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AUGMENTED REALITY MOBILE APPLICATION FOR HUMAN BLOOD CIRCULATORY SYSTEM

TEY CHWEE TENG

THESIS SUBMITTED IN FULFILMENT OF THE DEGREE IN COMPUTER SCIENCE (GRAPHICS AND MULTIMEDIA TECHNOLOGY) WITH HONOURS

FACULTY OF COMPUTER SYSTEM & SOFTWARE ENGINEERING,

UNIVERSITI MALAYSIA PAHANG

DECEMBER 2014

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"I hereby declare that I have read this thesis and in my opinion, this thesis is sufficient in terms of scope and quality for the award of the degree of Bachelor of Computer Science (Graphics and Multimedia Technologies) with Honours"

Signature : .....

Supervisor's Name : DR TUTY ASMAWATY BINTI ABDUL KADIR

Date : 5/1/2015

DEDICATION

Special dedication to my supervisor, Dr.Tuty Asmawaty Binti Abdul Kadir for being my mentor, my beloved family members that always love me and support me, lecturers and all my fellow friends for being caring and supportive.

Sincerely,
Tey Chwee Teng

ACKNOWLEDGEMENT

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Last but not least, I would like to thank everyone that helped me directly and indirectly, especially to my friends as well as my roommates, Liaw Hui Kim and Loke Jee Jia that always support me when I am facing difficulty in doing the research. Thank you very much.

ABSTRACT

Learning the topic of human blood circulatory system in form three science syllabus using conventional way was inadequate for the students to imagine and understand the whole circulatory process in a short time. Students get bored when they were learning in traditional method by reading the text and see the picture on a book. Therefore, an Augmented Reality Mobile Application for Human Blood Circulatory System was developed to enhance the learning experience for students or anyone who wish to learn more about the human blood circulatory system with more interesting. This AR mobile application was developed by using ARToolKit applying the marker-based tracking technique with template marker. There were three main topics of the learning materials which are the heart, blood vessels and blood. Basically, this AR application is used along with the AR book where the students can aim camera of their smartphone or tab at the marker to see and interact with the related 3D models object. This AR mobile application also provides some teaching modules such as the educational videos, anatomies and the quizzes besides applying the Augmented Reality technology. Based on the survey results from the users, it is found that this AR application had an ability to increase the student understanding about the topic of the human blood circulatory system in an interesting and effective way.

ABSTRAK

Pembelajaran secara tradisional bagi topik sistem peredaran darah manusia di dalam silibus tingkatan tiga kurang memberi ruang kepada para pelajar untuk membayangkan dan memahami proses peredaran darah secara keseluruhan dalam masa yang singkat. Pembelajaran menggunakan kaedah membaca teks dan melihat gambar di dalam buku ini juga mengakibatkan pelajar cepat berasa bosan. Oleh yang demikian, satu Aplikasi Mobile berasaskan Augmented Reality (AR) bagi Sistem Peredaran Darah Manusia telah dibangunkan untuk meningkatkan kaedah pembelajaran pelajar atau sesiapa sahaja yang ingin belajar dengan lebih lanjut tentang sistem peredaran darah manusia dengan lebih menarik. Aplikasi mobile AR ini telah dibangunkan menggunakan ARToolKit dengan bantuan teknik pengesanan berasaskan template penanda. Terdapat tiga topik utama di dalam aplikasi ini, iaitu jantung, saluran darah dan darah. Pada asasnya, aplikasi AR ini perlu digunakan bersama-sama dengan buku AR di mana pelajar boleh mensasarkan kamera telefon pintar atau tab mereka di penanda untuk melihat dan berinteraksi dengan model objek 3D yang berkaitan. Selain modul AR, aplikasi mobile ini juga mengandungi beberapa modul pengajaran lain seperti video pendidikan, anatomi dan kuiz. Berdasarkan hasil daripada kajian soal selidik yang telah dilaksanakan ke atas pengguna, didapati bahawa aplikasi AR ini mempunyai keupayaan untuk meningkatkan pemahaman pelajar mengenai topik sistem peredaran darah manusia dengan cara yang lebih menarik dan berkesan.

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LIST OF ABBREVIATIONS

TERM	MEANING
AR	Augmented Reality
HBCS	Human Blood Circulatory System
3D	Three-Dimensional
2D	Two-Dimensional
SDK	Software Development Kit
OS	Operating System
ADT	Android Developer Tools
IDE	Integrated Development Environment
UI	User Interface

CHAPTER 1

INTRODUCTION

1.1 Introduction

Augmented Reality (AR) is a combination of the real scene viewed by the user and a virtual scene generated by the computer. In short, AR combines real and virtual, interactive in real time and registered in 3D. It is a technology that superimposes a computer-generated sensory input such as audio, video, graphics or GPS data on a user's view of the real-world environment. It is about enhancing the actual world by using digitized content. This can be explained by running a mobile application, we can use a mobile phone's camera to identify and interpret a marker where the marker is usually in black and white barcode image. The software will then analyze the marker and create a virtual image overlay on the mobile phone's screen. Camera is required on mobile phone in order to use the AR applications.

With the use of AR technology, there are many AR applications have been created so that many areas can benefit from it such as gaming, commerce, navigation, etc. Figure 1.1 shows the AR applications of IKEA furniture. The AR application in education is one of the most potential and useful app, it has become popular for education while it transforms learning from the formal to the informal. It moves mobile technology from use for social and recreation activities to just in time learning and education (Horizon Report, 2011). It can be used by researchers and teachers in promoting more interactive learning environments. Nowadays, AR books have begun to appear in the marketplace as shown in Figure 1.2. It has been used around for sometimes now by educators as a teaching or learning tool. Normally, the appearance of those AR books are just like any other book;

however, when they are placed in front of computer's webcam or mobile phone's camera, it will shows some 3D elements, sounds, videos and some even include interactive elements.

Educators found that it is an another good way for teaching some complex subject with this AR tool, especially in subject science, and this would allow the students to receive the idea or information in an effective way. From the point of view of the educators, they know that learning deepens is not just through reading and listening, but also through creating and interacting. When AR technology is applying in learning environment, students will be able to interact with the virtual image or 3D models displayed on a book or mobile phone's screen through their Android or iOS devices, rather than just reading about them in a textbook.

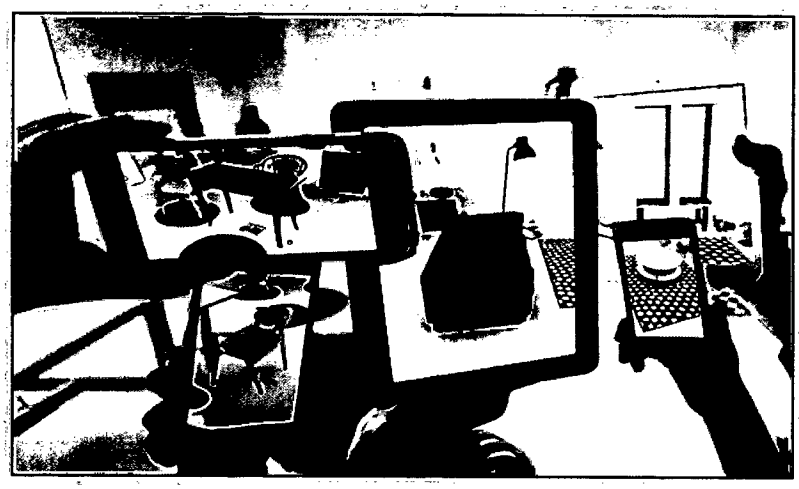


Figure 1.1 AR app of IKEA furniture

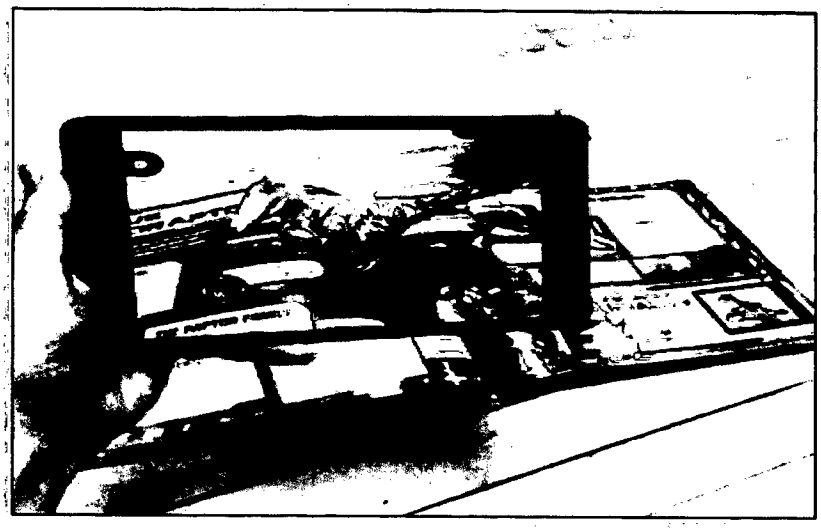


Figure 1.2 AR app of iDinosaur book

1.2 Problem Statement

Currently, there are various teaching methods in teaching human blood circulatory system. For example, the textbooks, pictures, references book and slide presentation are some of those teaching methods. However, all of these methods are inadequate for the students to imagine and understand the whole circulatory process in a short time. The students will face the difficulty to imagine the process of the system if they just reading the text and see the picture. They will take long time to memorize the process. The students found that reading in traditional method is boring and dull. As we all know, reading words can create a visual picture in our mind but when that virtual image comes to life, the impact is so much greater.

Therefore, the solution is by educating the students using the AR application (AR book) (Lauren Drell, 2012). By using this application, it will be easier for the students to understand the circulatory system and thus learning process will be fostered through the more interesting and interactive application. The value of a standard textbook will be enhanced by adding visualization in it as an educational material. It is an idea that playing

a role as an interactive tool which attract student attention or interest and at the same time learning in a fun way. This is because audio-visual content is more attractive than standard textbooks. In addition, it also has the potential for a low cost compare to other hardware such as human model.

Uninteresting or non-interactive lecture session can be transform into an interesting period when lesson delivered in the form of an AR book for secondary school science education. This could help the students to explore and experience science studies in a different view and improve teaching and learning environment. It is good for students when they are able to see the thing from different angle compared to just read it on a book. For example, the anatomy of human blood circulatory system. It is amazing where the students can interact with the 3D content or the anatomy of circulatory system by touching and see it changing. This can enhance their learning senses and takes education to an entirely new level when they are no longer be an observer.

Nowadays, there are many of the AR applications in education have been released. Google Sky Map is one of the AR applications that is special designed for those who like to study about astronomy. It makes the learning about astronomy in an interesting and fun way. By using this application, users are able to identify stars and constellations directly through their camera on smartphone. There is also an AR application namely 'FETCH! Lunch rush' which is released by PBS KIDS. It is an AR application of teaching math skills to elementary students through the use visualization of AR technology. Besides that, the GeoGoggle is another very useful tool for those people in learning the fundamentals of geography. It is designed for acquiring or assisting users in geography skills and judging distances to specific destinations.

1.3 Goal & Objectives

The goal of this research is:

- To develop an AR mobile application for Human Blood Circulatory System using AR technology.

The objectives of this research are:

i. To investigate the suitable techniques used in the development of the AR application.
ii. To develop an AR mobile application for Human Blood Circulatory System using marker tracking technique for 3D content display.
iii. To test the effectiveness of the AR mobile application in learning process.

1.4 Scopes

The following are the scopes of this research:

i. Data
   - According to the form three science syllabus which is focus on the subtopic of human blood circulatory system.

ii. User
   - The secondary school students and teachers or anyone who wish to learn more about human blood circulatory system.

iii. Module
   - In developing this application, the module involving the Splash Screen and Main Interface Module, Marker Module, 3D Model Module, About Module, Instruction Module, Component Descriptions Module, Video Module and the Quiz Module.

iv. Platform

- The application is developed in Android based system using ARToolKit/ Eclipse where the users would be able to view the 3D models on their mobile phone's screen from the markers.

1.5 Thesis Organization

This thesis consists of SEVEN chapters which are Chapter One: Introduction; Chapter Two: Literature Review; Chapter Three: Methodology; Chapter Four: Design; Chapter Five: Implementation; Chapter Six: Result & Discussion; Chapter Seven: Conclusion. Chapter One is mainly discuss about the AR overview. It is a brief explanation about the use of AR book and how the AR works. Chapter Two reviews the previous research and describes about the existing problem or solution done by other parties. All the relevant technical paper, journals, and books taken from those researches will be discussed in detail. This chapter is also study about the existing applications that available in market. The overall framework on the development of AR application will be discussed in Chapter Three. Meanwhile, Chapter Four is mainly about designing the application and interface. Besides, Chapter Five is a discussion on the details of the implementation of the study. Moreover, Chapter Six discuss about the application development and result that produced from the project. Lastly, Chapter Seven concludes the entire thesis.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter is discussing about the form three science syllabus, teaching methods, advantages of AR application and some case studies on existing AR applications in different areas.

2.2 Science Syllabus

The science curriculum for secondary school is organized around themes. There are nine themes of the curriculum content - A. Introducing Science, B. Man and the Variety of Living Things, C. Matter in Nature, D. Maintenance and Continuity of Life, E. Force and Motion, F. Energy in Life, G. Balance and Management of the Environment, H. Technological and Industrial Development in Society, and I. Astronomy and the Exploration of Outer Space. There are various learning areas and follow some learning objectives of each theme. A learning objective has one or more learning outcomes. Cognitive and affective are the two domains that considered of the learning outcomes. Levels for these two domains are different. For cognitive domain are: understanding, knowledge, application, synthesis, analysis and evaluation. While for affective domain are: to be in awe, to be appreciative, to be aware of, to practise, to be thankful, to love, and to internalize. Learning outcomes can be achieved implicitly through the learning activities. Therefore, teachers have the responsibility in forming the activities in class.

Teachers play an important role in delivering the knowledge or information to their students. They used many different types of innovative and effective learning activities to enhance the learning of science during their teaching process. Currently, the learning activities or methods used in school are lectures, experiments, discussion, visits and so on. Student's critical and creative thinking skills will be activated through these learning methods. The learning of science is not limited to activities carried out in the school compound. Some external resources are also involved in the learning process. For example, zoos, animal sanctuaries, museums, science centres, research institutes, mangrove swamps, and factories. The learning of science is become more interesting, meaningful and effective by visiting these places.

2.3 Teaching Methods

There are several teaching methods for science education in secondary school:

i. Lecture

Lecture is the most general method used as a teaching method by the teachers in many different subjects. The teacher will stand in front of a class as the central focus of information transfer. They will present the science information through the slide show prepared before the class by using an overhead projector. Sometimes the teacher will play some educational science videos when giving his or her presentation in lecture. Besides that, they will also write some explanations or draw some scientific diagrams on a whiteboard in order to ensure that the information reach to the students. Usually, there is very little exchange occurs between the teacher and the students during a lecture. This is because the students are busying taking notes while listening to the lecture (Melissa Kelly, 2009).

ii. Laboratory

The laboratory activities are the most often used by the school teachers in teaching science. This is because experiments are a necessary part of the scientific process. It forms an integral part of effective science teaching. Generally, this method uses experimentation with materials and apparatus to discover or verify the scientific facts. By using this method, students will derive various scientific laws and principles on their own when they get involved in the experiment work.

Besides that, students will be able to deal with first-hand experiences about the facts obtained from the experimentation and investigation. A well-equipped laboratory is necessary for this. The students can carry out their experiments self-independently with the materials or facilities and proper instructions given by the teachers. Students need to make an observation and record the observation properly or draw a conclusion based on the experiments that they carrying on. This method is used to maximum possible extent by the teachers for science teaching (Himanshu Mallick, 2010).

iii. Discussion

This method is used in two ways by the teachers. For the first way, a brief introduction of the topic is given by the teachers to the students for discussion purpose. After that, those students will need to form a group study or make detailed study regarding the topic within a limited or specified time. Normally, the discussion can be conducted either individually or in group form by the students. The study group can be done in classroom or any other place as long as they can get the necessary source easily. Through this way, the students can ask for help and assistance from their teacher if they are facing any problem. Some question might be asked by the teacher to test the student's understanding about the discussing topic. Then, a discussion between teacher and students will begin.

Beside the Q&A session, the teacher will also ask the students to write down the important points of the studies on the whiteboard. While for the second way, the teacher will also give a brief introduction about the topic including some new concepts or terms, then the students are divided into different categories by the teacher. Each group will get a topic which is different from other group and sometimes a group leader will be assigned by the teacher. Every group need to gather the information of the related topic as much as possible. After that, each of the group is required to explain about the assigned topic on the presentation day. Some questions will be asked by the teacher based on the observations and information that students have been collected through various sources. This is to ensure that all the groups have a well understanding about the allotted topic through their explanation or giving their views on the topic with sound proofs and evidences (Himanshu Mallick, 2010).

iv. Outdoor learning activities

This is the one of the methods that science teacher will consider in order to enhance their teaching and learning in science. It is a form of learning that encouraging teachers to get outside with their students and give an opportunity for the students to learn outside the classroom by developing an understanding through experiencing the real world. It can be a more effective and simulating place to learn than indoors. It is necessary to match the activities selected with the objectives of the science topic when planning learning outside the classroom. Of course the safety of the students must be considered by the teacher before planning and choosing the place to be visit. Typically, the teacher will make a discussion with their students in choosing a suitable place to be visit which is regarding to the topic that they currently discussed in lecture.

Normally, for science outdoor learning activities, the places suggested to be visit are museums, science centres, zoos, research institutes, factories and etc. For example, the local power station provides the opportunity to investigate energy and heat. The teacher will directed their students to make some observations while visiting the places. In order to do so, the students will record some information or interpretation about the study of topic.

After the outdoor learning activities, the students are required to write a report to give further explanation and interpretation together regarding to the topic of the learning activities. Through this method, it builds student's confidence about the knowledge of science and having a good relationship than before with teachers (Kim Thomas, 2012).

2.4 Advantages of Augmented Reality Applications

The following are the advantages of Augmented Reality Application:

i. Unique / different (for the moment)
   - The novelty factor of such applications will obviously wear off as more and more are created and used. The possibilities of augmented reality are only just being explored, and any new developments are likely to achieve further exposure.

ii. Personalization
   - The concept of uploading our own media, for example the images which helps to create a highly personalized piece of media for the user. It relates specifically to them, which is likely to be far more engaging than a standard video or image.

iii. Content
   - It's likely that the vast majority of users wouldn't possess the ability or expertise to create a complex video. The AR applications allow users to create a quality piece of content that they wouldn't otherwise be able to create themselves.

iv. Interactivity
   - As well as being high quality, the content created by AR applications is highly entertaining and in many cases fun. The element of surprise that is achieved when

sharing such content makes for very entertaining viewing by other users, stimulating them to create their own version and share it once again.

2.5 Case Studies on Existing Augmented Reality Applications in Different Areas

There are various types of AR applications have been introduced to the market and many areas can benefit from the use of AR technology. It can be used in education, gaming, industrial design, medical, military, navigation, etc. For education, AR apps are changing the way educational content is offered which helps to improve classroom learning through interaction.

2.5.1 AR Basketball Game (*AR application in gaming)*

AR Basketball Game is developed by Augmented Pixels Co Ltd. This AR game is designed to attract those who love sport and technology in the best tradition of cyberpunk. It is a combination between the latest AR technology and the classical basketball game by Reality Hoops. Users are able to enjoy basketball everywhere with a basket overlaying a real world with the unique gameplay and realistic graphics. This AR game enables users to control the direction and the speed of their shots. Players will get various bonuses for certain successful shots. For those players who got very high scores, they may enhance their gaming experience with one of the super funky balls provided. In order to play this AR game, users need to print out the marker from a specific link http://augmentedpixels.com/arb_marker.pdf which is free of charge. This game is not only available for single player, but the player can also invite and play against friends. It is compatibles with iPhone, iPad, iPod touch, etc. Besides that, it is optimized for iPhone 5. Users are able to track their best scores with the Game Center Leaderboard support. Figure 2.1 below shows the marker needed for this application from the given link while Figure 2.2 shows the screenshots of AR Basketball.

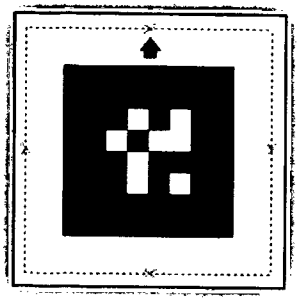


Figure 2.1 AR Basketball Marker

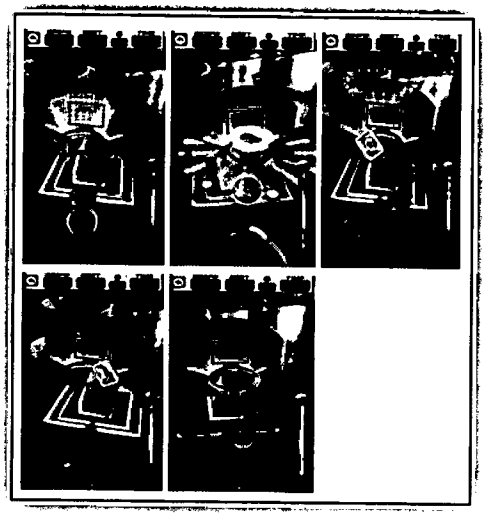


Figure 2.2 Screenshots of AR Basketball

2.5.2 MITL pille (*AR application in medical*)

A new application developed at the German Cancer Research Center in Heidelberg allows surgeons to view the internal organs of a patient during operations. The "MITK pille" iPad app is an augmented reality application to assist clinicians in visualizing internal body parts of patients while working on them. Figure 2.3 below shows the screenshots of MITK pille.

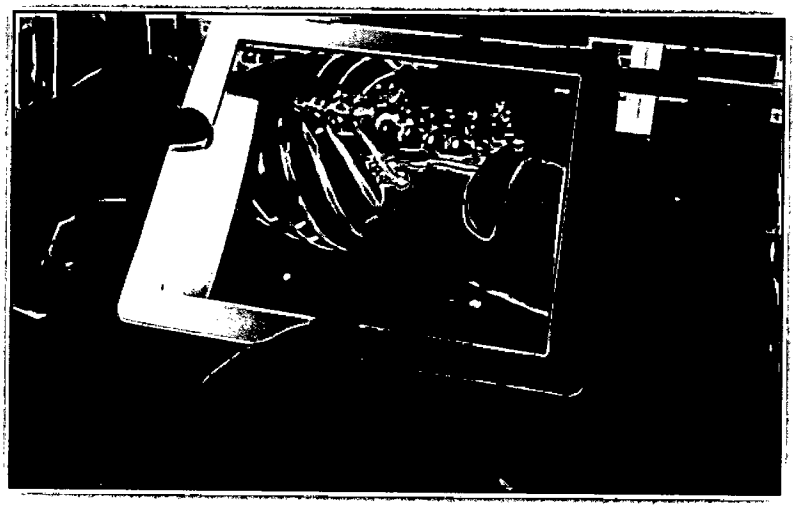


Figure 2.3 Screenshots of MITL pille

2.5.3 Spyglass (*AR application in navigation*)

Spyglass is developed by Pavel Ahafonau. It is an advanced compass as well as a useful AR GPS navigation application. It is very convenient tool since it can be used in everywhere such as a car, boat, aircraft, bike, etc. While its GPS navigation to drive, sail, fly, cycle, in the field or woods, in the sea and in the air. This powerful application is highly recommended as an essential toolkit for every outdoorsman. Users can use this application for finding car, camp or hotel during hunting, hiking, sports and touring. It functions as an AR navigator and a compass for the off-road navigation. This application offered many useful tools such as a hi-tech viewfinder (HUD), gyrocompass, milspec compass, tactical GPS, speedometer, maps, waypoint tracker, sniper's rangefinder, camera, etc. It allows users to save, find, track and share their position, bearings, multiple waypoints, Sun, Moon and Star. It operates in 3D and use AR to show real-time object positions. The coordinate systems supported by Spyglass are civilian, MGRS, OSGB, UTM and military. It is very suitable for those who want to play outdoor treasure hunt games like Geocaching. It compatibles with iPhone, iPad, and iPod touch. Besides that, it is also optimized for iPhone 5. Figure 2.4 below shows the screenshots of spyglass.

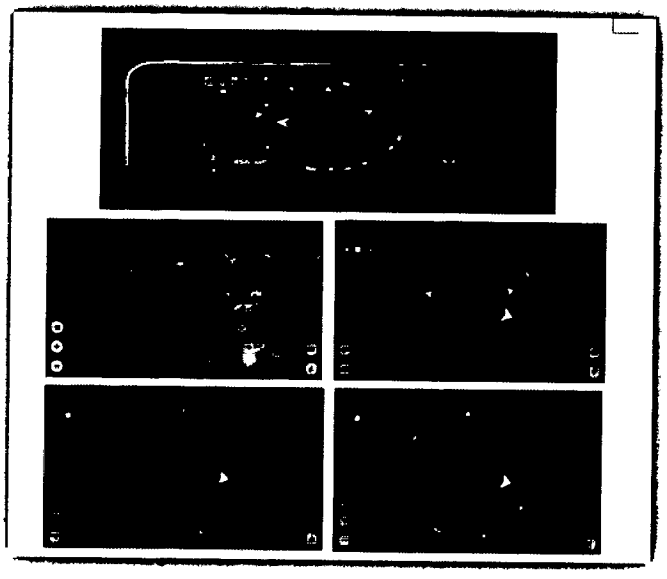


Figure 2.4 Screenshots of Spyglass

2.5.4 Google Sky Map *(AR applications in education)*

This AR application is special designed for those who like to study about astronomy. It makes the learning about astronomy in an interesting and fun way. By using this application, users are able to identify stars and constellations directly through their camera on smartphone. It is a very convenient application and useful for the users since they don't need to look at the descriptions of constellations on a book and then attempting to identify them in the sky. This application will be able to receive automatic identification of stars and constellations when the users simply move their smartphone up in the direction of the sky. So, it is easy to use. With the direction users point their camera, it will identify the elements automatically which display on their camera lens. It enables users to know the star or constellations directly without any guessing (Gabriela Jugaru, 2012). Figure 2.5 below shows the screenshots of Google Sky Map.

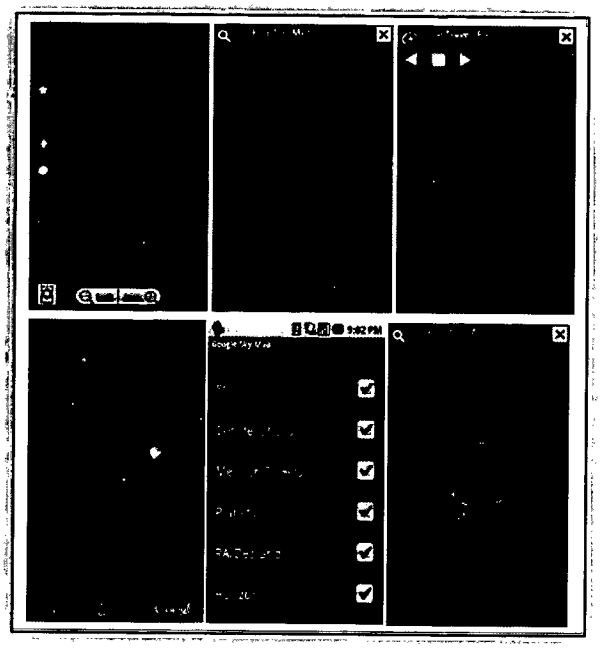


Figure 2.5 Screenshots of Google Sky Map

2.5.5 FETCH! Lunch rush *(AR applications in education)*

This application is released by PBS KIDS. It is an AR application of teaching math skills to elementary students through the use visualization of AR technology. It is designed in 3D and the graphics will be placed on the camera over real-world surroundings through the smartphone camera. Then, the elementary students can learn to add and subtract in real-world environment while solving math problems. It is a multi-player game for lunch orders from Ruff's movie crew. Player's challenge of this application is keeping track of how many pieces of sushi everyone wants. It compatibles with iPhone, iPad and iPod touch. It is the first AR application for education released by PBS KIDS (Gabriela Jugaru, 2012). Figure 2.6 below shows the screenshots of FETCH! Lunch Rush.

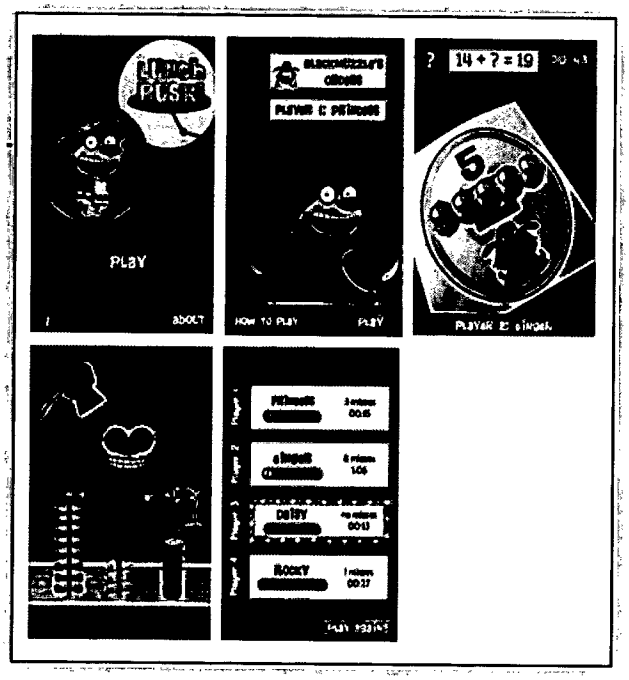


Figure 2.6 Screenshots of FETCH! Lunch Rush

2.5.6 GeoGoggle *(AR applications in education)*

GeoGoggle is a very useful tool for those people in learning the fundamentals of geography. It is designed for acquiring or assisting users in geography skills and judging distances to specific destinations. By using this application, it provides an opportunity for students in learning of geographical measurement such as latitude and longitude in real-world surroundings. Moreover, users are also will be able to calculate altitude and the distance between two points using a 3D compass. It uses overlay graphics combined with real-world environments just like other AR application (Gabriela Jugaru, 2012). Figure 2.7 below shows the screenshots of GeoGoggle.

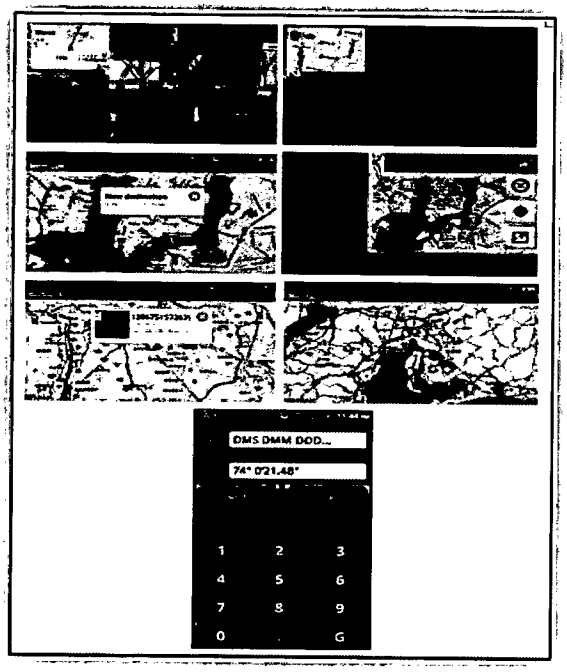


Figure 2.7 Screenshots of GeoGoggle

2.5.7 ZooBurst *(AR applications in education)*

This AR application is developed by ZooBurst LLC. It is designed as a digital storytelling tool with advanced AR technology for elementary level students in their learning process. Students will be able to create their own AR 3D character pop-up storybook so that they can learn through visual imaging. It is a very interactive AR tool for students as they can become a part in the story via webcam once the book is completed. The book can be specialized using a library of thousands of images. The learning experience or process of the students will become more interesting since some multimedia elements such as the Adobe flash animations, speech balloons and narrations can be added into the story. Students are also be able to get interact with the characters in the story as they can click on those characters to learn more about them. Moreover, the book is also can be rotated so that the students will be able to view it from different angle. This application is created for helping the students to complete certain task in school. For example to help them create presentations and to communicate some complex ideas which is difficult to explain (Gabriela Jugaru, 2012). Figure 2.8 below shows the screenshots of ZooBurst.

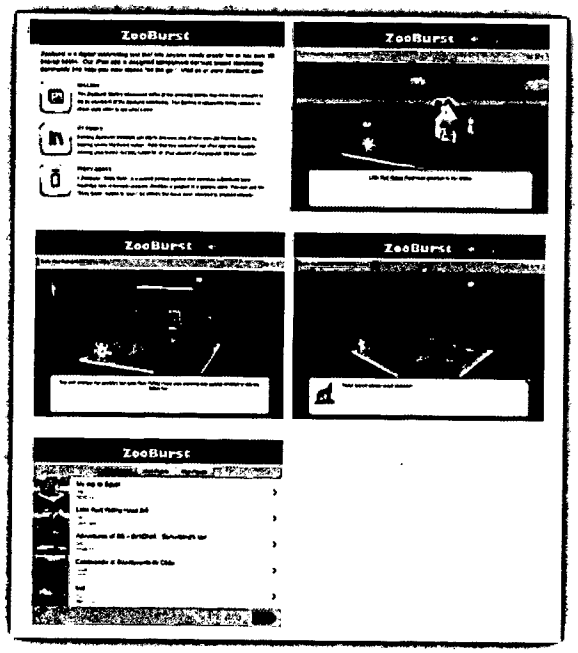


Figure 2.8 Screenshots of ZooBurst

2.5.8 AcrossAir *(AR applications in education)*

This application is developed by acrossair. It is an AR browser which is the one of the AR educational tool for the students. Basically, it is used to show the digital information of what happening around the users. Acrossair has a simple and refined user interface. It can be used in classroom for learning and discussion of the studies. It offered some useful functions as a navigator for the users where they can find and share the nearest locations to their friends via email. The learning environment could be in a fun way when it used to create interactive classroom project. It lets students participate in interactive photo walls which is displaying wiki and multimedia on a classroom topic. Students can also be involved in classroom discussion via Twitter AR by using this amazing application. This application is also enables users to check out the latest tweets by people near them via geotagging technology. Besides that, users can also see tweets by the people around them while imagining that they are holding up their smartphone (Gabriela Jugaru, 2012). Figure 2.9 below shows the screenshots of AcrossAir.

Features of the application:

- A simple and refined user interface;
- Choose your own search range to find places near you;
- Access Google, Yelp or Qype directly;
- Set your car location and store your own locations;
- Share locations with friends via email.

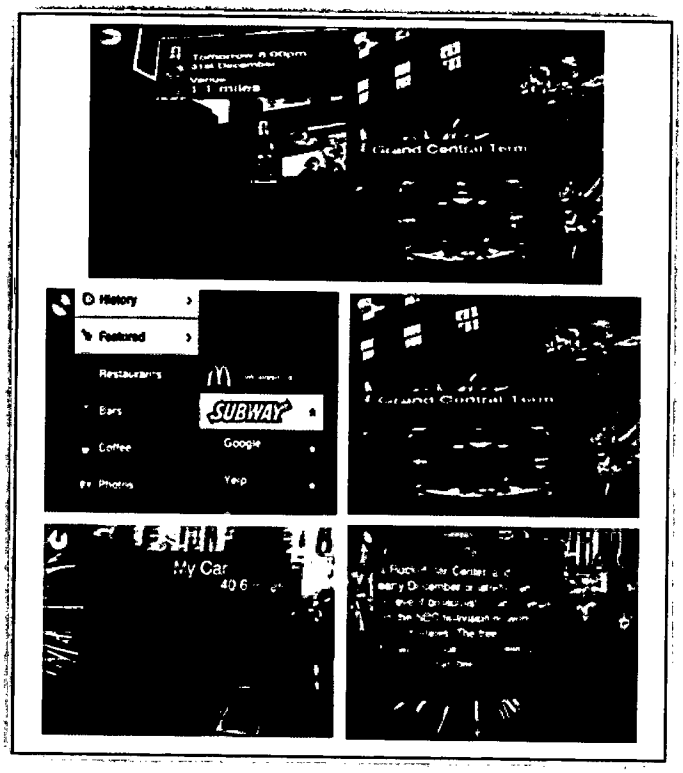


Figure 2.9 Screenshots of AcrossAir

2.6 Comparison Table between the AR Applications in Education

The AR applications in education have been compared from the aspect of its descriptions, methods, techniques, tools and platform. Table 2.1 below shows the comparison table between the AR applications in education.

Table 2.1 Comparison table between the AR Applications in education

AR applications	Descriptions	Methods	Techniques	Tools	Platform
Google Sky Map	Let users to identify stars and constellations directly through their camera on smartphone.	markerless	-	• Camera device • Smartphone (Android)	Android
FETCH! Lunch Rush	A multi-player game which the users need to keep up with lunch orders from Ruff's movie crew. The challenge is keeping track of how many pieces of sushi everyone wants.	marker-based	template marker	• iPhone • iPad • iPod toch • camera device	iOS
GeoGoggle	It is designed for acquiring or assisting users in geography skills and judging distances to specific destinations.	markerless	-	• Camera device • Smartphone (Android)	Android

ZooBurst	A digital storytelling tool that lets anyone easily creates his or her own augmented reality 3D pop-up books.	marker-based	template marker	• iPad • webcam	iOS
Acrossair	A navigator to get users to the nearest location of their choice. It is also packed full of additional information on points of interest near and around users.	markerless	-	• iPhone • iPad • iPod • camera devices	iOS

2.7 Augmented Reality Books

Nowadays, the influence of advanced technology on society is changing the life style of the young generation. The time spent of younger readers with print media is decreasing as they are now focusing to the digital readers, tablets and smartphones. Therefore, some AR books have been released by the innovator in publishing in order to encourage the readers with print media. Readers need to download the particular AR application for those books in order to view the 3D content on the books. Below are some examples of the AR book:

2.7.1 'Wonderbook™: Book of Spells' from J.K. Rowling

This AR book is released in November of 2012. It gives readers a lot of fun from it which they can enjoy this AR book in PlayStation 3 while it works with the PlayStation Move Motion Controller and the PlayStation Eye Camera. By using this AR book, the readers have the opportunity to become the students of Harry Potter's Hogwarts which is transformed from the book-slash-game. When the readers read through pages, they can cast spells by using the motion sensitive controller as a magic wand. It can be considered as an extraordinary device that offer an amazing or fantastic reading experience. Actually this AR book is not only focuses on the magical spirit of Harry Potter, but that the perfect use of the Move controller is the point of this AR book (JoAnne Brenzo, 2013). Figure 2.10 below shows the screenshots of Wonderbook™: Book of Spells.

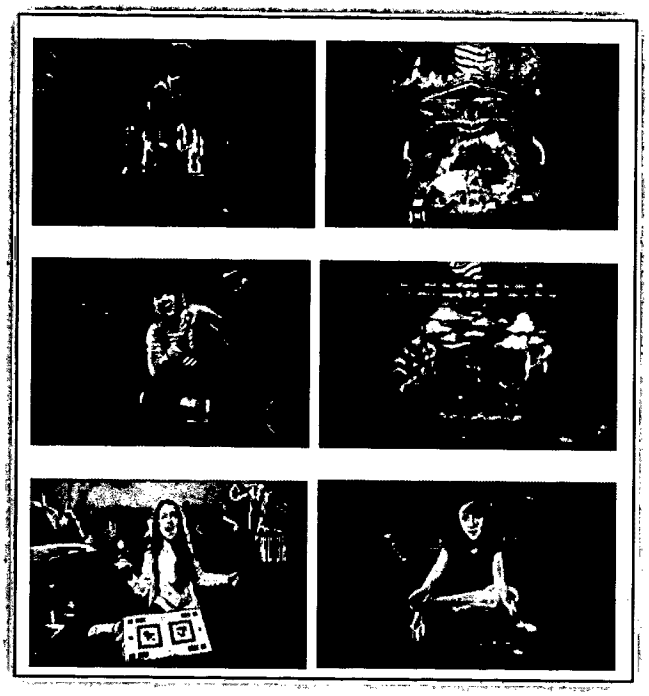


Figure 2.10 Screenshots of Wonderbook™: Book of Spells

2.7.2 'Princess and her Pals 3D' from PopAR Interactive Books for Kids

The AR storybooks are the 3D pop-up books which are special designed for children where the PopAR Toys is at the center of this trend. The learning experience can be enhanced because this AR storybook makes the ordinary pages come alive with 3D animated princesses, castle environments, games, and read-alongs. It makes the illustrations spring to life with detailed animations when the users point their camera device of their smartphone or tablet over the AR book with the "Princess and her Pals 3D" PopAR app". There are six series of the interactive book where the "Princess and her Pals 3D" is one of them. Another AR books including "3d Dinosaurs", "3D Bugs", "3D construction" and "3D Planets", all of these AR books are targeted from ages 5 to 11. PopAR's AR books have gains their popularity as the AR books received "Best Toy of the Toy Fair 2012" from The View. Besides that, the AR toys-slash-books also won the National

Parenting Seal of Approval 2012 and "Two Thumbs Up" from Inside Media (JoAnne Brenzo, 2013). Figure 2.11 below shows the screenshots of Princess and her Pals 3D.

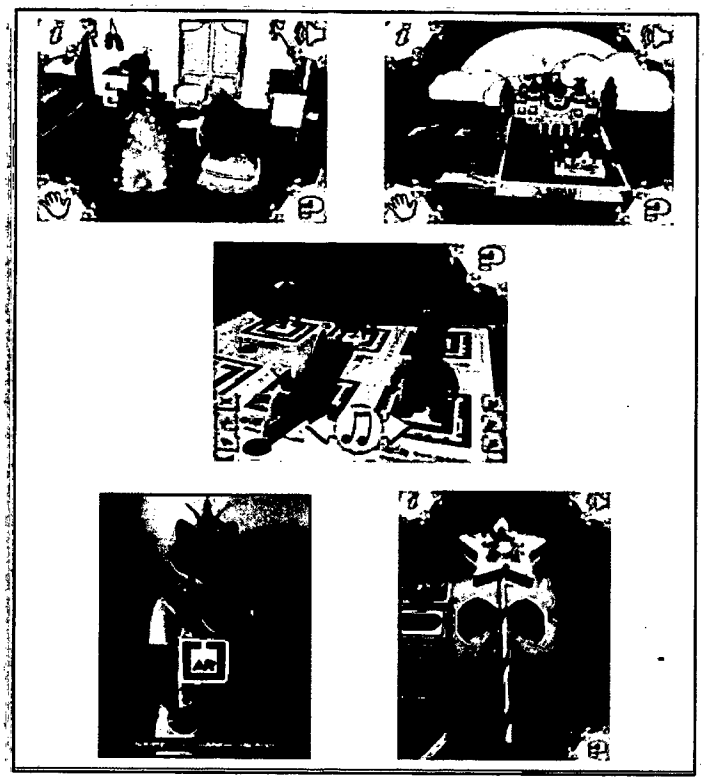


Figure 2.11 Screenshots of Princess and her Pals 3D

2.7.3 'Monsters Inc., An Augmented Reality Book'

This AR book of Disney's Monster's Inc. is released by Carlton Books Kids from a larger AR book series. It lets readers to explore Monstropolis using their PC webcam. Basically, this AR experience allows kids to virtually "dress up" as a monster, interact with animated monsters and find out exclusive facts about their favourite characters (JoAnne Brenzo, 2013). Figure 2.12 below shows the screenshots of Monsters Inc.

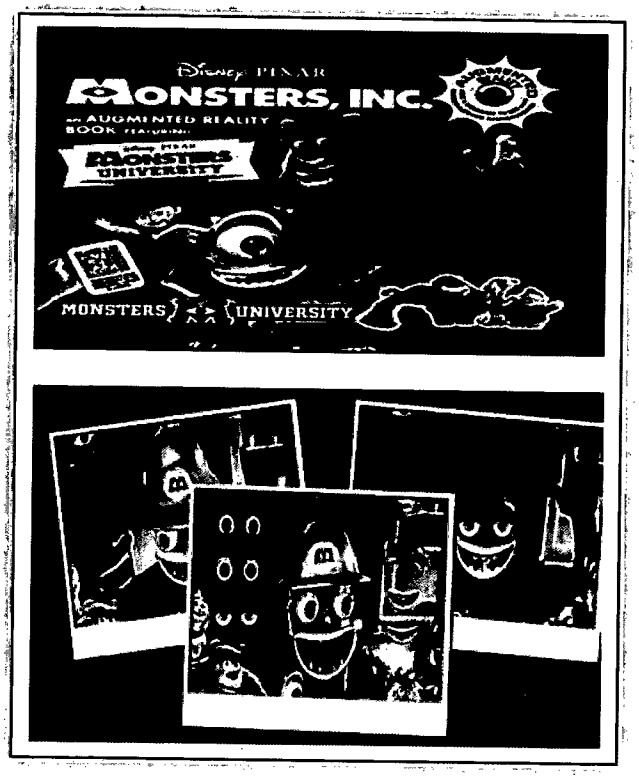


Figure 2.12 Screenshots of Monsters Inc.

2.7.4 'King of the Railway, An Augmented Reality Book with Thomas & Friends'

The application of this AR book is developed by Red Frog Digital Limited, while the publisher of this AR book is Carlton Books Kids. It lets the young Readers to enjoy the story in four unique AR experiences through their smartphone or tablet. The application can be launched in iPhone, iPad, iPod touch and Android. Its performance is strictly related to the device's CPU power and memory because of the use of High resolution 3D Models. Readers will get a lot of fun as they can interact with the familiar faces of Thomas and Friends and meet the new characters from the film (JoAnne Brenzo, 2013). Figure 2.13 below shows the screenshots of King of the Railway.

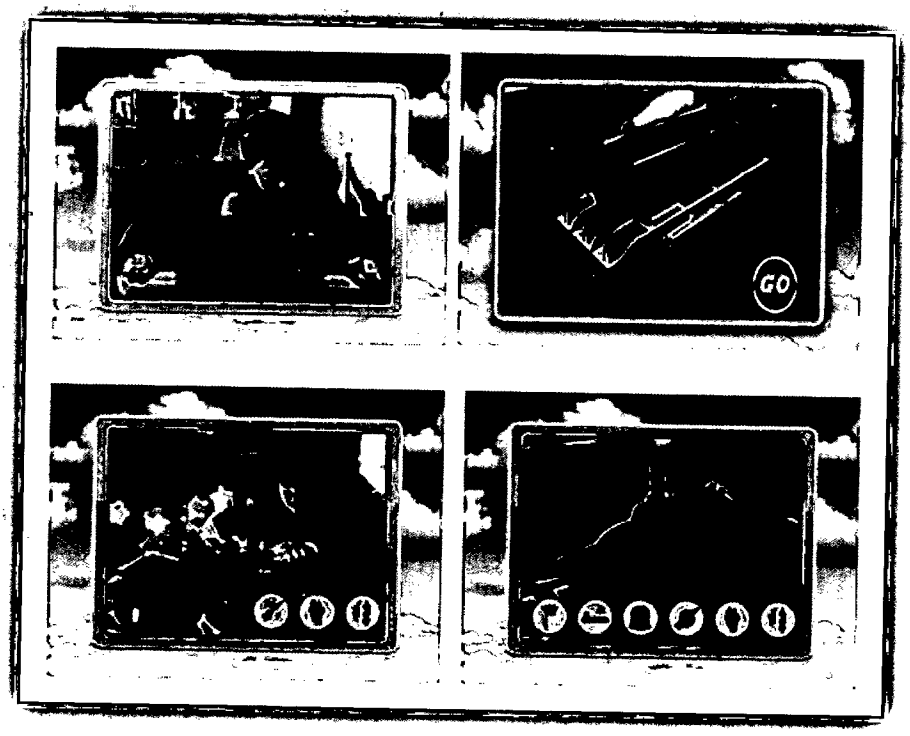


Figure 2.13 Screenshots of King of the Railway

2.7.5 iDinosaur

It is also one of the AR products from Red Frog Digital Limited. It is packed with dinosaur facts and stunningly realistic CGI dinosaur illustrations. In addition, it takes the dinosaur experience into another dimension with AR technology. Therefore, children will be able to see and interact with CGI 3D dinosaur in real time. The users can enjoy iDinosaur through their mobile devices which are including iPhone, iPad and Android phones or tablets. Users need to download iDinosaur AR application from the app store in order to view the fearsome 3D dinosaurs on the book (JoAnne Brenzo, 2013). Figure 2.14 below shows the screenshots of iDinosaur.

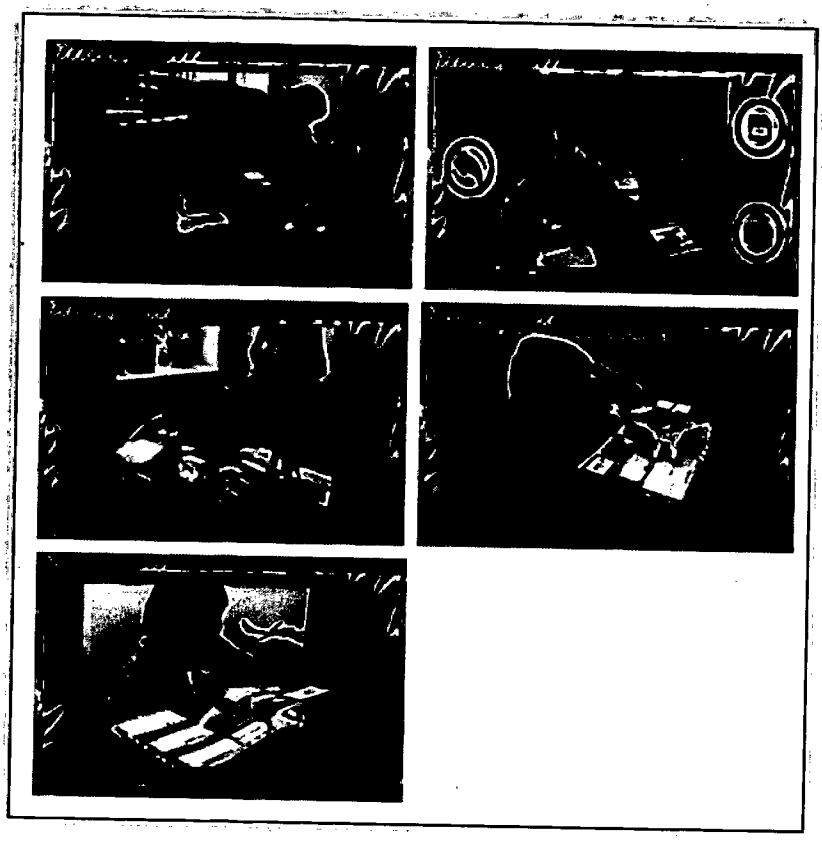


Figure 2.14 Screenshots of iDinosaur

2.8 Advantages of Augmented Reality Book

According to Albertina Dias who also studied the use of an augmented book, she got a conclusion that the AR book presented a rich user experience that enhanced the learning experience. In a preliminary evaluation with five adults, she found that the book's features impact learning in these ways:

- Adding visualization to a standard textbook will enhance its value as an educational material.
- The visualized text is easier to understand and thus learning process will be fostered.
- Audio-visual content is more attractive than standard text books.
- Adding visualization features to a standard textbook creates a new media concept and possibilities, resulting in completely new educational instruments.
- A very intuitive and easy to use authoring tool will allow for creativity during educational material preparation.

2.9 Technologies in Augmented Reality System Development

In order to develop an AR application, some of the technologies are needed to be considered. The technologies are listed as below:

i. Tracking

- The virtual content can be presented and retrieved when the user's viewpoint is detected by the system. Meaning that, the position and orientation of the system display are identified by the system in a physical coordinate system with known mapping to a virtual one. Tracking is the formed of orientation and position parameters.

ii. Registration

- Tracking is the final alignment between real and virtual information before displaying to the user. It is only a means to achieve registration. Registration must be made with pixel accuracy at interactive frame rates. Through this way, the illusion of real and virtual coexisting can be preserved in the same domain.

iii. Display

- A mix of real and virtual is the output of an AR system. The users are able to see the 3D graphics overlaying on the real world through the display.

2.10 Marker Techniques

Generally, AR can be achieved through two types of methods which are marker based and markerless.

2.10.1 Marker-based AR

The physical-world symbols are used in this technology which functions as a reference point for computer graphics to be overlaid. For instance, the computer will automatically interpret the symbol of a 2-dimensional printed marker when it is put in front of a webcam. Then, a 3D content or 3D graphic will be overlaid on the top of the marker in the physical world. Figure 2.15 below shows the example of marker-based AR used in marketing:

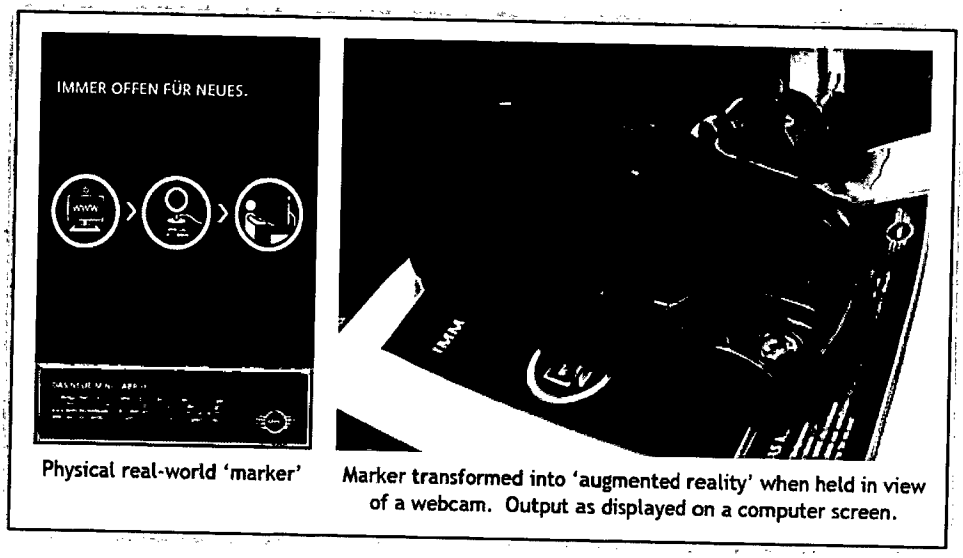


Figure 2.15 View of computer screen with AR car overlaid onto a physical 2D marker

Several methods have been developed which allow tracking beyond the visibility of markers for improving robustness. These techniques are highly efficient in the memory and CPU usage. Besides that, it also can run at interactive frame rates on mobile phones. Below is the list of the techniques of marker-based tracking:

i. Frame marker

Normally, the robustness of marker tracking is largely owed to the high contrast afforded by the black frame in a thresholded image. The interior can be filled with picture or any specific artwork because the frame itself is not disturbing in many situations. Actually a digital id with error correction has been encoded at the interior side of the frame, making it just look like a frame decoration. This type of marker is become highly attractive for branding by some companies, this is because a logo can be placed inside the marker (Daniel Wagner, 2008). Figure 2.16 below shows the sample of frame marker.

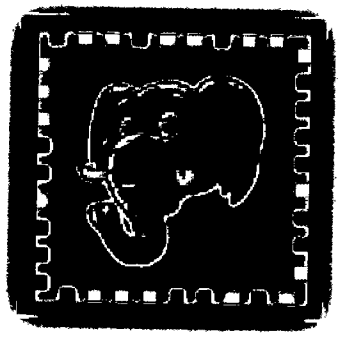


Figure 2.16 Frame Marker

ii. Split marker

Unlike the frame marker, the occupied area can be reduced since there is only two separate barcodes in split marker. The design of split marker is similar to Sony's Eye of Judgment game as these split markers are inspired by them. The interior area will not affect the tracking result same as the frame marker. Therefore, the users can be chosen arbitrarily. This type of marker makes the tracking process easier since it is only two sides (top and bottom) of the marker contain features required for tracking, thus the users can conveniently hold the marker in the hand with the thumb covering another sides (left or right) of the marker, without affecting the tracking (Daniel Wagner, 2008). Figure 2.17 below shows the sample of split marker.

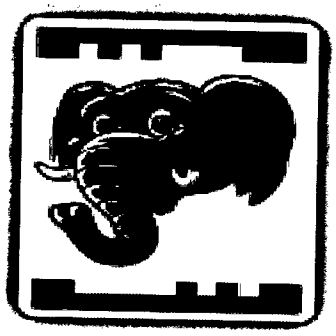


Figure 2.17 Split Marker

iii. Dot markers

The most often markers which are cover underlying objects or images are deemed undesirable. Therefore, the area covered by artificial markings is better to be reduced as much as possible instead using the already existing natural features. The analysis of natural texture will become fast and robust through this hybrid approach of minimal markings. It was taken with the dot markers. There is a two-dimensional grid of black circular dots with white surrounding rings in a dot marker which is

superimposed on a textured flat surface (Daniel Wagner, 2008). Figure 2.18 below shows the sample of dot marker.

Figure 2.18 Dot Marker

iv. DataMatrix markers (ISO/IEC16022)

DataMatrix is a very efficient ISO standard for 2D barcodes. A small area of square modules with a unique perimeter pattern is used in order to help the barcode scanner to determine the cell locations and decode the symbol. Large amount of binary (e.g. simple 3D models) or text (e.g. URLs) data can be stored in these markers. The information to be encoded can be numbers, text, characters and actual bytes of data (Daniel Wagner, 2008). Figure 2.19 below shows the sample of DataMatrix marker.

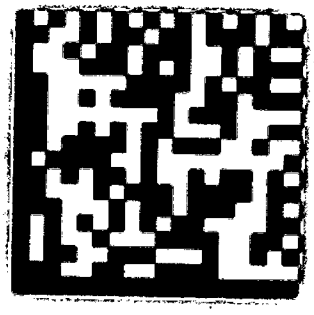


Figure 2.19 DataMatrix Marker

v. ID marker (simple-id and BCH)

This design of this marker is in black and white squares that are interpreted as binary numbers. It also can be called as a simple ID marker which is usually containing only an ID number. Although it is containing little information, but a database can be used if a system wishes to link more information to this type of marker (Daniel Wagner, 2008). It tracked at a speed of 185 images/sec on a Motorola Q phone with 312 Mhz. Figure 2.20 below shows the sample of ID marker.

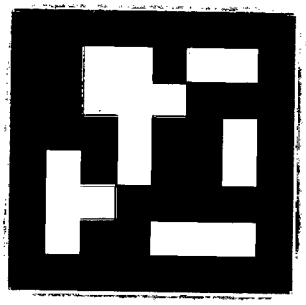


Figure 2.20 ID Marker

vi. Template markers (ARToolkit-style)

Generally, template markers are black and white markers and there is a simple image inside the black border. ARToolkit is using these template markers. The segmented images and the marker templates will be compared when the detection systems are identifying them. The marker templates are sample images of markers. A detected marker will be matched by the application against each template when the identification process is running. Then, an identity can be defined from the best match. It is only a name or ID associated with each marker for this type of marker. A database is needed just like the ID markers if a system wants to link more information to a template marker (Daniel Wagner, 2008). Figure 2.21 shows the sample of template marker.

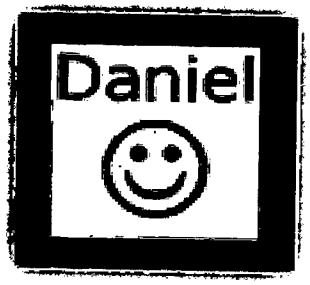


Figure 2.21 Template Marker

2.10.2 Markerless AR

Markerless AR technology has given rise to "mobile AR", the users can use this technology through their smartphones and tablets. The electronic devices' accelerometer, compass and location data (such as the Global Positioning System - GPS) are combined in order to run the AR application through the devices. The reason why such combination formed is to determine the position in the physical world, which way it is pointing and on which axis the device is operating. There is a database function as a reference or library for the location data to determine what the device is looking at and then allows the computer data/graphics to be displayed on-screen. Figure 2.22 below shows an iPhone app which is basically used to determine which Underground station is closest for the lost Londoners:

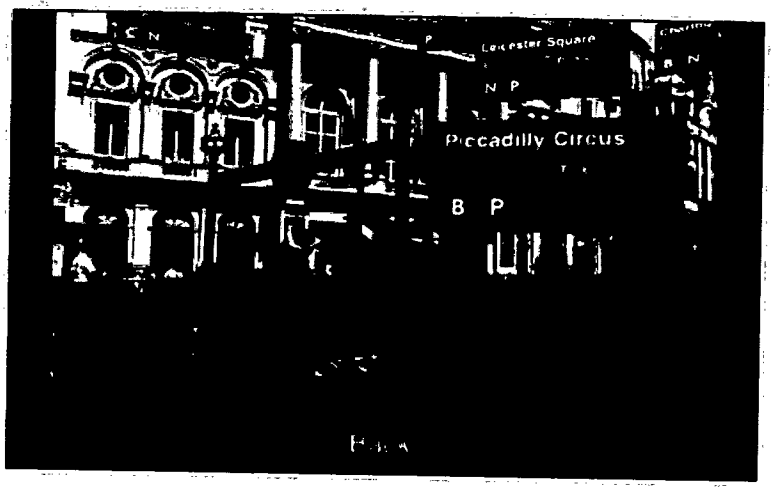


Figure 2.22 Navigating using AR in London

2.11 Software for Augmented Reality Application Development

There are many of the software in Augmented Reality application development. The following shows some of the software that are considered in this research:

2.11.1 ARToolkit

The AR applications can be created by using ARToolKit as a computer vision open source tracking library which allows the virtual imagery overlay on the real world. It can calculate the real camera position and orientation relative to markers in real time with its video tracking capabilities. A virtual camera can be positioned at the same point when the real camera position is known. Then, the 3D computer graphics models drawn exactly overlaid on the real marker. Therefore, the two of the main problems in Augmented Reality which are the viewpoint tracking and the virtual object interaction can be solved by using ARToolKit.

ARToolKit was developed by Hirokazu Kato of Nara Institute of Science and Technology in 1999. Then, it was released by the University of Washington HIT Lab. ARToolKit is widely used as an AR tracking library with over 160,000 downloads since 2004. It can be used in many different operating systems such as Microsoft Windows, Linux-based, Mac OS X and SGI IRIX. For the mobile AR application, it supports Symbian, iPhone, Windows Phone and Android.

Features:

- Single camera position/orientation tracking.
- Tracking code that uses simple black squares.
- The ability to use any square marker patterns.
- Easy camera calibration code.
- Fast enough for real time AR applications.
- Free and open source.

2.11.2 ATOMIC Authoring Tool

ATOMIC Authoring Tool was developed especially for non-programmers to create the AR applications. This is because it was created as a front end (Graphic Interface) for use ARToolKit library without the knowledge of programming. The language used is the programming language Processing which is licensed under the GNU GPL. Users can use this tool in many different operating systems such as Microsoft Windows, Mac OS X and Ubuntu since it is Multi-platform.

There are two versions of this tool that have been released: the first experimental version and the first stable version. The experimental version was released on September 7 of 2008 while the stable version 0.6 was released on March 6 of 2009. With this open source tool by ATOMIC, everyone is getting the opportunity to know more about the AR technology without too much technical knowledge.

2.11.3 Vuforia Augmented Reality SDK

Vuforia is a software that used to create AR applications with its Augmented Reality Software Development Kit (SDK) for mobile devices. It is able to recognize and track planar images (Image Targets) and simple 3D objects in real time by using its Computer Vision technology. It supports many different types of 2D and 3D target including 'markerless' Image Targets, Frame Marker and 3D Multi-Target configurations.

The Application Programming Interfaces (API) is provided by Vuforia. The API can be applied in C++, Java, Objective-C, and the .Net languages through an extension to the Unity game engine. The AR applications are compatible with a broad range of mobile devices including the iPhone (4/4S), iPad, tablets and Android when using Vuforia as the application development tool.

2.11.4 Conclusion of Software for Augmented Reality Development

Among these software stated above, I would like to conclude that the software I preferred to use in the development of AR application is ARToolkit. Below are some reasons why I choose this:

i. Simple prototypes can be made without big efforts.
   - ARToolKit provides video input and Graphics library as well as tracking library. It can work without camera calibration. It is not pose/position measurement, but registration.

ii. Light-weight processing
   - Tracking works 30fps@640x480 by Pentium III 600MHz. Applications want to use CPU resource for the main purpose.

iii. Cheap system
   - Applications can be made by only a camera without any other sensors, plus making markers is very easy.

iv. Many platforms
   - `Irix, Linux, Windows, MacOS; PDA, MobilePhone.

2.12 Platform Development Environment

Mobile application development is the process by which application software is developed for low-power handheld devices, such as personal digital assistants, enterprise digital assistants or mobile phones. These applications can be pre-installed on phones during manufacturing, downloaded by customers from various mobile software distribution platforms. Table 2.2 below summarizes the elements of some of the development environments.

Table 2.2 Comparison table between different platform development environments

Platforms	Programming language	Debuggers available	Emulator available	Integrated development environment available	Cross-platform deployment	Installer packaging options	Development tool cost
Android	Java but portions of code can be in C, C++	Debugger integrated in Eclipse, standalone debugging monitor available	Yes	Eclipse, IntelliJ IDEA, Project Kenai Android plugin for netBeans	Android only, because of Dalvik VM, march 2009	apk	Free, IntelliJ IDEA Community Edition - Free
Blackberry	Java	Debugger integrated in IDE	Yes	Eclipse, BlackBerry JDE	BlackBerry only, because of RIM API	alx, cod	Free
iOS SDK	Objective-C	Debugger integrated in Xcode IDE	Bundled with iPhone SDK, integrated	Xcode, AppCode	iPhone, iPad, iPod Touch	Only via App Store, needs review and approval by	Apple tools are free for an Intel-based Mac. Simulator

			with Xcode IDE			Apple Inc.	testing is free, but installing on a device needs a fee for a developer signing key. AppCode – Commercial license available.
Palm OS	C, C++, Pascal	Yes	OS 1.0 – 4.1: Free Emulator provided by Palm Source (Access); OS 5.0: - 5.4 Device – specific Simulators provided by Palm (palmOne)	Palm OS Development System (Eclipse), CodeWarrior, PocketStudio, HB++, Satellite Forms	Palm OS handhelds, or Windows Mobile with StyleTap emulator	PRC files, PalmSource Installer (.psi)	Free (POSE or GCC for Palm OS), or commercial (CodeWarrior), or various commercial rapid-development frameworks
Ubuntu Touch	Web-based: HTML5, CSS, JavaScript Native: QML,C, C++	Yes	style="background:#9F9;vertical-align:middle;text-align:cent	Ubuntu SDK	HTML5 app to be available web browser.	Ubuntu Touch through App store, Web URL	Development requires Ubuntu Desktop 12.04 or higher, Free

			er;"class= "table- yes"|Yes				
Windows Mobile	C, C++	Yes	Free emulator (source code available), also bundled with IDE	Visual Studio 2010, 2008, 2005, eMbedded VC++ (free), Satellite Forms	Windows Mobile, Windows FU, Windows CE	OTA deployment , CAB files, ActiveSync	Free command- line tools or eMbedded VC++, or Visual Studio (Standard edition or better)

2.12.1 Survey on Platform Choosing: THE TRUTH ABOUT SMARTPHONES (Henry Blodget & Leah Goldman, 2011)

The purpose of this survey is to find out more about what makes people choose one platform over the other. There are more than 2,000 responses received. Figure 2.23 below shows the chart of survey on platform choosing.

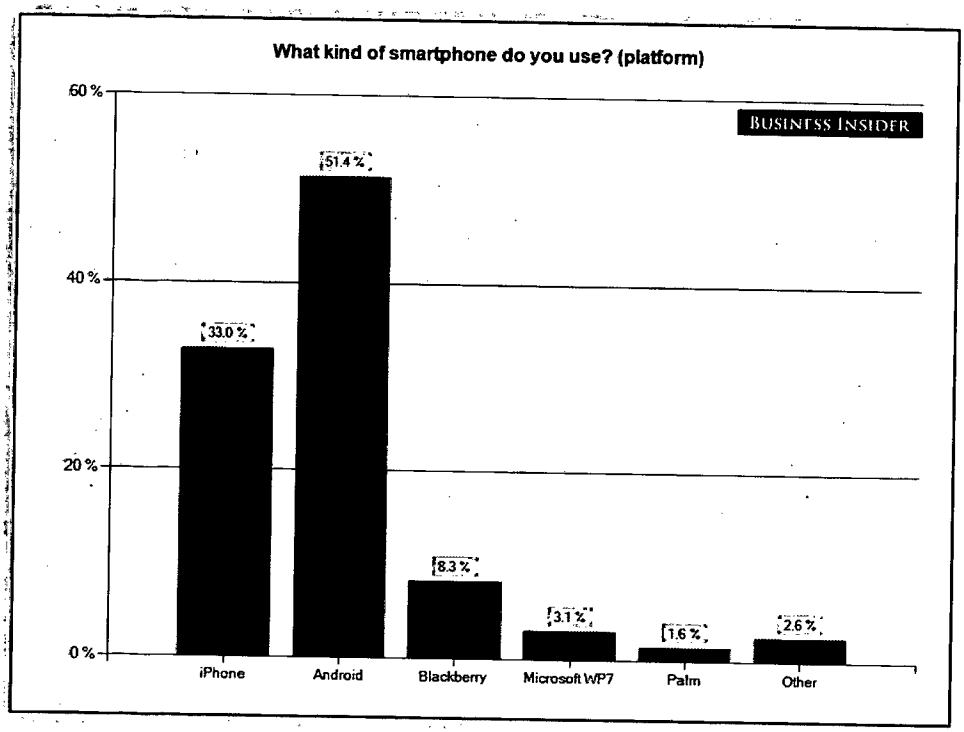


Figure 2.23 Survey on platform choosing

Here are the key points based on the survey result:

- ✓ The majority of participants use Android, with most of the rest using iPhones. (This is similar to the recent market-share figures from Comscore, although Android and iPhone appear to be over-represented and BlackBerry appears to be under-represented).
- ✓ Most participants say "features" and "platform" are the most important factors when choosing a smartphone. App selection is also important, but not as important as most people think.
- ✓ Most iPhone owners say they would buy an Android phone if there was an Android phone that was better in most key ways than an iPhone. This suggests the iPhone's feature lead still matters. It also suggests that the Apple platform does not have the "lock-in" that many Apple bulls believe. It also increases the pressure on the iPhone 5 to be a humdinger of an upgrade.
- ✓ Most Android users say they won't consider buying an iPhone because they "hate Apple."
- ✓ Most of the rest of Android users say they would consider buying an iPhone if iPhones worked better with non-Apple products. This highlights the risk of Apple's closed system.
- ✓ Almost no participants are planning to buy a BlackBerry, a Windows Phone 7 phone, or Palm.

2.12.2 Conclusion of Platform Development Environment

There are various mobile platforms like Android, iOS, BlackBerry, Windows, Palm and many more. When it comes to talk about mobile application development services, it is found that Android has been widely accepted mobile operating system that serves spectrum of features to its users. For me, I'll also choose Android as my mobile platform for my research. This is because by using Android applications, it is much easier for AR to get huge help in starting connection with their present and future users. Moreover, when it comes to talk about benefits of using application development for android in AR, there are many. It includes:

- ✓ No need to pay for any developer's program to develop and test apps in real devices,
- ✓ Open source platform with scope of more innovation (Less proprietary restrictions),
- ✓ Cost-effective prototyping for research and business
- ✓ Provide advanced integration,
- ✓ Enhanced features,
- ✓ Different distribution mechanisms,
- ✓ Easy to access,
- ✓ User friendly and many more.

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter is discussing about the framework of project and the activities for each phase of research process. The development of AR application of human blood circulatory system is discussed as a study on the architecture of the AR application before move to implementation phase. In addition, this chapter will be describing the software and hardware used in this project. A Gantt chart will also be created to make sure that the development process runs smoothly.

3.2 Framework of Project

The development framework used is based on Software Development Life-Cycle (SDLC) modified waterfall approach with some modification in order to match the development process of AR application as shown in Figure 3.1. The modified waterfall model is a sequential development approach, in which development is seen as flowing steadily downwards (like a waterfall) through the phases of requirements analysis, design, implementation, testing (validation), integration, and maintenance. It is used to describe a sequential model of non-overlapping and distinctive activities related to software development.

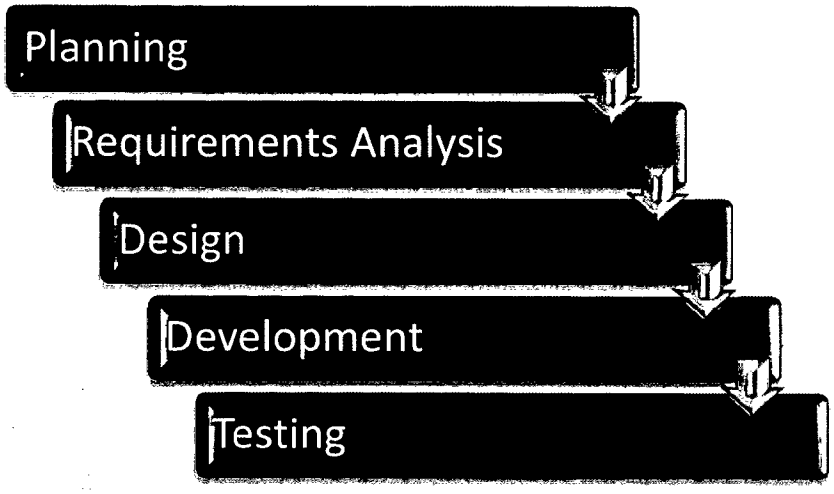


Figure 3.1 Modified Waterfall Life-Cycle Model

Table 3.1 Framework of the project

Phase	Activity	Output
Planning	• Define the term of Augmented Reality (AR) • Define project problem statement, goals, objective and scope	• Having clear project problem statement, goals, objective and scope
Requirements Analysis	• Decide the topic from the science syllabus • Analyze the teaching methods of science education in secondary school • Analyze the features of existing AR applications especially in science education • Define the marker techniques in AR • Define the techniques of marker-based tracking in AR • Define software and hardware/platform	• A topic (human blood circulatory system) from science syllabus is chosen • A technique of marker-based tracking is chosen • Application

	requirement	requirements specification
Design	• Design AR book contents • Design AR application interfaces • Design the workflow of the AR application	• AR book contents • Interfaces of AR application
Development	• Identify the software and hardware used • Create 3D models in Maya • Create marker of the AR application • Build the AR application based on the design and software chosen • Integration of AR application and mobile phone	• 3D models are created • Marker is created • Program code • Android AR application exported as .apk file format
Testing	• Do survey from the target user	• Test reports

3.2.1 Planning Phase

Through this phase, a well-organized and well started of the project can be ensured. The activities in this phase include the determination of the AR application project's needs, problem statements, overall goals, objectives and the scope. All of these can be considered as some important steps before the project started and it can be found in Chapter 1 for more details. After that, the duration of the project development is constructed in a Gantt chart by using Microsoft Project 2010. The duration of activities are stated as well in order to break a large project into a series of smaller tasks in an organized way. Therefore, it is very useful since the chart shows when each task should begin and how long it should take. This can make sure that all the tasks are completed before the due date. The framework of the project is divided into five phases which are including the planning phase, requirements analysis phase, design phase, development phase and testing phase. The duration for each phase is different –

planning phase: 14 days; requirements analysis phase: 11 days; design phase: 32 days; development phase: 110 days; testing phase: 21 days. The detailed of the project's framework can be referred to Gantt chart (Appendix A).

3.2.2 Requirements Analysis Phase

There are many topics of science syllabus in secondary school, so a particular topic which is considered as a hard topic for the students is identified. An analysis on the teaching methods for science education is made next. This step is quite important to investigate the effectiveness of using the traditional teaching methods. Through this way, the market value of AR applications for augmented book can be proved. Case Studies on Existing Augmented Reality Applications have been studied in chapter 2. It is found that AR applications have been widely used in many different areas.

The details of the advantages of AR applications can be found in Chapter 2. After that, the project requirements analyses are made. There are several analysis are made to determine the requirements need to meet for development purpose. The analyses are as below:

i. The features of existing AR applications
   - The features are including the function of the AR application, marker techniques, the techniques of marker-based tracking (if marker-based), the tools/devices and the platform used.

ii. Analysis on marker techniques used
   - Selection: marker-based AR
   - Reason: It is the fact that one can actively look for known features in an image. It can search for fixed size markers within an image, therefore it doesn't takes a lot of processing power.

iii. Analysis on the software tools for the development of AR application
   - Selection: ARToolKit
   - Reason: Simple prototypes can be made without big efforts, light-weight processing, cheap system and it supports many platforms.

iv. Analysis on the techniques of marker-based tracking
   - Selection: Template marker
   - Reason: It is the default technique of marker-based tracking in ARToolKit.

v. Analysis on the platform development environment
   - Selection: Android
   - Reason: It is an open source platform with scope of more innovation, easy to access, user friendly, cost-effective prototyping, etc.

3.2.3 Design Phase

The criteria of the proposed AR mobile application need to be identified in order to know the pattern or style of the application that should be designed. The content of the application with AR techniques is based on the topic of Human Blood Circulatory System under the science syllabus of secondary school. When designing the application, the required learning material regarding the Human Blood Circulatory System need to be collected, and create appropriate teaching materials for integration into the AR application. The particular learning material can be identified through the science syllabus, to gather material for use in the construction of the content for the AR learning application. Since the topic is about Human Blood Circulatory System, so the content of the application will studying about the heart, blood vessels and blood. It is same for the AR book design which will provide some explanations or notes about those three categories. Besides that, the studies of relevant technologies and learning theories will be reviewed to determine the technical feasibility of the proposed

approach, through AR techniques along with research on the design principles for acquired learning application. The interfaces design of the AR application allows users to follow a series of learning activities. For example, the learner can see the heart in 3D or for accessing supplementary information about the object by clicking on the particular button provided. Besides, the workflow of the application is also need to be designed in order to understand more on how the application is running. The details of the design part can be referred to chapter 4.

3.2.4 Development Phase

The project is developed based on the planning design and the AR application will be developed by using ARToolKit. The detailed information about ARToolKit can be found in Chapter 2. There are five parts in this phase:

i. Software and Hardware Requirements
ii. Software Installation
iii. 3D Models Creation
iv. Marker Creation and the AR Environment Development
v. AR Application Development

3.2.4.1 Software and Hardware Requirements

In order to develop the application, some of the software and hardware have been used in this project. There are two types of tools that are used in the project development which are:

i. Software tools (Windows based) as shown in Table 3.2
ii. Hardware tools as shown in Table 3.3

Table 3.2 Software Tools

Software Tools	Purposes
Windows 7 Home Premium 64-bit Operating System	Platform of whole development of project
Microsoft Word 2010	Platform of documentation of the project
Microsoft Power Point 2010	Platform for creating presentation slides and for designing the interfaces of AR application
Microsoft Project 2010	Platform for drawing Gantt Chart and planning the project outline
Google Chrome/ Mozilla Firefox	Web browser for research purpose
Avira Free Antivirus	Protection of viruses and malware
Adobe Reader	Viewing platform of PDF files
ARToolKit	For the creation of AR application
Adobe Photoshop CS6	For image editing purpose when designing the pattern of marker
Autodesk Maya 2013	For creating 3D models
Eclipse	For application development purpose

Table 3.3 Hardware Tools

Hardware Tools	Specifications	Purposes
Laptop	Name: Dell Processor: Intel (R) Core (TM) i3 CPU GHz RAM: 4GB System type: 64-bit Operating System	• Research purpose • Overall project development platform

Mobile Phone/ tab with camera	Platform: Android	• For running the AR application
Augmented Book	Based on science syllabus of secondary school	• For viewing the 3D objects via markers

3.2.4.2 Software Installation

In order to develop the proposed AR application, the very first step is to install the software required in the development. Some of the software such as Autodesk Maya 2014, Android SDK and Eclipse had been installed into the laptop with OS Window 7.

For the installation of Autodesk Maya 2014,

1) Download Autodesk Maya 2014 from the Autodesk website (student version) http://students.autodesk.com/?nd=download_center
2) Register as a member of Autodesk to get free product. When the installer is downloaded, launch it and then follow the instruction for installing the software.

For the installation of Java (JDK7),

1) Download the free version of Java DK from the website http://www.oracle.com/technetwork/java/javase/downloads/index.html

For the installation of Eclipse IDE and Android SDK

Eclipse is considered as an Integrated Development Environment (IDE) which is written in Java programming language for developing applications. The Android Software Development Kit (SDK) provides user the API libraries and

Android Developer Tools (ADT) as the plugin of Eclipse IDE that enable developer to set up new Android project, create the application UI, add packages based on the Android framework API, and debug the Android application. The Android application is exported as an .apk files.

1) Download Android SDK from http://developer.android.com/sdk/index.html
2) Setting up the ADT Bundle
   - ✓ Unpack the ZIP file (adt-bundle-windows-x86.zip) and save it to an appropriate location. Figure 3.2 below shows the Eclipse folder located in Local Disk (C:) directory.
   - ✓ Open the adt-bundle-windows-x86/eclipse/directory and launch eclipse as shown in Figure 3.3 below.

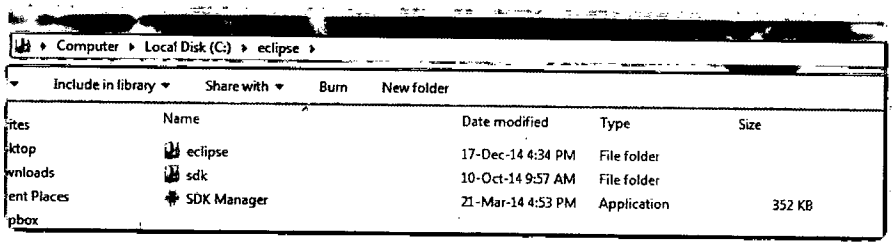


Figure 3.2 Eclipse (adt-bundle-windows-x86) folder located in Local Disk (C:) directory

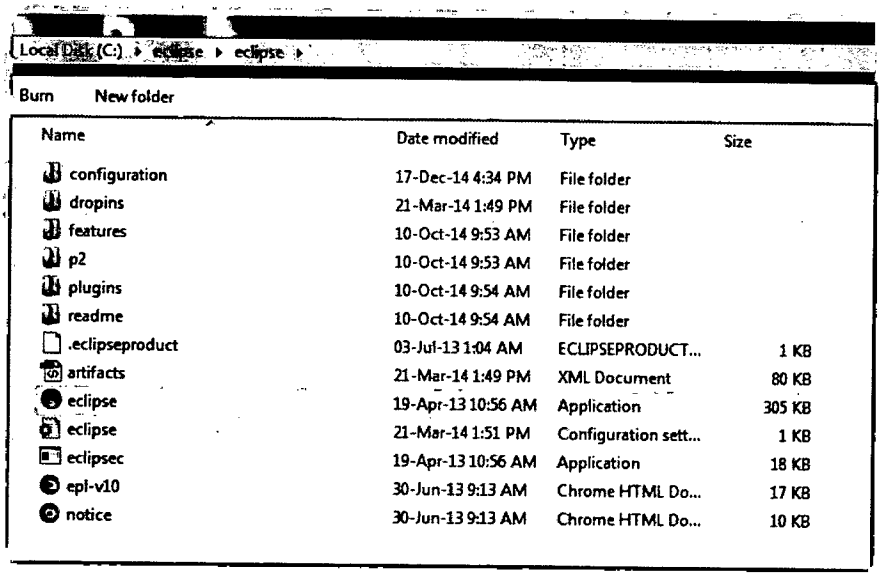


Figure 3.3 Launch eclipse.exe from eclipse folder

3) Installing the Eclipse Plugin
   - ✓ Run Eclipse, then select Help> Install New Software.
   - ✓ Click Add, in the top-right corner.
   - ✓ In the Add Repository dialog that appears, enter "ADT Plugin" for the Name and the following URL for the Location: http://dl-ssl.google.com/android/eclipse
   - ✓ Restart Eclipse after the installation completed.

3.2.4.3 3D Models Creation

Currently, there are many of the 3D modelling software in the market. For this project, the 3D models will be created by using Autodesk Maya 2014 in .mb file format. This is because Maya has a great ability to simulate realistic animations and effects. Figure 3.4, Figure 3.5 and Figure 3.6 below show some examples of 3D models that will be applied in AR mobile application for HBCS. The human heart 3D model had been created by using Maya software as shown in Figure 3.7.

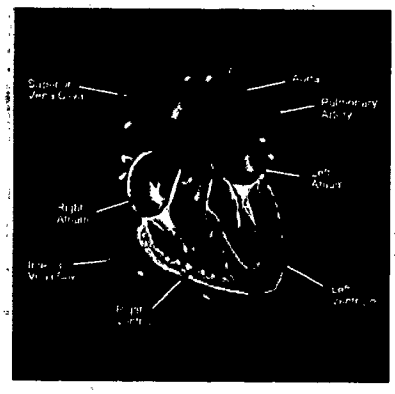


Figure 3.4 The Heart Structure

Figure 3.5 The Blood Vessels Structure

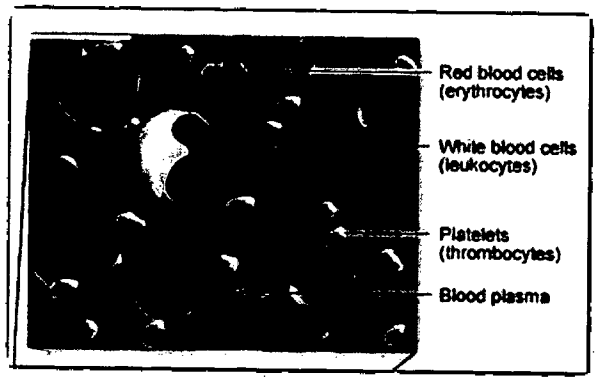


Figure 3.6 The Blood Structure

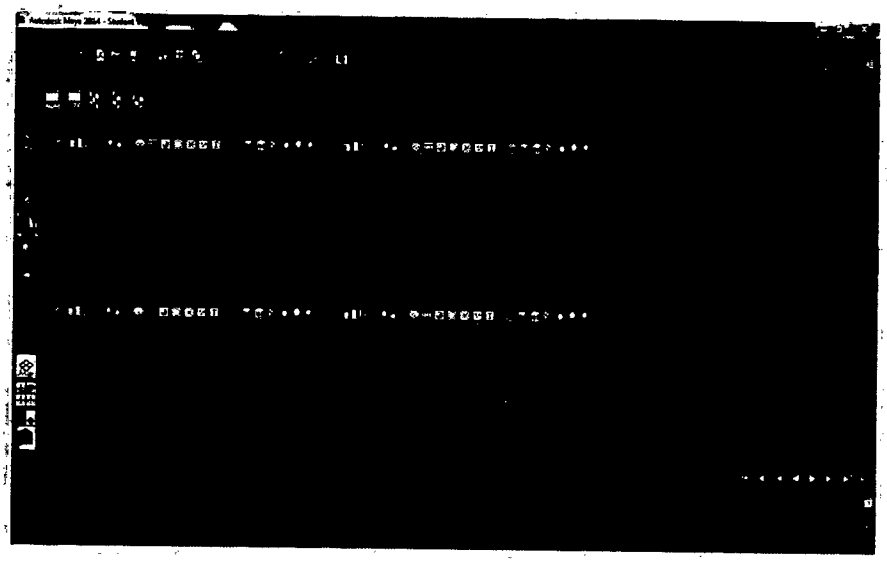


Figure 3.7 3D Human Heart Model in Autodesk Maya 2014

3.2.4.4 Marker Creation and The AR Environment Development

Marker is used in order to display the 3D content through the application. The 3D model will be generated when the camera of the device scans the relevant marker. Designing a pattern can be done with by using any image editing program. While designing pattern, there are some precautions to be taken as shown in Table 3.4.

Table 3.4 Precautions while designing a pattern

Precautions	Reason
The design must be unique (to avoid confusion)	• The system will be confused if the designs of two separate patterns are similar due to the fact that the resolution of the input hardware is not sensitive enough.
The design must not be symmetrical in both x-axis and y-axis	• To ensure that the orientation information which is important for AR application will not be lost.
The length of each side must be known	• The AR application needs to know the exact length for distance calculate purpose.
The design inside the blank marker must be in pure black	• Pattern recognition mechanism fails to recognize the design if done otherwise.

The marker techniques used in ARToolKit is marker-based and the type of marker is template markers. Figure 3.8 shows the marker that is used in this application. Its pattern is edited by using Adobe Photoshop CS6. It is generated through the ARToolKit Marker Maker in .pdf file format which is from a website http://www.roarmot.co.nz/ar/ as shown in Figure 3.9.

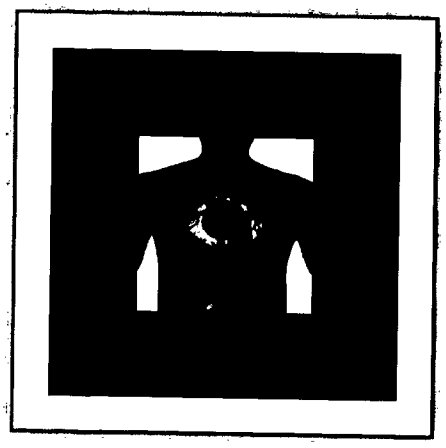


Figure 3.8 Marker used in AR Human Blood Circulatory System

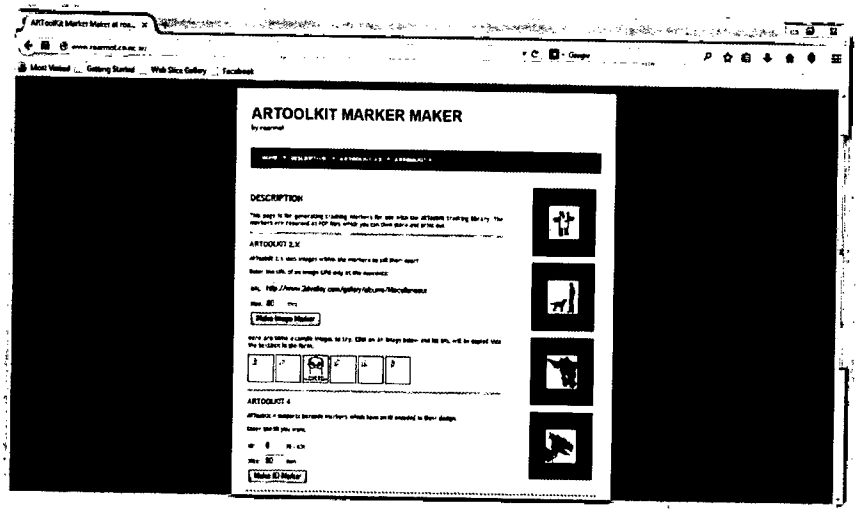


Figure 3.9 Website of generating marker in .pdf file format

A marker is printed out after the marker in .pdf file format has been generated. The marker has to be readable and recognized by the NyARToolKit. Therefore, the marker is converted into .pat file format through the website http://flash.tarotaro.org/blog/2009/07/12/mgo2/ as shown in Figure 3.10.

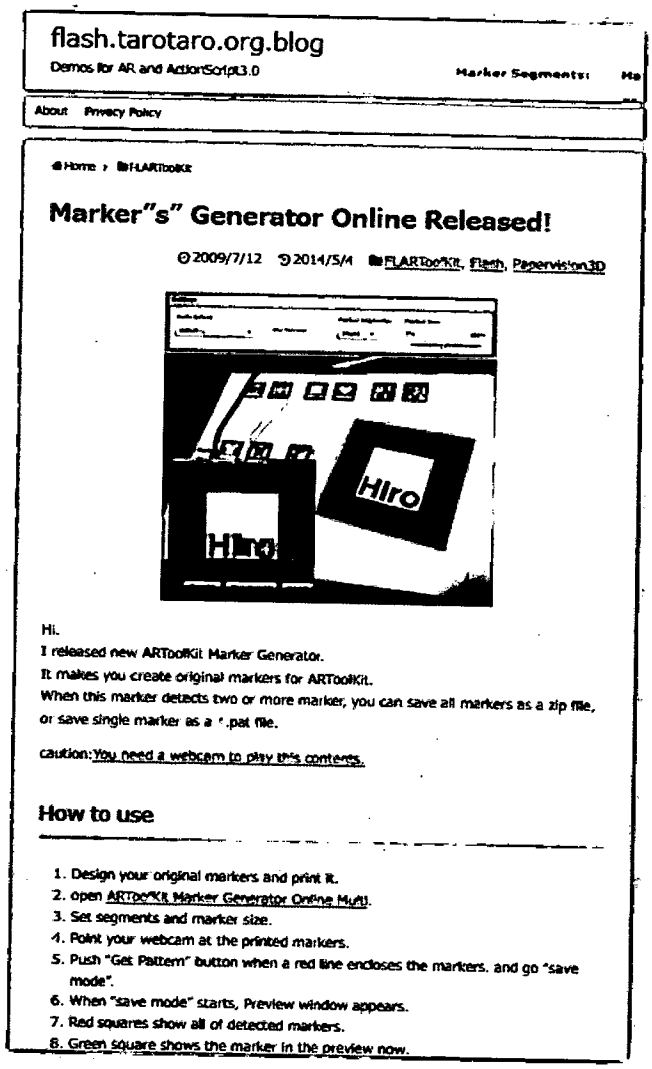
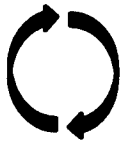


Figure 3.10 Website of converting marker into .pat file format

The core of ARToolKit is composed of a main loop. As seen in Table 3.5, there are six steps of ARToolKit. The functions, which correspond to steps two through five, run repeatedly from main loop. First of all, 3D video frame is transformed into 2D.

Table 3.5 Steps inside an application using ARToolKit

ARToolKit Step	Function	Process
1. Initialize the application	*init*	Initialization
2. Grab a video input frame **3. Detect the markers** **4. Calculate camera transformation** **5. Draw the virtual objects**	*arVideoGetImage* *arDetectMarker* *arGetTransMat* *draw*	Main Loop 
6. Close the video path down	*cleanup*	Shutdown

After that, the algorithm searches for the black squares which are called markers. Next, all markers are examined to see if they are matching patterns. After the transformation calculations, all patterns are aligned with virtual objects. These steps run simultaneously until the program is aborted. Figure 3.11 below shows the basic principles of ARToolKit:

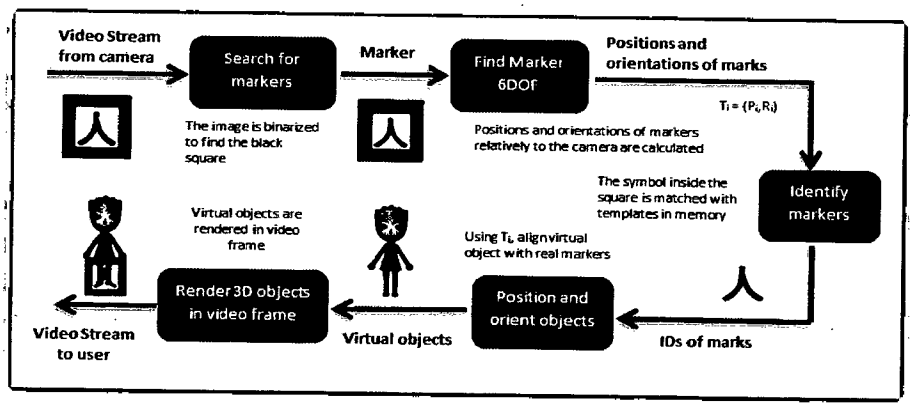


Figure 3.11 ARToolKit Basic Principles

3.2.4.5 AR Application Development

The details of the AR application development can be referred to Chapter 5.

3.2.5 Testing Phase

There are three parts are discussed during testing phase:

i. Testing Types
ii. Participants
iii. Evaluation Method

3.2.5.1 Testing Types

After the completion of the AR application, a testing will be conducted to test the application from various aspects. This is to ensure that the application is worth enough to have a positive experience from the user when they use the AR mobile application. In order to test the effectiveness of the AR application in the learning process, some of the aspects have been considered such as functionality, usability and performance. Table 3.6 below shows the aspects and the types of testing that will be used in testing the application.

Table 3.6 The aspects and the types of testing

Aspect	Areas/ Types of testing
1) Functionality	• Does all of the individual function of the AR application working well?
2) Usability	• Does the AR application will be useful in helping student to understand the science topic (human blood circulatory system)? • Does the interface of the AR application have user friendly design? • Does the AR application is easy to use?
3) Performance	• Does the transaction completion time(s) of each of the individual function in the AR application is satisfied?

3.2.5.2 Participants

20 of the participants will be selected randomly from those who wish to use this AR application especially for the secondary school science student.

3.2.5.3 Evaluation Method

In order to get the feedback about the application from users, a google survey form's link will be given to 20 users. An analysis about the feedback will be conducted in order to know the level of effectiveness of the AR mobile application. The details questions can be referred to chapter 6. Below are the sample questions that will be asked in the google form:

Table 3.7 Sample question asked in the google survey form

Aspect	Sample Questions
1) Functionality	• All of the individual function of the AR application working well?
2) Usability	• The application is useful for my learning/teaching in science (human blood circulatory system)? • The application has user friendly interface design? • The AR application is easy to use?
3) Performance	• The transaction completion time(s) of each of the individual function is fast?

CHAPTER 4

DESIGN

4.1 Introduction

Design is an important step in application development and it should be done before developing the AR application. This chapter is basically discussing about the AR book design for the application, the interface design of the proposed AR application and the workflow design of the application.

4.2 AR Book Design for HBCS

This 3D Augmented Reality Book consists of nine pages including the cover page and the end page. It is developed specifically for the form three students who are learning subject science. The topic covered in this AR book is Human Blood Circulatory System which is focusing on the three main parts of the circulatory system – The Heart, The Blood Vessels and The Blood. Basically, the book is made by using A4 paper 80 g/m^2 and the background color used for each page is the same which is white in color.

The first page of the AR book is the cover page. It is just a common page which includes text and a picture only. Figure 4.1 shows the cover page of the AR book. The first page of the AR book is the instruction page as shown in Figure 4.2. This page is guiding the students on how to use the AR book with the AR application.

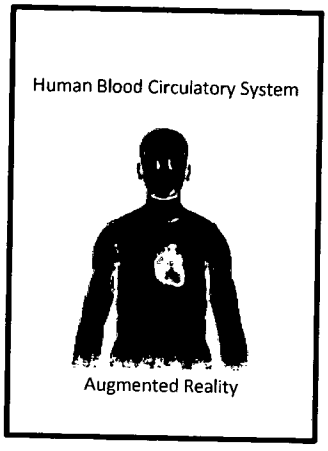


Figure 4.1 Cover Page of AR book

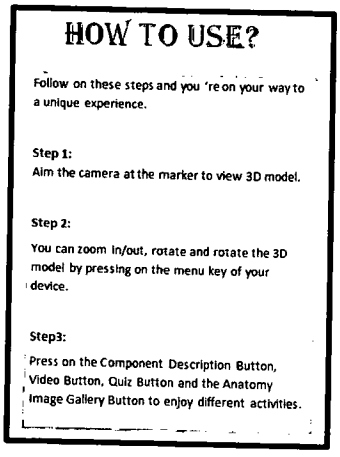


Figure 4.2 Instruction Page of AR book

There are two pages of each component description. Therefore, the component descriptions pages are from the second page until the seventh page. These pages are just performing the same flow of use. There are the heart page, the blood vessels page and the blood page respectively. It includes a picture of heart or a picture of blood vessels or a picture of blood, a marker and a text area. The students can read and understand the information or explanation written on the book as usual. Then, there is a marker placed at the last page of the AR book as shown in Figure 4.6. Users can be started to enjoy the AR learning experience with the AR application when they aim the camera of their smartphone or tab to the marker. Besides reading the sentences in the explanation text area, they can play around with the 3D object in AR learning environment on the marker. There are some teaching materials provided by the AR application such as component descriptions, educational videos, anatomy image galleries and quizzes. The students are learning science in the fun way with AR technology.

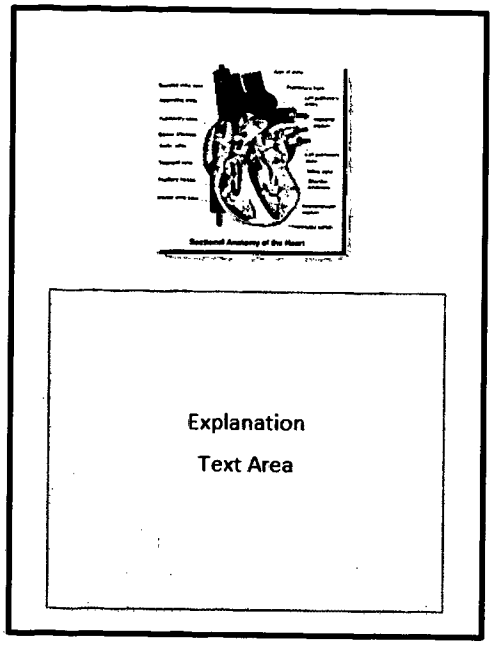


Figure 4.3 The Heart Page of AR book

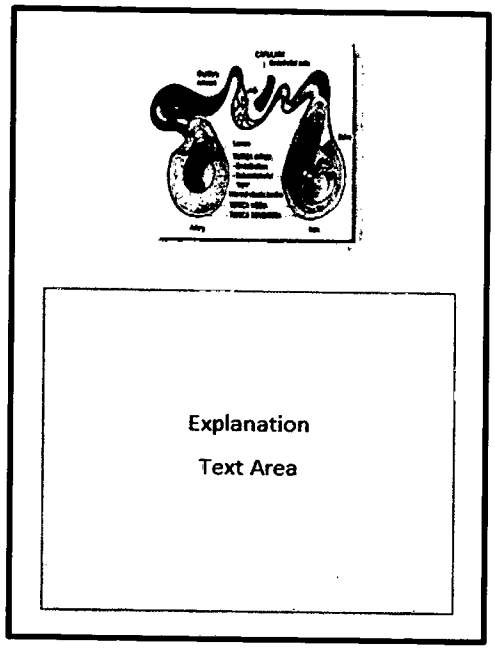


Figure 4.4 The Blood Vessels Page of AR book

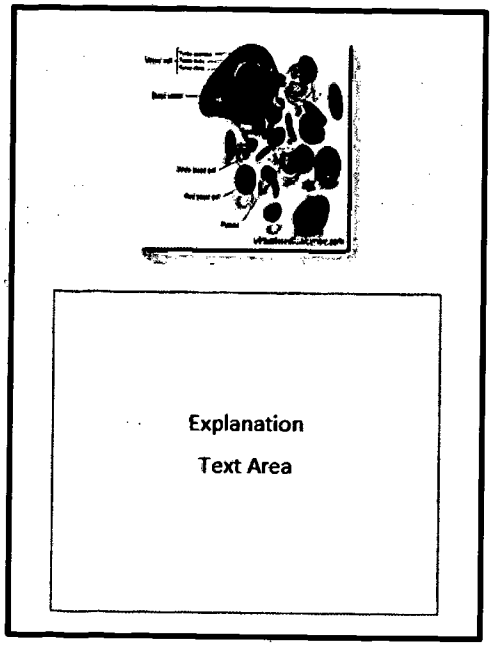


Figure 4.5 The Blood Page of AR book

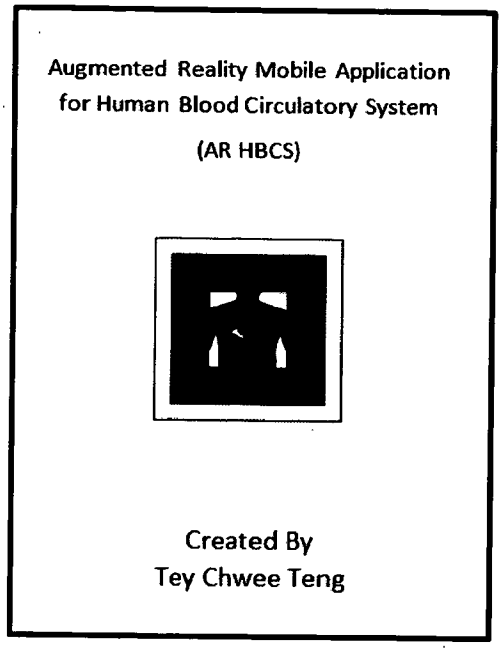


Figure 4.6 The Marker and End Page of AR book

4.3 AR Mobile Application Interface Design for HBCS

Basically, this AR application is divided into several modules – Splash Screen and Main Interface Module, 3D Model Module, About Module, Instruction Module, Component Descriptions Module, Video Module, Quiz Module and Anatomy Image Gallery Module. Since there are three subtopics covered under HBCS, so all of these three subtopics are includes those modules. The interface design of one of the subtopic which is the heart is shown as below. For the interface design of another two subtopics, it is just the same. The expected interfaces of AR HBCS are shown in Figure 4.7, Figure 4.8, Figure 4.9, Figure 4.10, Figure 4.11, Figure 4.12, Figure 4.13, Figure 4.14, Figure 4.15 and Figure 4.16 respectively.

Figure 4.7 below shows the splash screen of the AR application. It consists of the related texts and picture only.

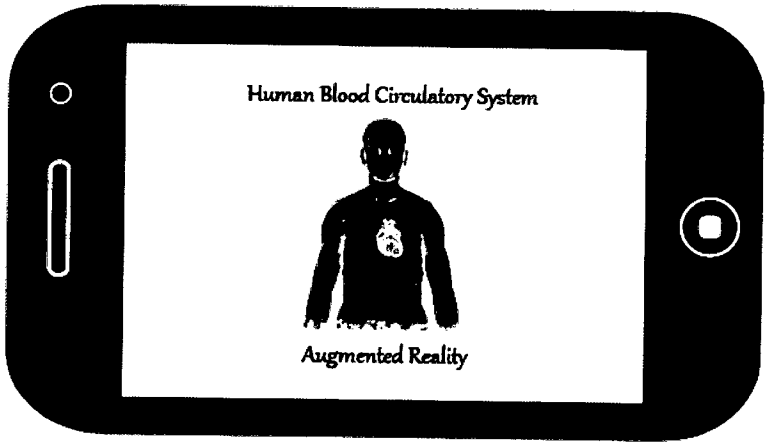


Figure 4.7 Splash Screen of the AR application

Since Human Blood Circulatory System consists of the heart, blood vessels and blood, so there are three buttons in the main menu page as shown in Figure 4.8. The brief description and the image of the component will be displayed on each of the button.

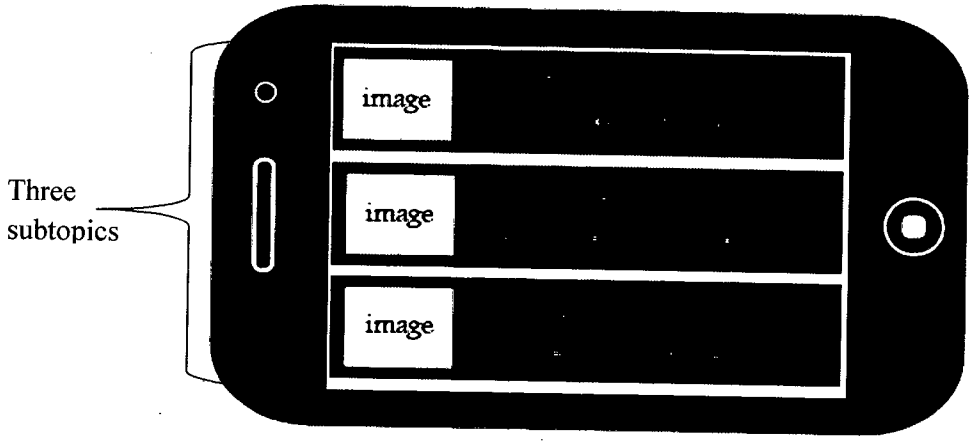


Figure 4.8 Main Menu of the AR application

Figure 4.9 below shows the 3D model page. Users can see a 3D heart pop-up on the marker in this page. It consists of the instruction button, component descriptions button, video button and quiz button. Besides, there are some tools at the bottom of the screen for interaction between the users and the 3D model. The tools including the zoom tool, rotate tool, move tool and the anatomy image gallery.

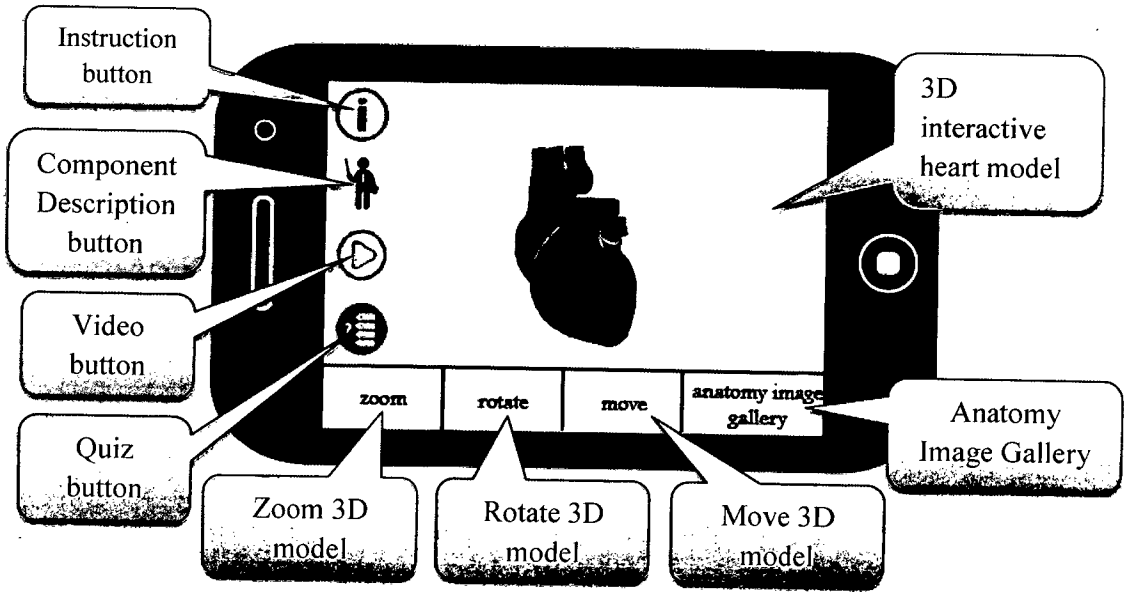


Figure 4.9 3D model page of the AR application

Figure 4.10 below shows the anatomy image gallery page. Some anatomy images will be displayed at the bottom of the screen for selection. Users can see the structure of the heart through the images in this page.

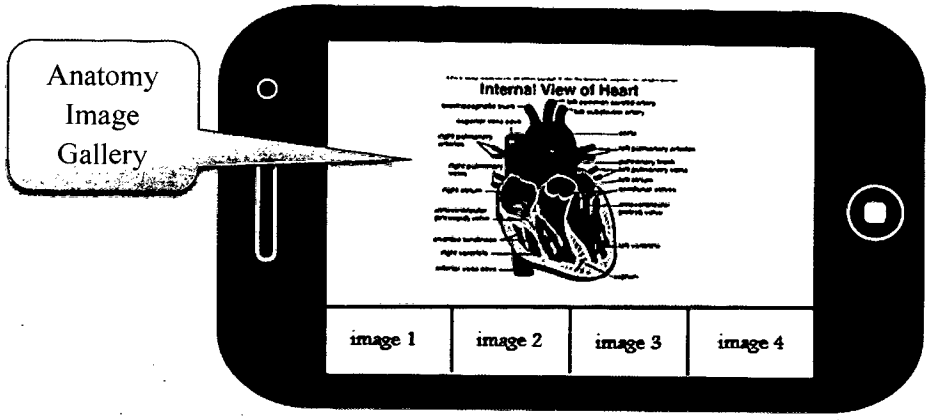


Figure 4.10 Anatomy image gallery page of the AR application

Figure 4.11 below shows the instruction page. It will show the steps on how to use the AR application.

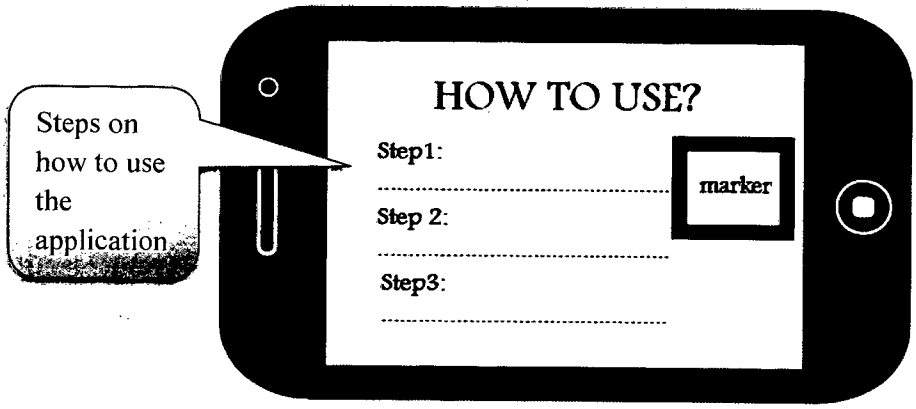


Figure 4.11 Instruction page of the AR application

Figure 4.12 shows the component descriptions page. This page is mainly displays the notes or explanation about the selected component.

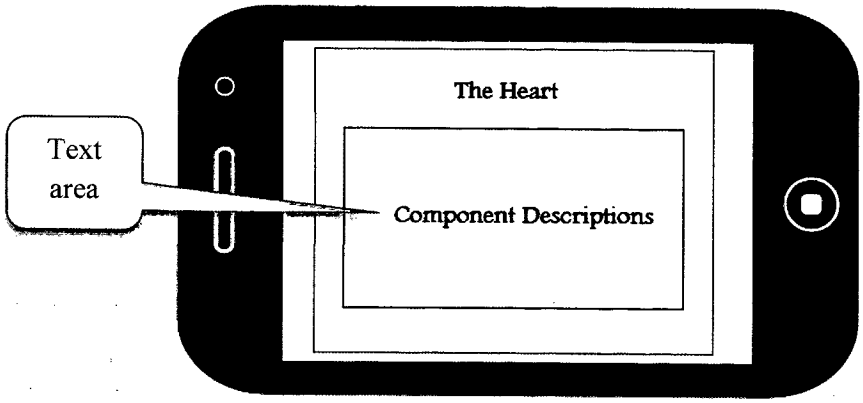


Figure 4.12 Component descriptions page of the AR

Figure 4.13 below shows the video page. This page allows students to play an educational video of the related subtopic.

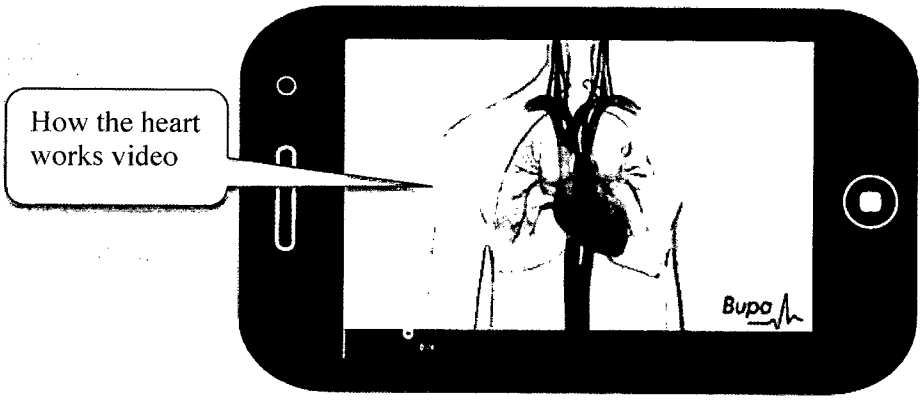


Figure 4.13 Video page of the AR application

Figure 4.14 shows the quiz page. There are ten questions in the quiz with three options of the answer. Figure 4.15 shows the result page from the quiz. It displays the result (correct/incorrect) of each of the questions and shows the score at the bottom of the screen.

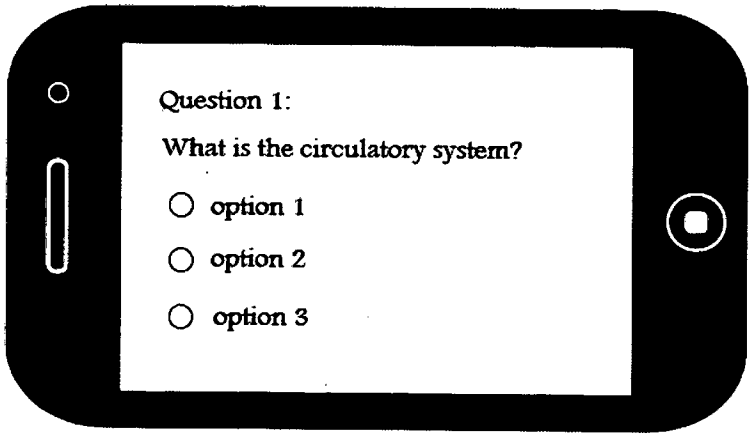


Figure 4.14 Quiz page of the AR application

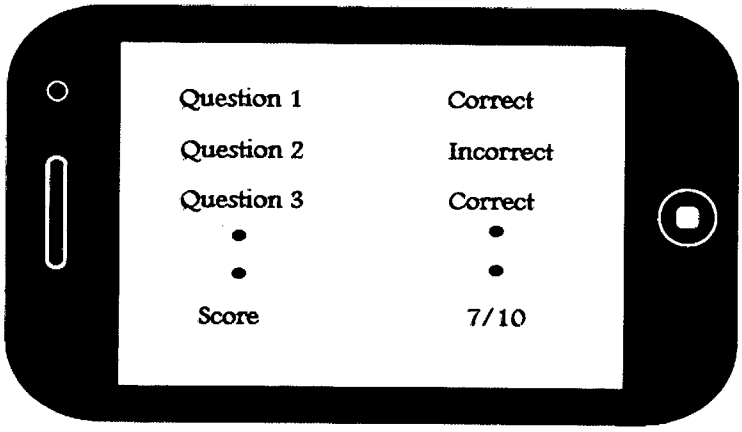


Figure 4.15 Result page from the Quiz

Figure 4.16 shows the about page. Some information about the application is displayed in this page. For example, the developer's name, version of the application, copyright of the application, etc.

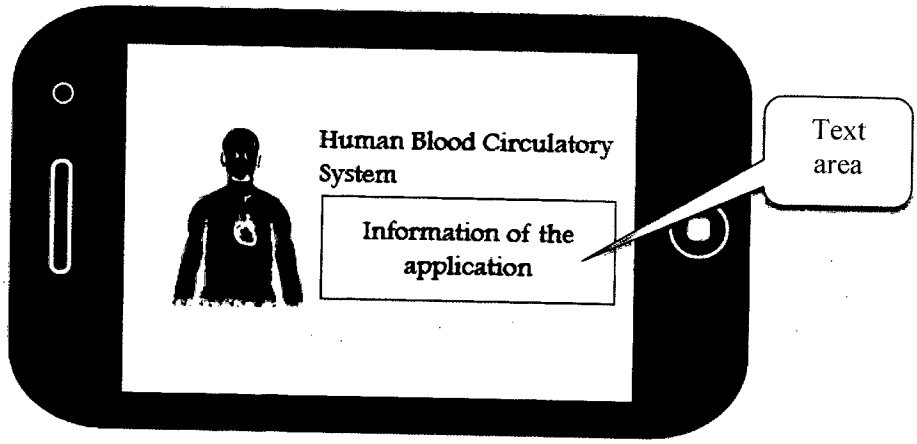


Figure 4.16 About page of the AR application

4.4 Workflow Design of AR HBCS

The workflow of the application is designed according to the flow chart as shown in Figure 4.17. It is showing the steps or algorithm when the users running the application.

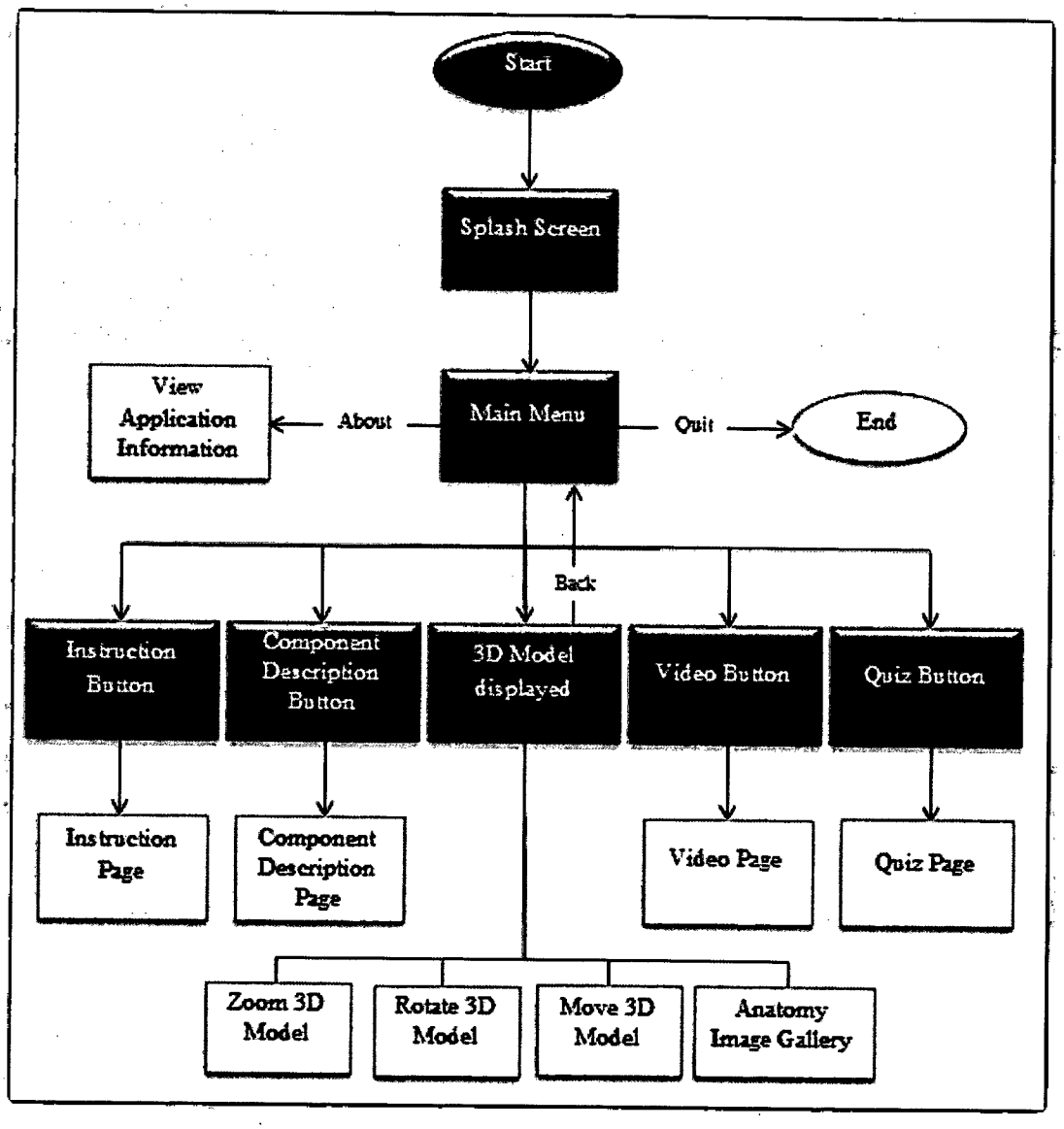


Figure 4.17 Workflow of AR HBCS

CHAPTER 5

IMPLEMENTATION

5.1 Introduction

This chapter is mainly discussing about the interface and coding of the AR mobile application for Human Blood Circulatory System in Android.

5.2 Splash Screen and Main Menu Module

The Splash Screen is the first view for the users when the application starts loading. It displays a picture of human blood circulatory system and greeting text with its application name while the application is loading as shown in Figure 5.1. It will automatically proceed to the Main Menu Page after 4 seconds once the application starts loading. The code of splash screen interface is shown in Figure 5.2 while the code of its implementation part is shown in Figure 5.3. The Main Menu Page interface of AR Human Blood Circulatory System is shown in Figure 5.4 where its coding parts are shown in Figure 5.5 and Figure 5.6 respectively.

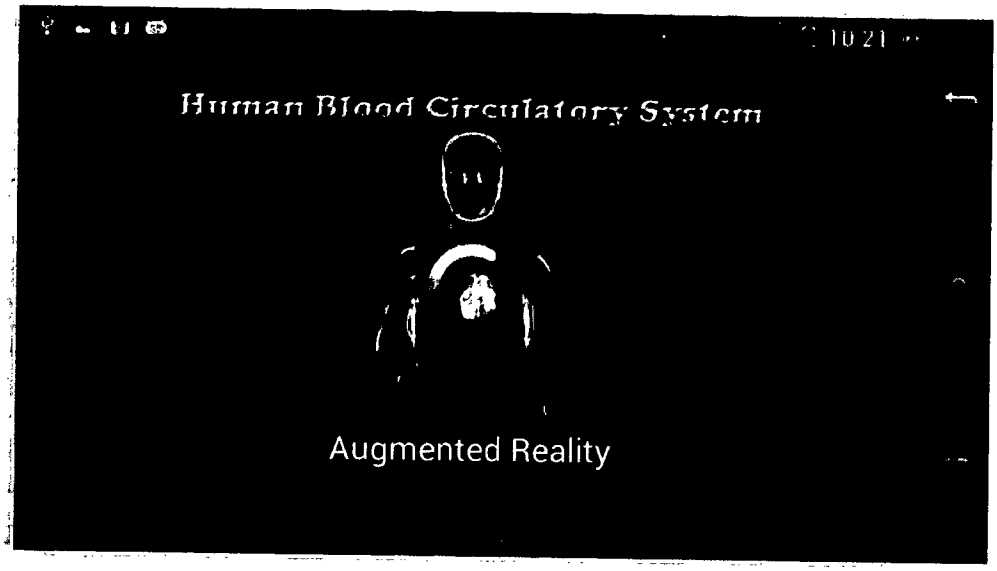


Figure 5.1 Splash Screen of AR Human Blood Circulatory System

```
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="wrap_content"
    android:layout_height="match_parent"
    android:background="@drawable/background"
    android:gravity="top"
    android:minWidth="100dip"
    tools:context=".SplashActivity" >

    <TextView
        android:id="@+id/textView1"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_below="@+id/imageView2"
        android:layout_centerHorizontal="true"
        android:text="@string/ar"
        android:textAppearance="?android:attr/textAppearanceLarge" />

    <ImageView
        android:id="@+id/imageView1"
        android:layout_width="400dp"
        android:layout_height="400dp"
        android:layout_alignParentBottom="true"
        android:layout_centerHorizontal="true"
        android:layout_marginBottom="81dp"
        android:contentDescription="@string/ar"
        android:src="@drawable/human" />

    <ImageView
        android:id="@+id/imageView2"
        android:layout_width="1500dp"
        android:layout_height="200dp"
        android:layout_alignParentLeft="true"
        android:layout_alignParentTop="true"
        android:layout_marginTop="26dp"
        android:contentDescription="@string/ar"
        android:src="@drawable/greetingtext" />

    <ProgressBar
        android:id="@+id/progressBar1"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_below="@+id/textView1"
        android:layout_centerHorizontal="true"
        android:layout_marginTop="56dp"
        android:minHeight="60dp"
        android:minWidth="60dip" />

</RelativeLayout>
```

Figure 5.2 Splash Screen interface xml codes

```
 1  package com.ar.hbcsar;
 2
 3⊕ import com.ar.hbcsar.R;
 8
 9  public class SplashActivity extends Activity {
10
11⊖     @Override
12      public void onCreate(Bundle savedInstanceState) {
13          super.onCreate(savedInstanceState);
14          setContentView(R.layout.activity_splash);
15
16⊖         Thread logoTimer = new Thread(){
17⊖             public void run(){
18                  try{
19                      sleep(4000);
20                      Intent menu = new Intent("android.intent.action.MAINMENUACTIVITY");
21                      startActivity(menu);
22                  }
23                  catch (InterruptedException e) {
24                      // TODO Auto-generated catch block
25                      e.printStackTrace();
26                  }
27                  finally{
28                      finish();
29                  }
30              }
31          };
32          logoTimer.start();
33      }
34
35⊖     @Override
36      protected void onPause() {
37          // TODO Auto-generated method stub
38          super.onPause();
39      }
40  }
41
```

Figure 5.3 Splash Screen implementation java codes

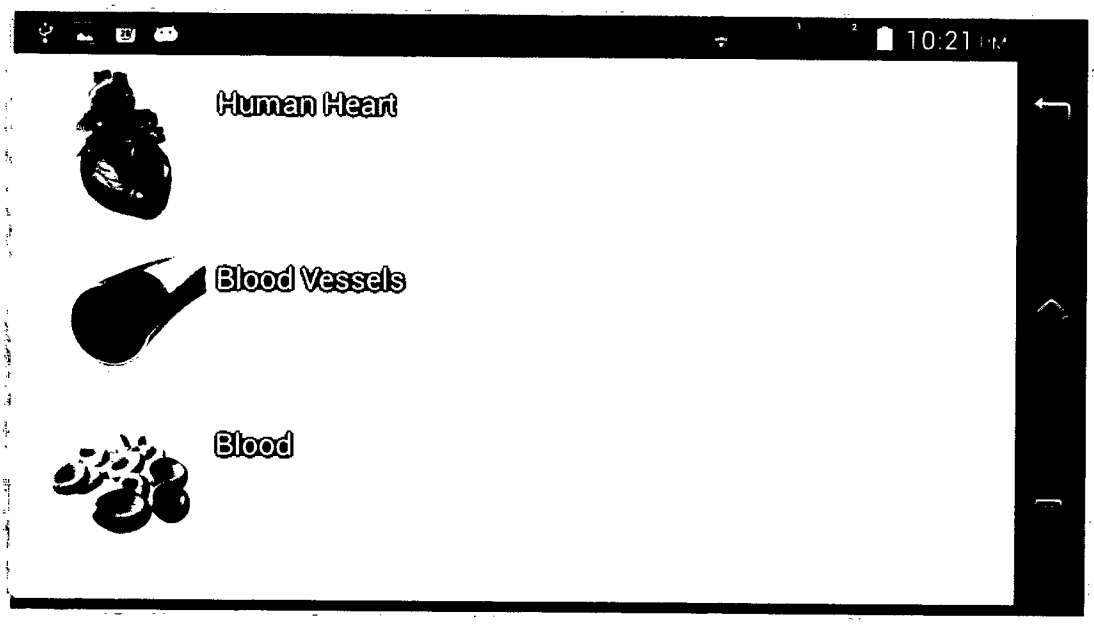


Figure 5.4 Main Menu Page of AR Human Blood Circulatory

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:orientation="horizontal" >

    <ImageView
        android:id="@+id/imageView1"
        android:layout_width="100dp"
        android:layout_height="100dp"
        android:layout_marginLeft="10dp"
        android:src="@drawable/c1" />

    <LinearLayout
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:orientation="vertical"
        android:padding="5dp" >

        <TextView
            android:id="@+id/textView1"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_marginTop="5dp"
            android:text="@+id/label"
            android:textAppearance="?android:attr/textAppearanceMedium" />

        <TextView
            android:id="@+id/textView2"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:layout_marginTop="14dp"
            android:text="Small Text"
            android:textAppearance="?android:attr/textAppearanceSmall" />
    </LinearLayout>
</LinearLayout>
```

Figure 5.5 Main Menu Page interface xml codes

```
1  package com.ar.showroom;
2
3  import com.ar.showroom.R;
4
5  import android.os.Bundle;
6  import android.app.Activity;
7  import android.content.Context;
8  import android.content.Intent;
9  import android.view.LayoutInflater;
10 import android.view.Menu;
11 import android.view.MenuInflater;
12 import android.view.MenuItem;
13 import android.view.View;
14 import android.view.ViewGroup;
15 import android.widget.AdapterView;
16 import android.widget.BaseAdapter;
17 import android.widget.GridView;
18 import android.widget.ImageView;
19 import android.widget.TextView;
20 import android.widget.AdapterView.OnItemClickListener;
21
22 public class MainMenuActivity extends Activity {
23
24     GridView gridView;
25
26     static final String[] CAR_MODEL = new String[]{
27         "Human Heart", "Blood Vessels"};
28
29     @Override
30     public void onCreate(Bundle savedInstanceState) {
31         super.onCreate(savedInstanceState);
32         setContentView(R.layout.activity_main_menu);
33
34         GridView gridview = (GridView) findViewById(R.id.gridView1);
35         gridview.setAdapter(new ImageAdapter(this, CAR_MODEL));
36
37         gridview.setOnItemClickListener(new OnItemClickListener(){
38
39          public void onItemClick(AdapterView<?> parent, View v, int position, long id) {
40              // TODO Auto-generated method stub
41              if(position == 0){
42                  Intent i = new Intent("android.intent.action.SHOWROOM");
43                  startActivity(i);
44              }else if(position == 1){
45                  Intent i = new Intent("android.intent.action.MENU2ACTIVITY");
46                  startActivity(i);
47              }else{
48
49              }
50
51          }
52
53      });
54  }
55
56  public class ImageAdapter extends BaseAdapter{
57
58      public final String[] mModel;
59
60
61      public Integer[] mThumbIds = {
62              R.drawable.c1, R.drawable.c2, R.drawable.c3,
63              R.drawable.c4, R.drawable.c5, R.drawable.c6, R.drawable.c7};
64
65      private Context mContext;
66
67      public ImageAdapter(Context c, String[] m) {
68          // TODO Auto-generated constructor stub
69          this.mContext = c;
70          this.mModel = m;
71      }
```

Figure 5.6 Main Menu Page implementation java codes

5.3 Marker Module

The marker which has been converted into .pat file format is then imported into the raw folder in the Eclipse project. It will then read and recognized by the system in the initialization process of the application through the codes as shown in Figure 5.7 below.

```
private void initializeGLSurfaceView() {

    // initialize ARToolkit.
    if (arToolkitDrawer == null) {
        InputStream camePara = getResources().openRawResource(R.raw.camera_para);
        int[] width = new int[2];
        for (int i = 0; i < 2; i++) {
            // Specify the marker size
            width[i] = 80;
        }
        ArrayList<InputStream> patt = new ArrayList<InputStream>();
        // Set marker patterns
        patt.add(getResources().openRawResource(R.raw.pattmarker));

        arToolkitDrawer = new ARToolkitDrawer(camePara, width, patt, mRenderer);
```

Figure 5.7 Java code of recognizing the marker pattern

5.4 3D Model Module

In this module, three of the 3D models will be generated and exported as .md2 file format with its texture in .png file format by using Blender. There are the heart, the blood vessels and the blood. Then, the object is imported to the raw folder of the Eclipse project while the texture of the 3D model is imported into the drawable folder. When the correct marker is detected, the 3D model will be generated and displayed through the application. The interface of one of the subtopic which is the heart is shown in Figure 5.8. All of the 3D models will be displayed on a same marker depends on what the action performed by the users. The java codes of generating the 3D object in .md2 file format is shown in Figure 5.9.

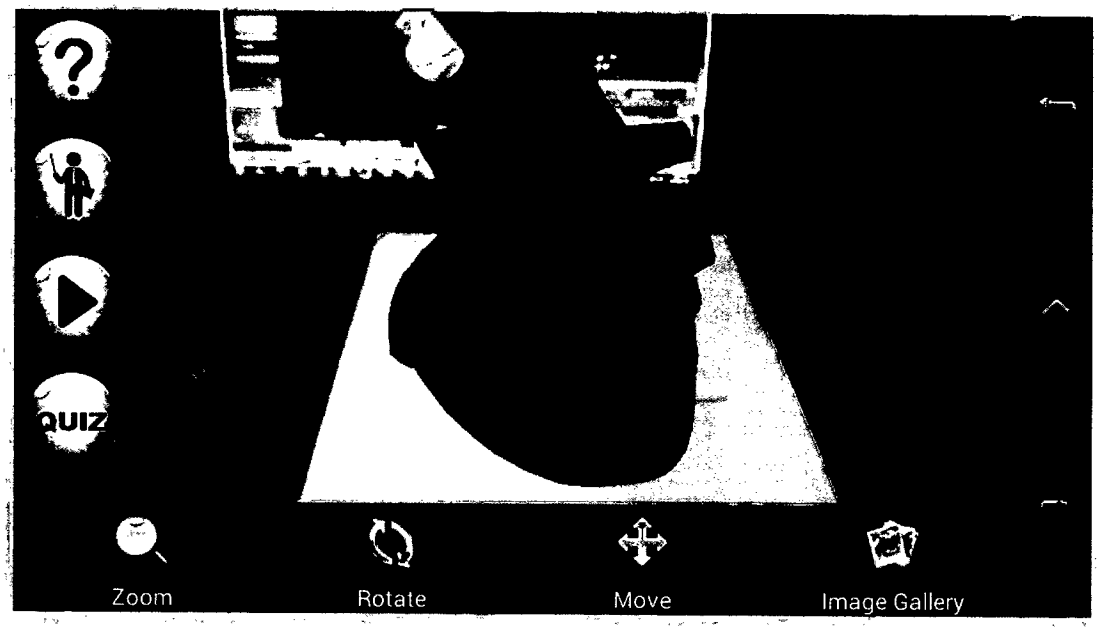


Figure 5.8 A 3D object view of AR Human Blood Circulatory System

```
AnimationObject3d animationObject3d = null;

public void initScene(){
    // Set light settings and depth
    scene.lights().add(new Light());
    scene.camera().frustum.zFar(10000.0f);
    //scene.camera().frustum.shortSideLength(0.77f);

    IParser parser;

    // Get the data model

    parser = Parser.createParser(Parser.Type.MD2,
            getResources(), "com.ar.showroom:raw/heart", false);
    parser.parse();

    // The size of the model data, angle, animation settings
    animationObject3d = parser.getParsedAnimationObject();
    animationObject3d.rotation().z = 0.0f;
    animationObject3d.scale().x = animationObject3d.scale().y = animationObject3d.scale().z = 0.25f;
    scene.addChild(animationObject3d);
    animationObject3d.setFps(30);
```

Figure 5.9 Java code of generating the 3D object in .md2 file format

5.5 Anatomy Image Gallery Module

Anatomy Image gallery module shows the anatomy of the related 3D model in 2D images. There is a list of images displaying in the bottom of the page. When users click on the small images, the original size image will be shown as in Figure 5.10. Users would be able to gain more understanding about the anatomy of the particular 3D model or the process of blood circulation system. The xml codes of the interface and the java codes of the implementation part for this page are shown in Figure 5.11 and Figure 5.12 respectively.

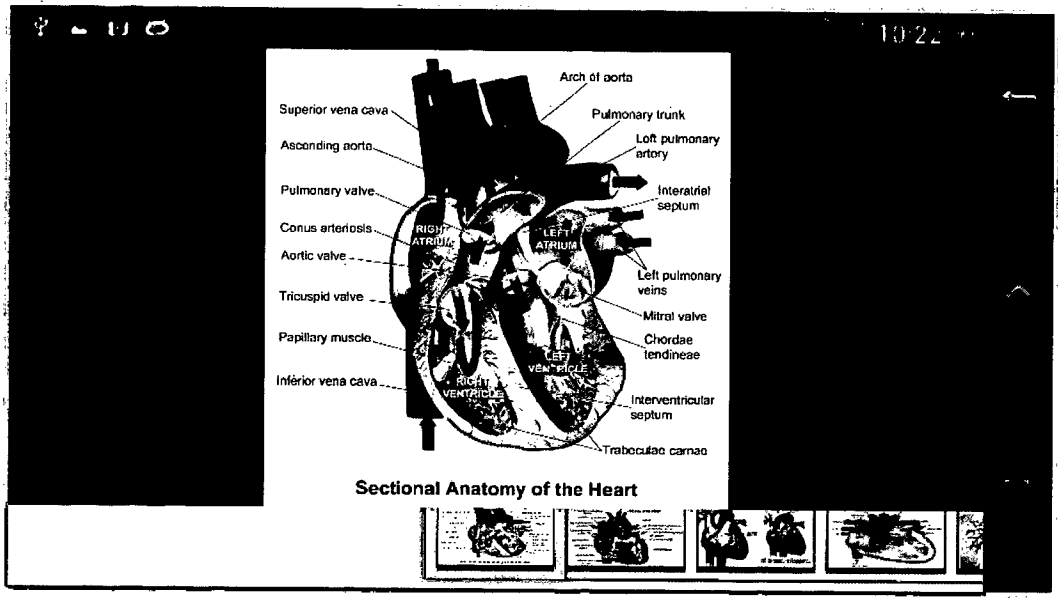


Figure 5.10 Anatomy Image Gallery of the heart anatomy

```
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    tools:context=".GalleryActivity" >

    <Gallery
        android:id="@+id/gallery"
        android:layout_width="match_parent"
        android:layout_height="wrap_content"
        android:layout_alignParentBottom="true"
        android:layout_alignParentLeft="true" />

    <ImageSwitcher
        android:id="@+id/switcher"
        android:layout_width="match_parent"
        android:layout_height="match_parent"
        android:layout_alignParentLeft="true"
        android:layout_alignParentTop="true"
        android:layout_marginBottom="50dp" >

    </ImageSwitcher>

</RelativeLayout>
```

Figure 5.11 Anatomy Image Gallery interface xml codes

```
package com.ar.showroom;

import com.ar.showroom.R;

public class GalleryActivity extends Activity implements ViewFactory {

    private ImageSwitcher iSwitcher;
    private Integer[] iImageIds = {
            R.drawable.c1, R.drawable.c2, R.drawable.c3,
            R.drawable.c4, R.drawable.c5, R.drawable.c6, R.drawable.c7};

    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        requestWindowFeature(Window.FEATURE_NO_TITLE);
        setContentView(R.layout.activity_gallery);

        iSwitcher = (ImageSwitcher) findViewById(R.id.switcher);
        iSwitcher.setFactory(this);
        iSwitcher.setInAnimation(AnimationUtils.loadAnimation(this, android.R.anim.fade_in));
        iSwitcher.setOutAnimation(AnimationUtils.loadAnimation(this, android.R.anim.fade_out));
        iSwitcher.setImageResource(iImageIds[0]);

        Gallery g = (Gallery) findViewById(R.id.gallery);
        g.setAdapter(new ImageAdapter(this));
        g.setOnItemClickListener(new OnItemClickListener(){

            public void onItemClick(AdapterView<?> parent, View v, int position,
                    long id) {
                // TODO Auto-generated method stub
                iSwitcher.setImageResource(iImageIds[position]);
            }
    });
}

public class ImageAdapter extends BaseAdapter{

    private Context iContext;

    int iGalleryItemBackground;

    public ImageAdapter(Context c) {
        // TODO Auto-generated constructor stub
        iContext = c;
        TypedArray a = obtainStyledAttributes(R.styleable.Gallery);
        iGalleryItemBackground = a.getResourceId(R.styleable.Gallery_android_galleryItemBackground,
        a.recycle();
    }

    public int getCount() {
        // TODO Auto-generated method stub
        return iImageIds.length;
    }

    public Object getItem(int position) {
        // TODO Auto-generated method stub
        return position;
    }

    public long getItemId(int position) {
        // TODO Auto-generated method stub
        return position;
    }
```

Figure 5.12 Anatomy Image Gallery implementation java codes

5.6 About Module

About module displays the simple information about the AR Human Blood Circulatory System as shown in Figure 5.13. Users can get back to the previous page by pressing the Back Button of the device or quit the application by pressing the Quit Button provided in the application as shown in Figure 5.14. The xml codes of the interface and the java codes of the implementation part for this page are shown in Figure 5.15 and Figure 5.16 respectively.

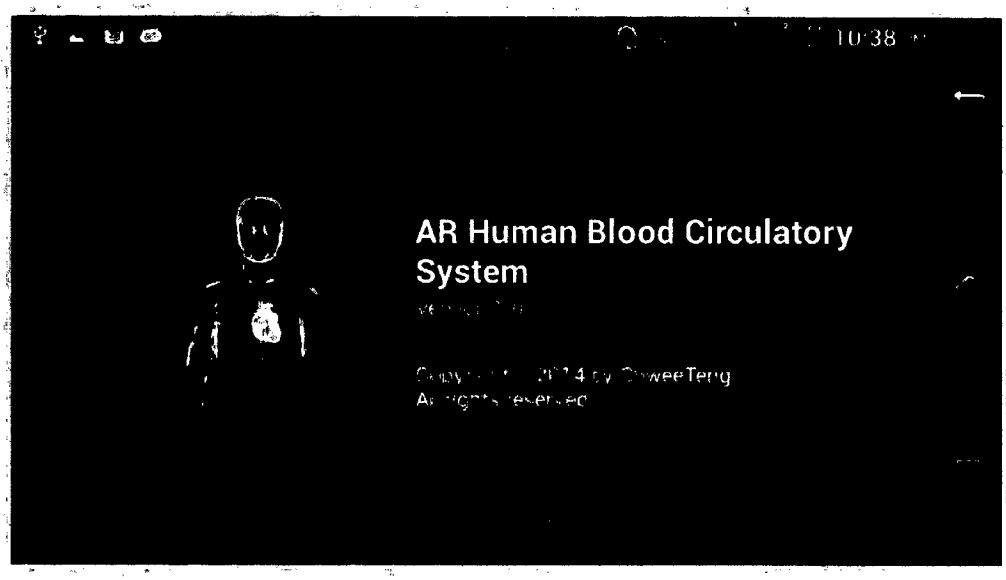


Figure 5.13 About Page of AR Human Blood Circulatory System

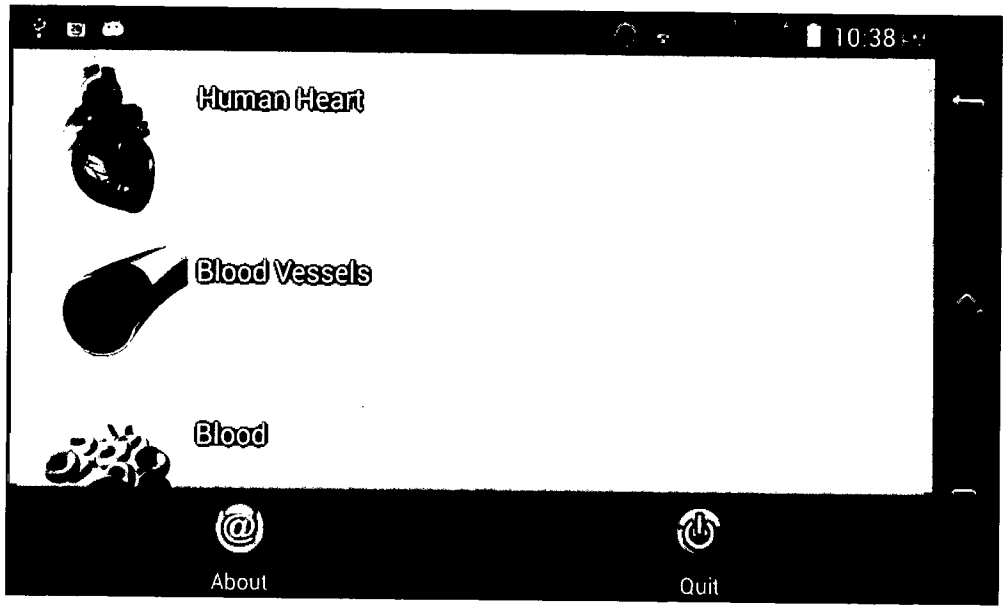


Figure 5.14 About and Quit buttons on the Menu Page

```
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="fill_parent"
    android:layout_height="fill_parent"
    android:background="@drawable/background"
    android:orientation="horizontal"
    tools:context=".AboutActivity" >

    <ImageView
        android:id="@+id/imageView1"
        android:layout_width="150dp"
        android:layout_height="150dp"
        android:layout_centerVertical="true"
        android:layout_marginLeft="85dp"
        android:contentDescription="@string/app_name"
        android:src="@drawable/human" />

    <LinearLayout
        android:id="@+id/linearLayout1"
        android:layout_width="wrap_content"
        android:layout_height="wrap_content"
        android:layout_centerVertical="true"
        android:layout_marginLeft="25dp"
        android:layout_toRightOf="@+id/imageView1"
        android:orientation="vertical" >

        <TextView
            android:id="@+id/textView1"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:text="@string/app_name"
            android:textAppearance="?android:attr/textAppearanceLarge"
            android:textStyle="bold" />

        <TextView
            android:id="@+id/textView2"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:text="@string/version"
            android:textAppearance="?android:attr/textAppearanceSmall" />

        <TextView
            android:id="@+id/textView4"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:textAppearance="?android:attr/textAppearanceMedium" />

        <TextView
            android:id="@+id/textView3"
            android:layout_width="wrap_content"
            android:layout_height="wrap_content"
            android:text="@string/copyright"
            android:textAppearance="?android:attr/textAppearanceSmall" />
    </LinearLayout>

</RelativeLayout>
```

Figure 5.15 About Page interface xml codes

```
package com.ar.showroom;

import com.ar.showroom.R;

public class AboutActivity extends Activity {

    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.activity_about);
    }

    @Override
    public void onBackPressed() {
        // TODO Auto-generated method stub
        finish();
        finishActivity(000);
        super.onBackPressed();
    }

}
```

Figure 5.16 About Page implementation java codes

5.7 Instruction Module

The main function of instruction module is to guide the users on how to use this AR Human Blood Circulatory System mobile application as shown in Figure 5.17. The xml codes of the interface and the java codes of the implementation part for this page are shown in Figure 5.18 and Figure 5.19 respectively.

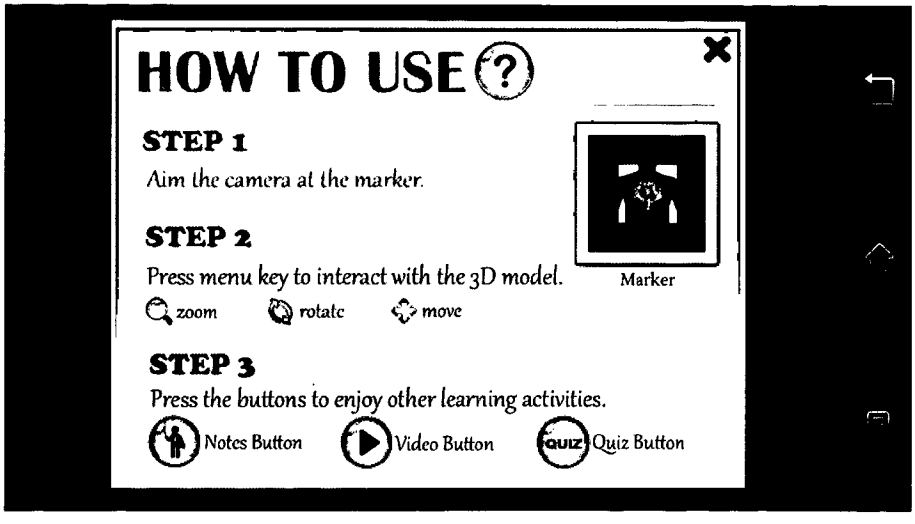


Figure 5.17 Instruction Page of AR Human Blood Circulatory System

```
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="450dp"
    android:layout_height="fill_parent"
    android:gravity="center"
    tools:context=".Instruction" >

    <ImageView
        android:id="@+id/instruction"
        android:layout_width="450dp"
        android:layout_height="wrap_content"
        android:scaleType="fitXY"
        android:contentDescription="@string/instruction"
        android:src="@drawable/instruction" />

    <ImageView
        android:id="@+id/closeinstruction"
        android:layout_width="40dp"
        android:layout_height="40dp"
        android:layout_alignParentRight="true"
        android:layout_alignParentTop="true"
        android:clickable="true"
        android:contentDescription="@string/close"
        android:focusable="true"
        android:src="@drawable/delete" />

</RelativeLayout>
```

Figure 5.18 Instruction Page interface xml codes

```
package com.ar.showroom;

import com.ar.showroom.R;

public class Instruction extends Activity {

    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        requestWindowFeature(Window.FEATURE_NO_TITLE);
        setContentView(R.layout.activity_instruction);

        ImageView cls = (ImageView) findViewById(R.id.closeinstruction);
        cls.setOnClickListener(new OnClickListener(){

            @Override
            public void onClick(View v) {
                // TODO Auto-generated method stub
                finish();
                finishActivity(929);
            }});
    }
}
```

Figure 5.19 Instruction Page implementation java codes

5.8 Component Descriptions Module

Component Descriptions module displays the brief explanation of the subtopic from the selected category. Users would be able to read through the information given to learn more about the subtopic beside playing around with the 3D model as shown in Figure 5.20. The xml codes of the interface and the java codes of the implementation part for this page are shown in Figure 5.21 and Figure 5.22 respectively.

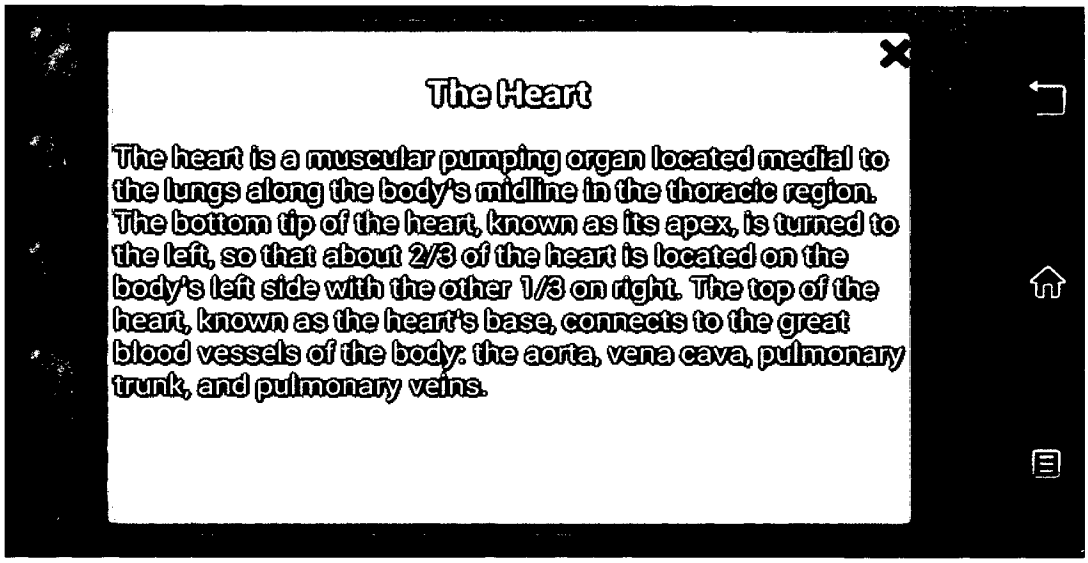


Figure 5.20 Component Descriptions Page of the heart

```
<RelativeLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    style="@style/Theme.Transparent"
    android:layout_width="500dp"
    android:layout_height="fill_parent"
    android:layout_gravity="center"
    android:orientation="horizontal"
    android:background="@drawable/infobg"
    tools:context=".InfoActivity" >

    <ScrollView
        android:id="@+id/scrollView1"
        android:layout_width="fill_parent"
        android:layout_height="fill_parent"
        android:layout_gravity="center"
        android:layout_margin="15dp" >

        <LinearLayout
            android:layout_width="match_parent"
            android:layout_height="fill_parent"
            android:layout_gravity="top|center"
            android:orientation="vertical" >

            <TextView
                android:id="@+id/textView1"
                android:layout_width="wrap_content"
                android:layout_height="wrap_content"
                android:layout_gravity="center"
                android:layout_margin="15dp"
                android:text="@string/mmodel"
                android:textAppearance="?android:attr/textAppearanceLarge"
                android:textStyle="bold" />

            <TextView
                android:id="@+id/textView2"
                android:layout_width="wrap_content"
                android:layout_height="wrap_content"
                android:text="@string/mengine"
                android:textAppearance="?android:attr/textAppearanceMedium" />

        </LinearLayout>
    </ScrollView>

    <ImageView
        android:id="@+id/closeinfo"
        android:layout_width="40dp"
        android:layout_height="40dp"
        android:layout_alignParentRight="true"
        android:layout_alignParentTop="true"
        android:clickable="true"
        android:contentDescription="@string/close"
        android:focusable="true"
        android:src="@drawable/delete" />
</RelativeLayout>
```

Figure 5.21 Component Descriptions Page interface xml codes

```
package com.ar.showroom;

import com.ar.showroom.R;

public class InfoActivity extends Activity {

    @Override
    public void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        requestWindowFeature(Window.FEATURE_NO_TITLE);
        setContentView(R.layout.activity_info);

        ImageView close = (ImageView) findViewById(R.id.closeinfo);
        close.setOnClickListener(new OnClickListener(){

            @Override
            public void onClick(View v) {
                // TODO Auto-generated method stub
                finish();
                finishActivity(107);
                /////System.exit(0);
            }

        });
    }

}
```

Figure 5.22 Component Descriptions Page implementation java codes

5.9 Video Module

Video module plays the relevant video of the selected category. This is good for the users where they can watch the video in teaching the process of human blood circulatory system besides reading the notes given as shown in Figure 5.23. The xml codes of the interface and the java codes of the implementation part for this page are shown in Figure 5.24 and Figure 5.25 respectively.

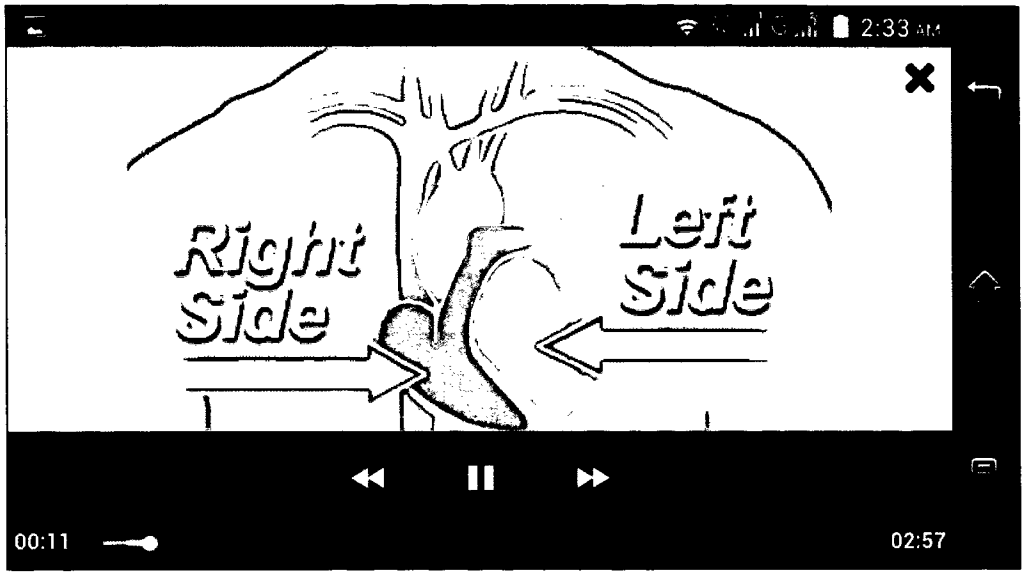


Figure 5.23 Video Page of the heart

```
<FrameLayout xmlns:android="http://schemas.android.com/apk/res/android"
    xmlns:tools="http://schemas.android.com/tools"
    android:layout_width="fill_parent"
    android:layout_gravity="center"
    android:layout_height="fill_parent" >

    <VideoView
            android:id="@+id/video_view1"
            android:layout_width="match_parent"
            android:layout_height="wrap_content"
            android:layout_gravity="center" />

    <RelativeLayout
        android:layout_width="fill_parent"
        android:layout_height="395dp" >

        <ImageView
            android:id="@+id/closeplayer"
            android:layout_width="40dp"
            android:layout_height="40dp"
            android:layout_alignParentRight="true"
            android:layout_alignParentTop="true"
            android:clickable="true"
            android:contentDescription="@string/close"
            android:focusable="true"
            android:src="@drawable/delete" />
    </RelativeLayout>

</FrameLayout>
```

Figure 5.24 Video Page interface xml codes

```
package com.ar.showroom;

import com.ar.showroom.R;


public class Video1 extends Activity {

    private VideoView myVideoView;
    private int position = 0;
    private ProgressDialog progressDialog;
    private MediaController mediaControls;

    @Override
    protected void onCreate(final Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        requestWindowFeature(Window.FEATURE_NO_TITLE);

        // Get the layout from video_main.xml
        setContentView(R.layout.player1);

        ImageView close = (ImageView) findViewById(R.id.closeplayer);
        close.setOnClickListener(new OnClickListener(){

            @Override
            public void onClick(View v) {
                // TODO Auto-generated method stub
                finish();
                finishActivity(107);
                /////System.exit(0);
            }
        });
```

```
    if (mediaControls == null) {
        mediaControls = new MediaController(Video1.this);
    }

    // Find your VideoView in your video_main.xml layout
    myVideoView = (VideoView) findViewById(R.id.video_view1);

    // Create a progressbar
    progressDialog = new ProgressDialog(Video1.this);
    // Set progressbar title
    progressDialog.setTitle("Blood Circulation");
    // Set progressbar message
    progressDialog.setMessage("Loading...");

    progressDialog.setCancelable(false);
    // Show progressbar
    progressDialog.show();

    try {
        myVideoView.setMediaController(mediaControls);
        myVideoView.setVideoURI(Uri.parse("android.resource://" + getPackageName() + "/" + R.raw

    } catch (Exception e) {
        Log.e("Error", e.getMessage());
        e.printStackTrace();
    }
```

Figure 5.25 Video Page implementation java codes

5.10 Quiz Module

Quiz module allows the users to attempt a quiz after they go through the component descriptions module and the video module as shown in Figure 5.26. Ten questions will be asked in the quiz. Each questions including three options for users to use. Users need to sweep over to left hand side in order to proceed to the next question. Users would be able to see their result after submit all the answers as shown in Figure 5.27. Therefore, their understanding level on the human blood circulatory system will be tested. The xml codes of the interface and the java codes of the implementation part for this page are shown in Figure 5.28, Figure 5.29, Figure 5.30 and Figure 5.31 respectively.

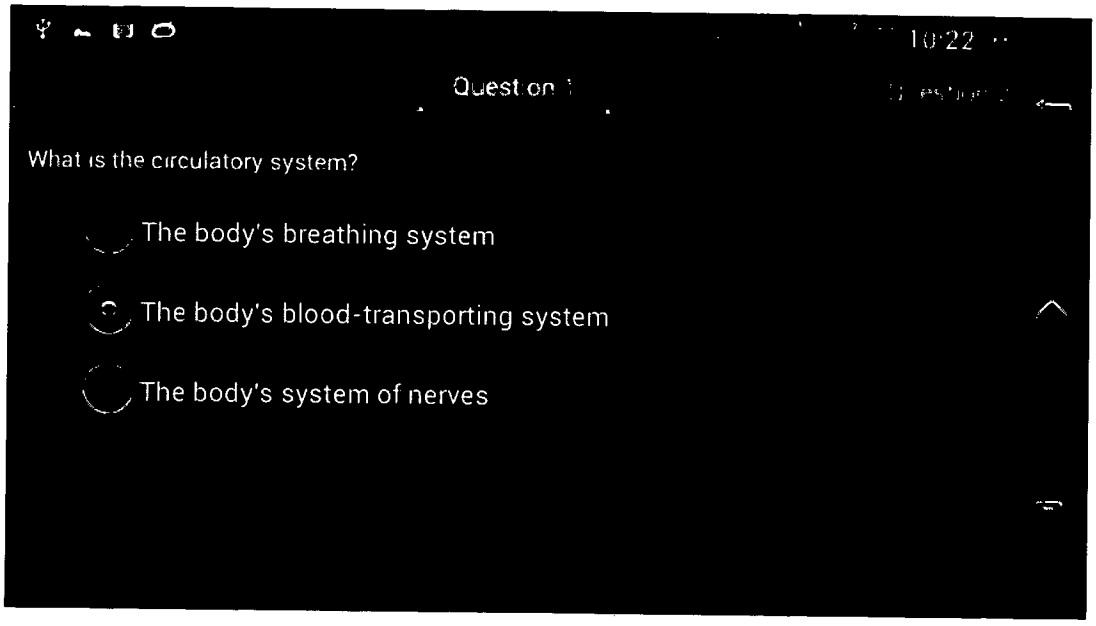


Figure 5.26 Quiz Page of the heart

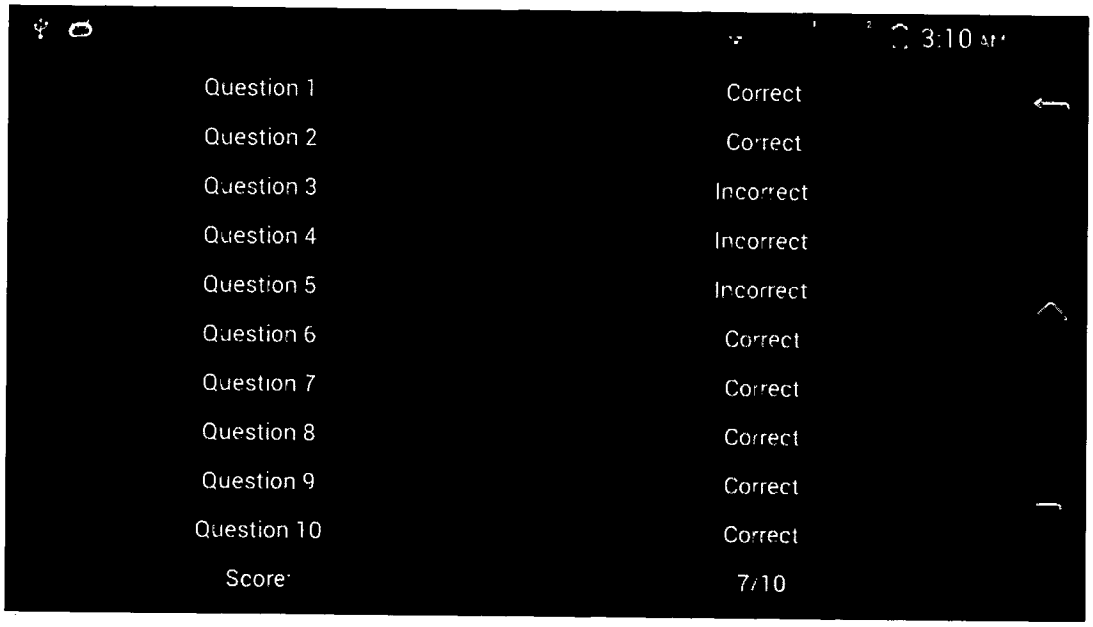


Figure 5.27 Result from the Quiz Page of the heart

```
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:orientation="vertical"
    xmlns:app="http://schemas.android.com/apk/res/com.ar.showroom">
    <com.viewpagerindicator.TitlePageIndicator
        android:id="@+id/indicator"
        android:layout_width="fill_parent"
        android:layout_height="wrap_content"
        android:background="#000000"
        android:textColor="#99C224"
        app:footerColor="#99C224"
        app:footerLineHeight="1dp"
        app:footerIndicatorStyle="underline"
        app:footerIndicatorHeight="3dp"
        app:selectedColor="#99C224"
        app:selectedBold="true" />

    <android.support.v4.view.ViewPager
        android:id="@+id/pager"
        android:layout_width="match_parent"
        android:layout_height="0dp"
        android:layout_weight="1"/>

</LinearLayout>
```

Figure 5.28 Quiz Page interface xml codes.

```
<?xml version="1.0" encoding="utf-8"?>
<LinearLayout xmlns:android="http://schemas.android.com/apk/res/android"
    android:layout_width="match_parent"
    android:layout_height="match_parent"
    android:orientation="vertical"
    android:paddingTop="20dip"
    android:paddingLeft="10dip"
    android:paddingRight="10dip" >
    <TextView
        android:layout_width="match_parent"
        android:layout_height="wrap_content"
        android:text="@string/q1question1"
        android:paddingBottom="10dip"/>
    <RadioGroup
        android:id="@+id/q1_group"
        android:layout_width="match_parent"
        android:layout_height="wrap_content"
        android:paddingLeft="30dip"
        android:orientation="vertical"
        android:paddingBottom="30dip">
        <RadioButton
            android:id="@+id/q1a1"
            android:layout_width="match_parent"
            android:layout_height="wrap_content"
            android:text="The body's breathing system"
            android:clickable="true"/>
        <RadioButton
            android:id="@+id/q1a2"
            android:layout_width="match_parent"
            android:layout_height="wrap_content"
            android:text="The body's blood-transporting system"
            android:clickable="true"/>
        <RadioButton
            android:id="@+id/q1a3"
            android:layout_width="match_parent"
            android:layout_height="wrap_content"
            android:text="The body's system of nerves"
            android:clickable="true"/>
    </RadioGroup>

</LinearLayout>
```

Figure 5.29 Quiz Page Question 1 interface xml codes

```
package com.ar.showroom;

import com.viewpagerindicator.PageIndicator;

public class Quiz1 extends FragmentActivity {

    FragmentAdapter mAdapter;
    ViewPager mPager;
    PageIndicator mPageIndicator;
    String share_name = "Q1_Answer";

    @Override
    protected void onCreate(Bundle savedInstanceState) {
        super.onCreate(savedInstanceState);
        setContentView(R.layout.quiz1);

        mAdapter = new FragmentAdapter(getSupportFragmentManager());

        mPager = (ViewPager)findViewById(R.id.pager);
        mPager.setAdapter(mAdapter);

        mPageIndicator = (PageIndicator)findViewById(R.id.indicator);
        mPageIndicator.setViewPager(mPager);

    }
}
```

Figure 5.30 Quiz Page implementation java codes

```
package com.ar.showroom;

import android.content.SharedPreferences;
public class Quiz1Question1 extends Fragment{

    RadioButton q1a1,q1a2,q1a3;
    Button btn1;

    public View onCreateView(LayoutInflater inflater, ViewGroup container, Bundle savedInstanceState
        View v = inflater.inflate(R.layout.quiz1question1, null);
        return v;
    }

    @Override
    public void onActivityCreated(Bundle savedInstanceState){
        super.onActivityCreated(savedInstanceState);
        q1a2 = (RadioButton)getView().findViewById(R.id.q1a2);
        q1a1 = (RadioButton)getView().findViewById(R.id.q1a1);
        q1a3 = (RadioButton)getView().findViewById(R.id.q1a3);

        q1a2.setOnClickListener(listener);
        q1a1.setOnClickListener(listener);
        q1a3.setOnClickListener(listener);

    }

    Button.OnClickListener listener = new Button.OnClickListener(){
        @Override
        public void onClick(View v){
            final SharedPreferences app_preferences = PreferenceManager.getDefaultSharedPreferences(
            SharedPreferences.Editor editor = app_preferences.edit();

            if (q1a2.isChecked()){
                editor.putInt("answer_value", 1);
            } else {
                editor.putInt("answer_value", 0);
            }
            editor.commit();
        }
    };

}
```

Figure 5.31 Quiz Page Question 1 implementation java codes

5.11 Application Requirements

The requirements needed for this application are listed in the AndroidManifest.xml as shown in Figure 5.32, such as the minimum of the API level needed and the permission to use the components.

```
<?xml version="1.0" encoding="utf-8"?>
<manifest xmlns:android="http://schemas.android.com/apk/res/android"
    package="com.ar.showroom"
    android:versionCode="1"
    android:versionName="1.0" >

    <supports-screens
        android:largeScreens="true"
        android:normalScreens="true"
        android:smallScreens="true" />

    <uses-permission
        xmlns:android="http://schemas.android.com/apk/res/android"
        android:name="android.permission.INSTALL_PACKAGES" >
    </uses-permission>
    <uses-permission
        xmlns:android="http://schemas.android.com/apk/res/android"
        android:name="android.permission.DELETE_PACKAGES" >
    </uses-permission>
    <uses-permission
        xmlns:android="http://schemas.android.com/apk/res/android"
        android:name="android.permission.RESTART_PACKAGES" >
    </uses-permission>
    <uses-permission
        xmlns:android="http://schemas.android.com/apk/res/android"
        android:name="android.permission.CAMERA" >
    </uses-permission>
    <uses-permission
        xmlns:android="http://schemas.android.com/apk/res/android"
        android:name="android.permission.ACCESS_SURFACE_FLINGER" >
    </uses-permission>
```

```
<activity
    android:name="com.ar.showroom.Quiz1"
    android:label="@string/title_quiz1"
    android:screenOrientation="Landscape"
    android:theme="@android:style/Theme.NoTitleBar" >
    <intent-filter>
        <action android:name="android.intent.action.QUIZ1" />

        <category android:name="android.intent.category.DEFAULT" />
    </intent-filter>
</activity>
<activity
    android:name="com.ar.showroom.Quiz2"
    android:label="@string/title_quiz2"
    android:screenOrientation="Landscape"
    android:theme="@android:style/Theme.NoTitleBar" >
    <intent-filter>
        <action android:name="android.intent.action.QUIZ2" />

        <category android:name="android.intent.category.DEFAULT" />
    </intent-filter>
</activity>
<activity
    android:name="com.ar.showroom.Quiz3"
    android:label="@string/title_quiz3"
    android:screenOrientation="Landscape"
    android:theme="@android:style/Theme.NoTitleBar" >
    <intent-filter>
        <action android:name="android.intent.action.QUIZ3" />

        <category android:name="android.intent.category.DEFAULT" />
    </intent-filter>
```

Figure 5.32 AndroidManifest.xml codes

CHAPTER 6

RESULT AND DISCUSSION

6.1 Introduction

The main purpose of this chapter is discussing about the effectiveness of the interactive AR mobile application for Human Blood Circulation System on student learning experience. The results analysis, the limitation and the future enhancement are discussed in this chapter.

6.2 Unit Test

The developed AR HBCS mobile application is tested by the developer before distributing it to the target user to ensure that the application is functioning correctly.

6.2.1 Splash Screen and Menu Interface

For this screen, users no need to press anything where the application will automatically navigate user to the second interface which is the menu interface. In the second interface, there are three categories which are including the human heart, the blood vessels and the blood. Users need to press on either one category in order to navigate to the Augmented Reality Main Interface. Besides, by pressing the menu button of the device in this interface, the About Button and the Quit Button will be shown at the bottom of the screen. These two buttons will bring to

the other interfaces respectively. Table 6.1 shows the testing on function of the splash screen and the menu interface.

Table 6.1 Testing on function of the splash screen and the menu interface

Testing Object	Testing Procedure	Testing Result
• The splash screen.	• Wait around 4 seconds.	• It has navigated user to the menu interface automatically.
• Category selection buttons.	• Press on each of the buttons.	• The buttons have navigated to a new interface based on the selected category as the Augmented Reality Main Interface.
• The menu or multitasking button of the device.	• Press on the menu or multitasking button of the device	• The About Button and the Quit Button are shown at the bottom of the screen.
• The About Button and the Quit Button.	• Press on the buttons.	• The new interfaces which are under those buttons are displayed or functioned respectively.
Result: Pass		

6.2.2 Augmented Reality Main Interface

This interface is such as the main view of the application after the users have chosen a category from the menu interface. The camera of the device will be automatically opened and a 3D model from that category will automatically pop out when the users aim their camera of their device at the marker. There are four buttons located on the left hand side of the screen which are including the Instruction Button, the Information Button, the Video Button and the Quiz Button. Each of the buttons will navigate to the different activity when the users press on it. Besides, by pressing the Menu Button of the device in this interface, it will bring out the Zoom Button, the Rotate Button, the Move Button and the Anatomy Image Gallery Button at the bottom of the screen. The first three buttons are functioning as the setting tools for the 3D model where the users can zoon in/out, rotate and move the 3D model. A new interface which is in image gallery view will be opened when the users press on the Anatomy Image Gallery Button. Table 6.2 below shows the testing on function of the Augmented Reality Main Interface.

Table 6.2 Testing on function of the Augmented Reality Main Interface

Testing Object	Testing Procedure	Testing Result
• The main view.	• Aim the camera of the device at the marker.	• The camera view is automatically opened. • A 3D model of the selected category is displayed.
• The four buttons which are located on the left hand side of the screen.	• Press on each of the buttons.	• The buttons have navigated to the different activities respectively. E.g. guiding on how to use the application, reading brief information about the selected category, learning the process by watching the video and attempting a quiz to know the level of understanding.

• The menu or multitasking button of the device.	• Press on the menu or multitasking button of the device	• The Zoon Button, Rotate Button, Move button and the Anatomy Image Gallery Button are shown at the bottom of the screen.
• The Zoon Button, Rotate Button and the Move button.	• Press on each of the buttons.	• It allows users to zoom in/out, rotate and move the 3D model.
• The Anatomy Image Gallery.	• Press on the button.	• The button has navigated to a new interface which is in image gallery view.
Result: Pass		

6.2.3 Unit Test Summary Result

Table 6.3 below shows the Unit Test Summary result.

Table 6.3 Unit Test Summary result

Type of Testing	Result	Problem of Application Submitted	Remarks
Splash Screen and Menu Interface	Pass	None	None
Augmented Reality Main Interface	Pass	None	None

6.3 Survey

A survey has been made to 20 users to test and use the application. The users have attempted the survey online via Google Docs after they used the application. Below are the questions that have been asked in the survey:

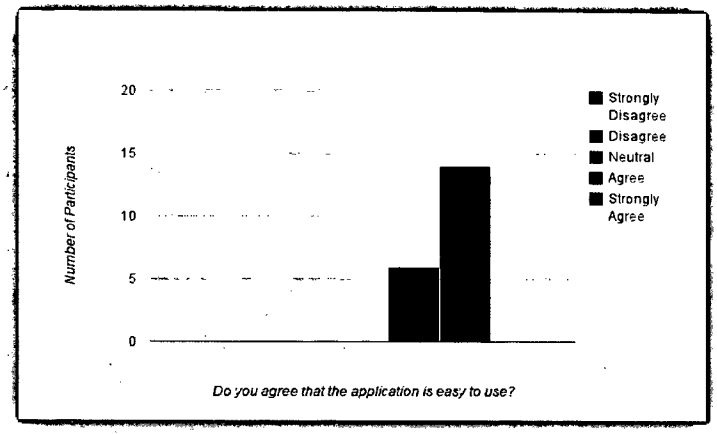


Figure 6.1 Survey Result (Do you agree that the application is easy to use?)

Based on the Figure 6.1, there are 14 users strongly agree and 6 users agree that the application is easy to use.

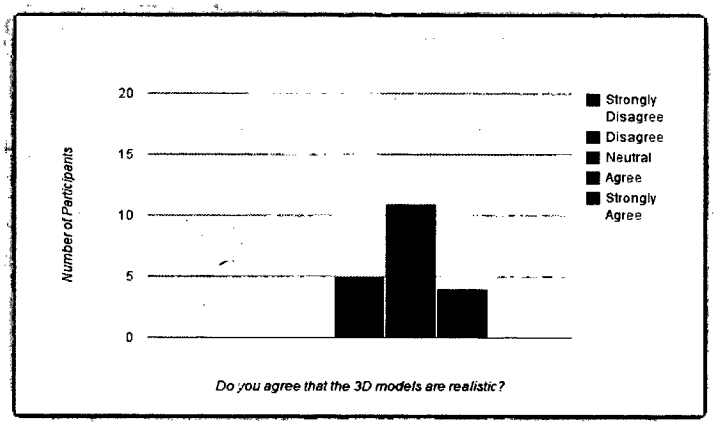


Figure 6.2 Survey Result (Do you agree that the 3D models are realistic?)

Based on the Figure 6.2, there are 4 users strongly agree, 11 users agree and 5 users response as neutral that the 3D models are realistic.

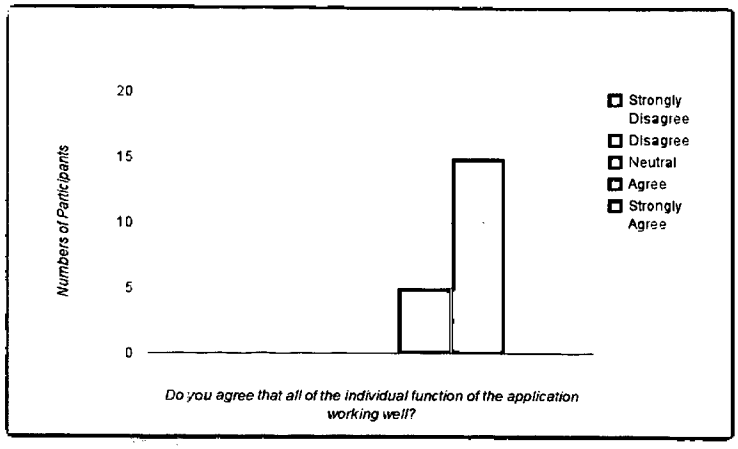


Figure 6.3 Survey Result (Do you agree that all of the individual function of the application working well?)

Based on the Figure 6.3, there are 15 users strongly agree and 5 users agree that all of the individual function of the application are working well.

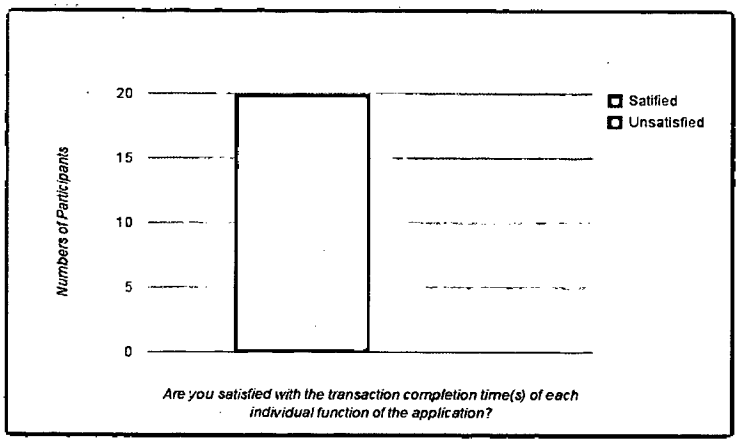


Figure 6.4 Survey Result (Are you satisfied with the transaction completion(s) time of each individual function of the application?)

Based on the Figure 6.4, all of the users satisfied with the transaction completions time of each individual function of the application.

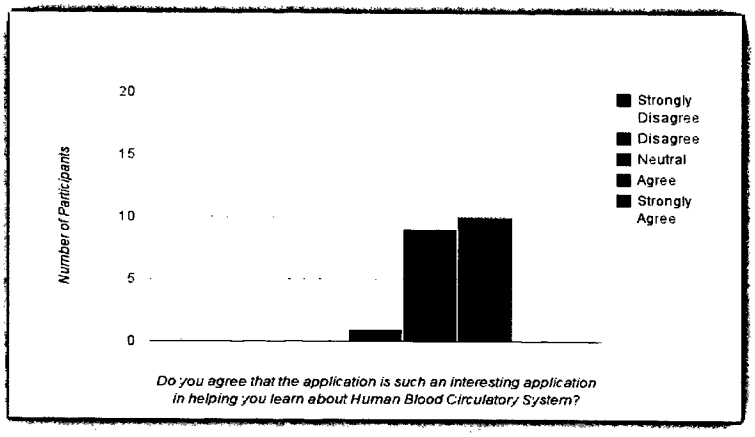


Figure 6.5 Survey Result (Do you agree that the application is such an interesting application in helping you learn about Human Blood Circulatory System)

Based on the Figure 6.5, there are 10 users strongly agree and 9 users agree that the application is such an interesting application in helping them learn about Human Blood Circulatory System. But there is 1 user responses as neutral about this.

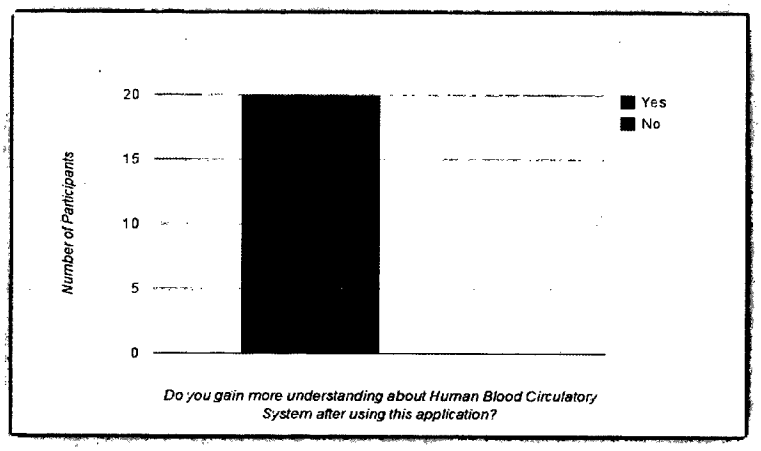


Figure 6.6 Survey Result (Do you gain more understanding about Human Blood Circulatory System after using this application)

Based on the Figure 6.6, all of the users said that they have gain more understanding about Human Blood Circulatory System after using the application.

In conclusion, evaluation has been done after the feedbacks obtained from the users. Most of the users thought that the application is easy to use as the function of each buttons is very clear without any confusion. For the 3D models, majority of the users agreed that the 3D models are realistic. There are also some users thought neutral about this due to the low polygon 3D model. From the survey, all of the users agreed that the individual function of the application working well where they can interact with the 3D model by zoom in/out, rotate and move the 3D model. Besides, they can go through the instruction page, component description page, video page, quiz page and the anatomy image gallery smoothly. Therefore, all of them satisfied with the transaction completions time of each individual function. Majority of the users said that the application is such an interesting application in helping them learn about Human Blood Circulatory System because of the Augmented Reality technology. Furthermore, all of the users said that they have gain more understanding about Human Blood Circulatory System after using this application. In other words, this application is considered as a good learning application which the learning materials are transferred effectively to the users.

6.4 Discussion and Analysis on the Outcomes

The proposed interactive AR HBCS application was successfully developed and run without errors. The goal and the objectives of the research have been achieved as shown in Table 6.4 and Table 6.5.

Table 6.4 Analysis on the goal of the research

Goal	Status	Step
• To develop an AR mobile application for Human Blood Circulatory System using AR technology.	Achieved	• By developing the proposed system completely with the several modules as shown in Chapter 5 with the interfaces screenshots of each part of the system modules and the implementation coding.

Table 6.5 Analysis on the objectives of the research

Objectives	Status	Step
• To investigate the suitable techniques used in the development of the AR application.	Achieved	• By studying on the techniques used by the similar application in AR technology as shown in Chapter2.
• To develop an AR mobile application for Human Blood Circulatory System using marker tracking technique for 3D content display.	Achieved	• By displaying the 3D model when the users aim their camera of their device at the marker.
• To test the effectiveness of the AR application in learning process.	Achieved	• By doing online survey via Google Docs and analyze on the survey result.

6.5 Limitation

The limitations of this research are divided into two parts:

i. Development Limitation
ii. System Limitation

6.5.1 Development Limitation

Since the mobile operating system (OS) of the developed application is Android based, therefore the mobile device with Android OS is required in order to run or use the application. A built-in camera is also needed in the mobile device for the system to detect the relevant marker. It is encouraged that the application is used in larger screen size for better visualization of the 3D models. A minimum platform version Android 2.2 (API Level 8) is also required to ensure that the application is running properly on the device.

6.5.2 System Limitation

Below are the system limitations of the developed application:

i. Unable to view the interior part of the 3D models.
ii. Unable to enlarge the images in the anatomy image gallery part.
iii. Unable to know the correct answer of each question after attempted to the quiz.

6.6 Future Enhancement

Future enhancement on the developed application is a necessary step in order to improve the functionality of the application. The quality of the 3D model can be improved for better user's vision as well as some animations can be applied on the 3D model. For example, the 3D pumping heart model instead of common 3D heart model. It is good if the interior part of 3D model can be viewed as the users are able to see the blood flow through the heart's chambers for a 3D pumping heart. Besides, a zoom in/out function is needed for the images in the anatomy image gallery to ensure that the users are able to read on the details more clearly. The sound or background music is also can be added into the application in order to make it more attractive. In addition, the correct answers are also need to be included in the quiz part after attempted the quiz so that the users won't make the mistake again and gain knowledge from the questions. Therefore, the further research is needed to enhance the application.

CHAPTER 7

CONCLUSION

As a conclusion, an interactive augmented reality human blood circulatory system application has been developed successfully. This application is mainly proposed for the secondary school student in learning the topic of human blood circulatory system under the science subject. It is encouraged that this application is also to be used by those who want to learn more about human blood circulatory system.

By using this application, it allows the users to view the components which are included in the human blood circulatory system as 3D model. The interaction between the users and the 3D model can be seen as the users are able to zoom in/out, rotate and move the 3D model. Besides, the buttons provided in the application lets the users to do different tasks or activities within the application for learning purpose. For example, the explanation in words or sentences form; the explanation in video form; and the knowledge testing in quiz form.

Based on the survey, many of the users think that this application is interesting and it could help them in understanding the Human Blood Circulatory System in an effective way. It enhances the traditional teaching method which is considered as non-interactive lecture session by applying the augmented reality technology. With the augmented reality technology, it is good for the students where they can observe the component in 3D view compared to just read it on a book. It helps the students to explore and experience science studies in a different view and improve teaching and learning environment. It can be used or played at anytime, anywhere as long as a mobile device with Android OS based is by your side. All the users need to do is download the application with the printed marker and

install it in their device. In short, the developed application can be considered as a simple augmented reality educational tools in human blood circulatory system.

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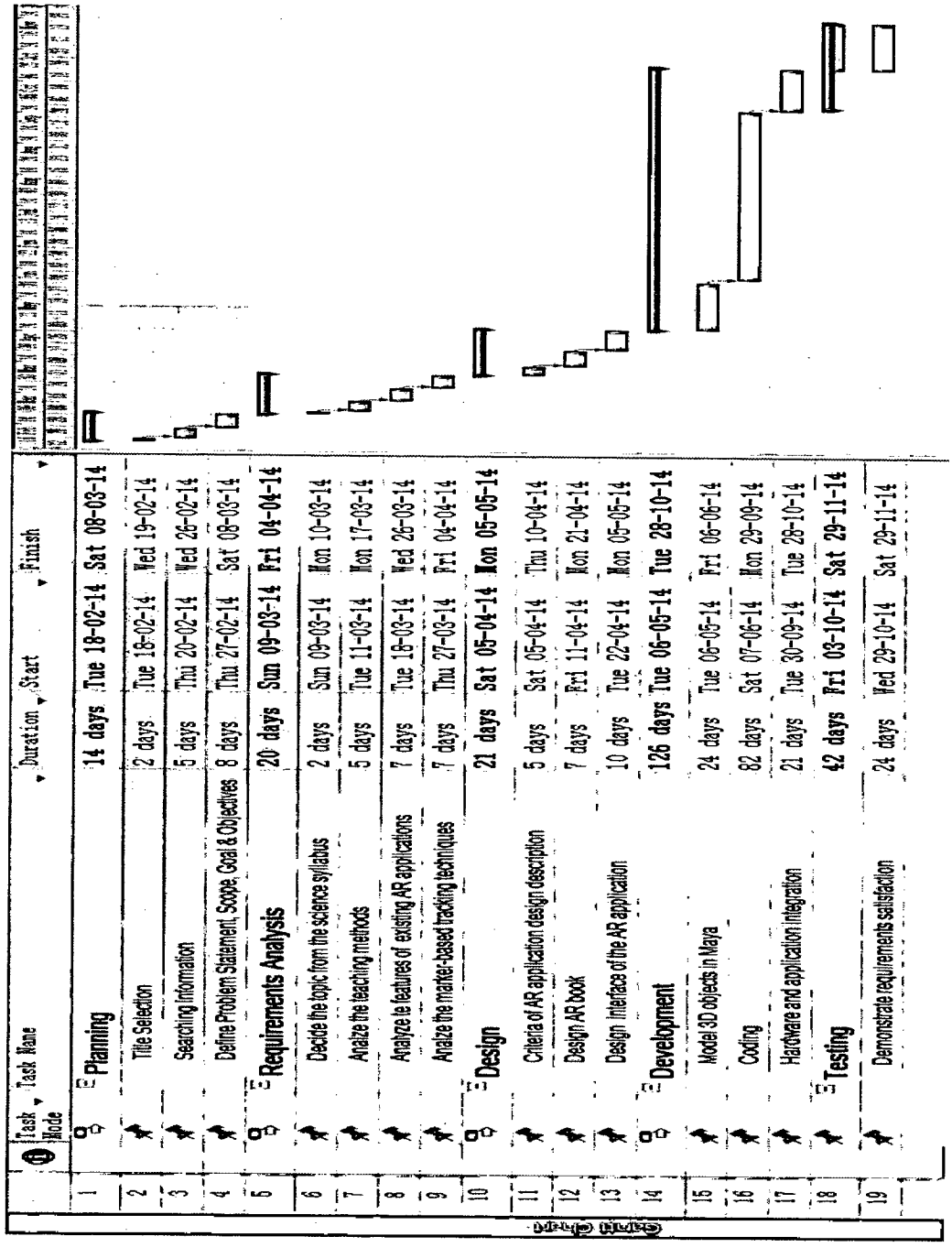
APPENDIX A

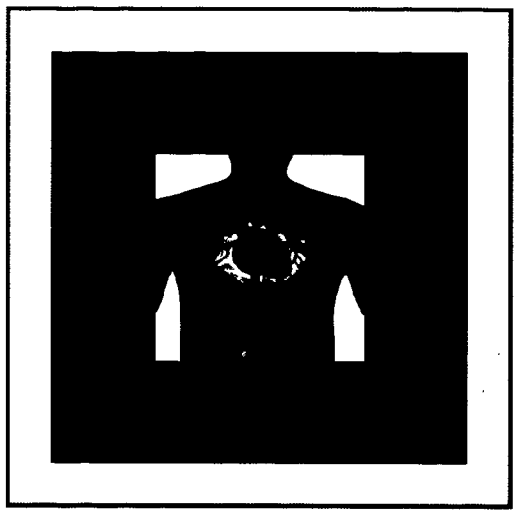
GANTT CHART



	Task Mode	Task Name	Duration	Start	Finish
1		**Planning**	**14 days**	**Tue 18-02-14**	**Sat 08-03-14**
2		Title Selection	2 days	Tue 18-02-14	Wed 19-02-14
3		Searching Information	5 days	Thu 20-02-14	Wed 26-02-14
4		Define Problem Statement, Scope, Goal & Objectives	8 days	Thu 27-02-14	Sat 08-03-14
5		**Requirements Analysis**	**20 days**	**Sun 09-03-14**	**Fri 04-04-14**
6		Decide the topic from the science syllabus	2 days	Sun 09-03-14	Mon 10-03-14
7		Analize the teaching methods	5 days	Tue 11-03-14	Mon 17-03-14
8		Analyze le features of existing AR applications	7 days	Tue 18-03-14	Wed 26-03-14
9		Analize the marker-based tracking techniques	7 days	Thu 27-03-14	Fri 04-04-14
10		**Design**	**21 days**	**Sat 05-04-14**	**Mon 05-05-14**
11		Criteria of AR application design description	5 days	Sat 05-04-14	Thu 10-04-14
12		Design AR book	7 days	Fri 11-04-14	Mon 21-04-14
13		Design Interface of the AR application	10 days	Tue 22-04-14	Mon 05-05-14
14		**Development**	**126 days**	**Tue 06-05-14**	**Tue 28-10-14**
15		Model 3D objects in Maya	24 days	Tue 06-05-14	Fri 06-06-14
16		Coding	82 days	Sat 07-06-14	Mon 29-09-14
17		Hardware and application integration	21 days	Tue 30-09-14	Tue 28-10-14
18		**Testing**	**42 days**	**Fri 03-10-14**	**Sat 29-11-14**
19		Demonstrate requirements satisfaction	24 days	Wed 29-10-14	Sat 29-11-14

APPENDIX B

AR MOBILE APPLICATION FOR HUMAN BLOOD CIRCULATORY SYSTEM MARKER



APPENDIX C

AR MOBILE APPLICATION FOR HUMAN BLOOD CIRCULATORY SYSTEM ICON

APPENDIX D

TURNITIN RESULT

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