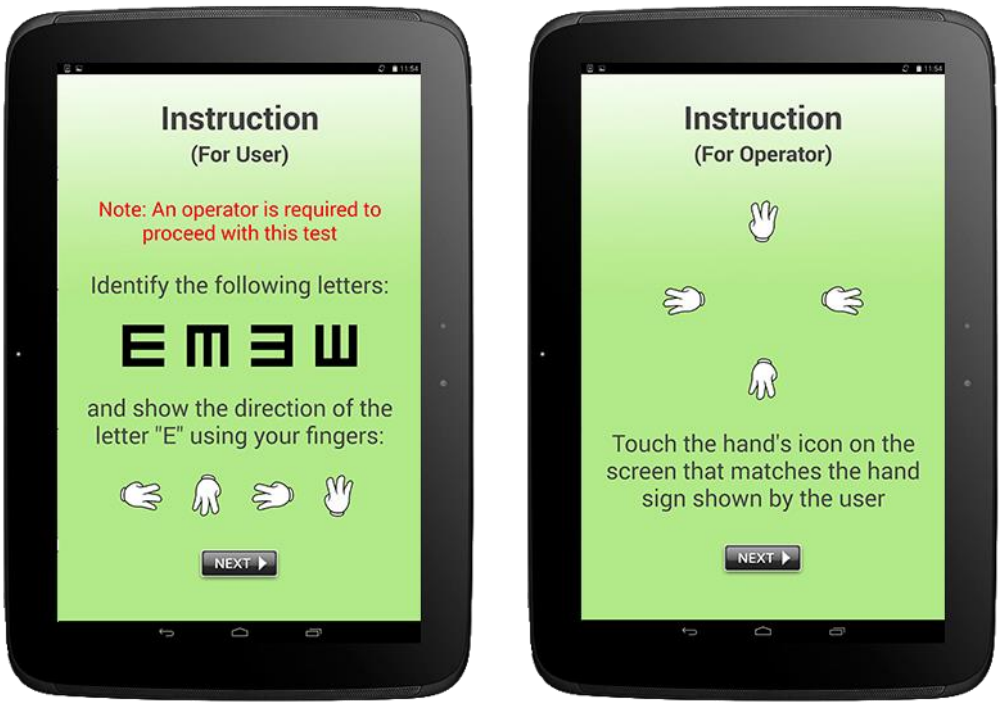

Figure 14: Simple Instructions to the User

Two eyes are tested differently with different sets of test questions. The user will be requested to close their right or left eye before running the eye test. This is illustrated in Figure 15.

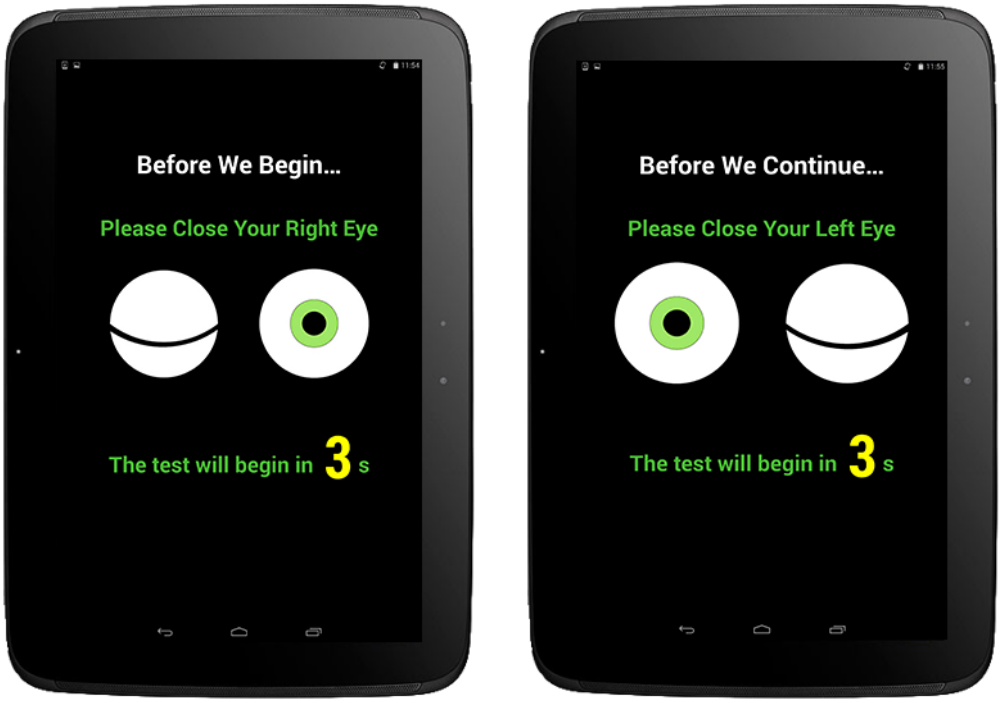

Figure 15: Instruction to Close the Eyes

An example of a test question is shown in Figure 16. The limbs of the letter E can point at four different positions, i.e. Up, Down, Right or Left. The size of the letter E will increase or decrease depends on the input received from the user. The test questions are randomly generated through the use of random function in the Java. With a random type of test questions, the users can repeatedly run through the eye test. Random test questions often results in a more accurate grading since the result is not affected by the effect of memory.

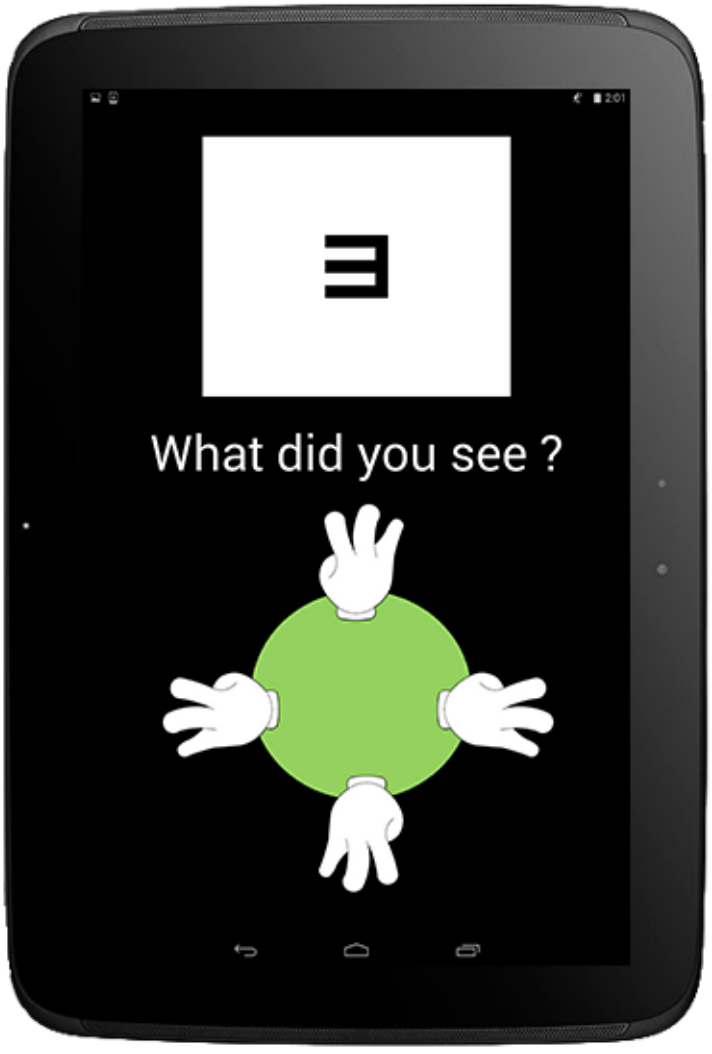

Figure 16: Sample of Test Question

The vision screening result will be displayed to the user as soon as the user completed the eye test for both eyes. The user will be presented with a recommendation on whether he or she should proceed for a full eye examination at the hospital. This is illustrated in Figure 17. Also, the user has an extra option to view the details of the eye score by clicking the “More Info” button.

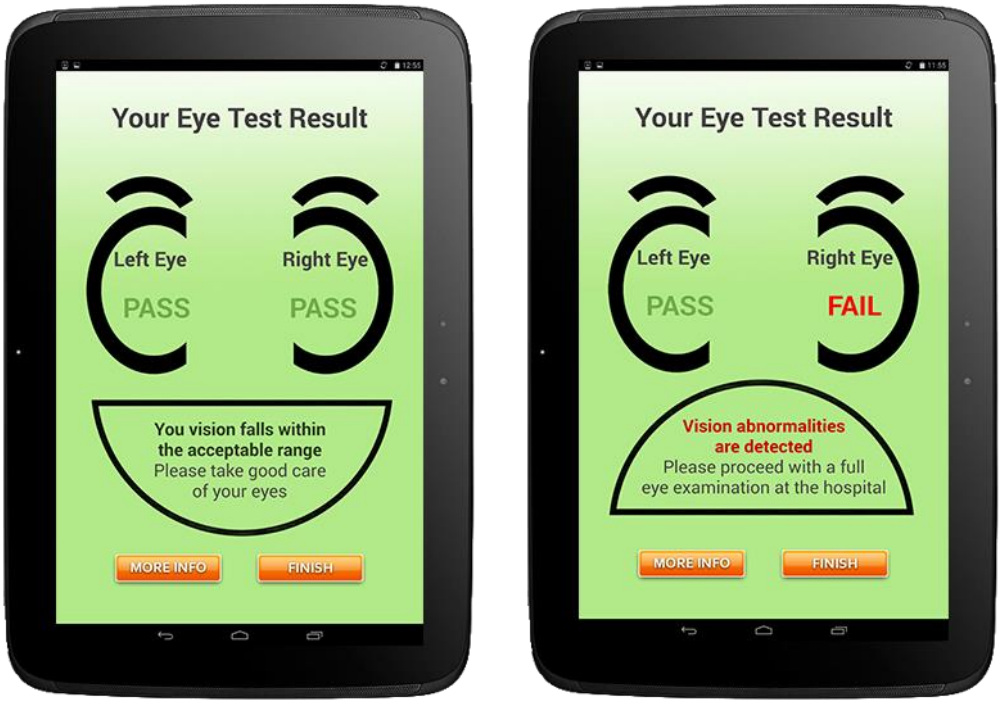

Figure 17: Result and Recommendation of the Eye Test

Figure 18 shows the details of the eye score. With this information, the user can decide whether or not to get a full eye check-up at the hospital.

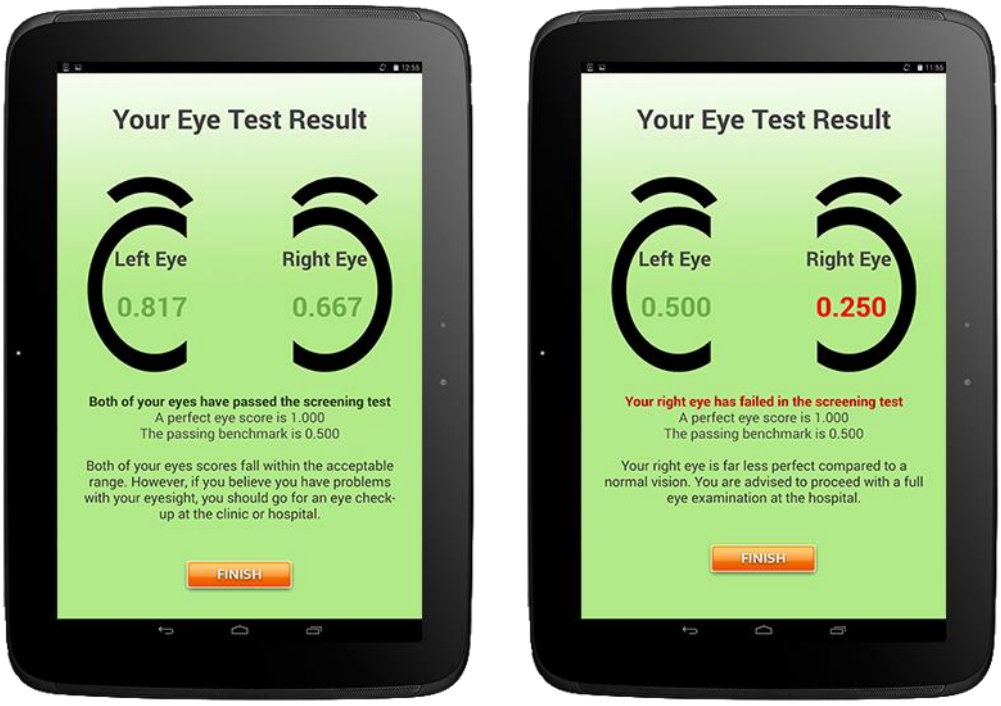

Figure 18: Explanation of the Eye Score

4.2 Experimental Results

Experiments have been conducted on 15 university students. Those with vision problems are taken as samples to measure the sensitivity of the application. The results obtained show that the application has constantly achieved more than 80% of accuracy in terms of specificity and sensitivity.

The score displayed in Table 6 represents the cumulative log score, which is converted from the decimal score obtained from the Original Eye Chart as well as the Android application.

Table 6: Experimental Results

Student	Eye Score (Original Eye Chart)		Eye Score (By the Application)		Percentage of Difference		Accuracy
	Left Eye	Right Eye	Left Eye	Right Eye	Left Eye	Right Eye	
1	1.0000	1.00000	1.00000	1.00000	0%	0%	100% Specificity
2	0.0000	0.52288	0.09691	0.52288	9.7%	0%	90.3% Sensitivity
3	0.09691	0.00000	0.09691	0.00000	0%	0%	100% Sensitivity
4	1.0000	1.00000	1.00000	0.91200	0%	9.6%	90.4% Specificity
5	Legally Blind	0.52288	Legally Blind	0.61088	0%	16.8%	83.2% Sensitivity
6	1.00000	0.91200	1.00000	1.00000	0%	9.6%	90.4% Specificity
7	0.52288	0.39794	0.52288	0.39794	0%	0%	100% Sensitivity

Student	Eye Score (Original Eye Chart)		Eye Score (By the Application)		Percentage of Difference		Accuracy
	Left Eye	Right Eye	Left Eye	Right Eye	Left Eye	Right Eye	
8	0.82391	1.00000	0.91200	1.00000	10.7%	0%	89.3% Specificity
9	0.09691	0.52288	0.09691	0.52288	0%	0%	100% Sensitivity
10	Legally Blind	Legally Blind	Legally Blind	Legally Blind	0%	0%	100% Sensitivity
11	0.61088	0.52288	0.61088	0.61088	0%	16.8%	83.2% Sensitivity
12	0.82391	1.00000	0.82391	0.91200	0%	9.6%	90.4% Specificity
13	0.82391	0.69897	0.91200	0.76097	10.7%	8.9%	89.3% Specificity
14	Legally Blind	0.09691	Legally Blind	0.00000	0%	9.7%	90.3% Sensitivity
15	1.00000	0.91200	0.91200	0.91200	9.6%	0%	90.4% Specificity

CHAPTER 5:

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

As a whole, this project had completed successfully in twenty-eight weeks. A portable eye test tool is realized by using Android SDK. Overall, the developed application has successfully achieved the following objectives:

- ✓ The designed application offers a multi-lingual interface, namely the Bahasa Malaysia, Mandarin as well as the English language.
- ✓ The designed application is portable. In other words, it is able to run on all types of android devices regardless of the different sizes of the screen or screen resolution.
- ✓ The designed application is able to detect any abnormal types of input by the user and a re-test will be made when necessary.
- ✓ The application has constantly achieve high accuracy (> 80% as recommended by the doctor) as compared to the test conducted with the original eye chart.

This application is built based on the advices received from the eye specialists from Selayang Hospital. It is portable and simple for the user to run without any prior experiences. By having this application, it is hope that the senior citizens can regularly run through the vision screening at least once every two months for an early detection of visual reduction which may be linked to an early symptom of age related eye diseases such as cataract, glaucoma or macular degeneration. Maintaining the vision quality at an acceptable level at all the times is important for the senior citizens to carry on with their normal life.

5.2 Suggested Future Work for Expansion and Continuation

The application can be improved further with additional features described below:

- Implement additional types of eye test such as Contrast Sensitivity Eye Test as well as Amsler's Grid Eye Test.
- Hand sign auto-recognition system may be implemented as an additional feature. With this feature, an operator is no longer needed to perform the eye test. The input (hand sign) from the user will be captured directly via the camera.
- Audio & video clips may be added to the application to make it more interactive.
- A database may be created to store all the eye test results so one may view their past test results and compare with the latest test result.
- Different profiles may be created with different types of recommendations according to age of the user.

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APPENDIX I – Experimentation on Real Eye Chart

APPENDIX II – Experimentation on Eye Test Application