

**AR APPLICATION FOR UPPER PARTS OF DIGESTIVE
SYSTEM ANATOMY LEARNING USING 3D
RECONSTRUCTION OF MEDICAL IMAGE**

BY

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DECLARATION OF ORIGINALITY

I declare that this report entitled “**AR APPLICATION FOR UPPER PARTS OF DIGESTIVE SYSTEM ANATOMY LEARNING USING 3D RECONSTRUCTION OF MEDICAL IMAGE**” is my own work except as cited in the references. The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

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ABSTRACT

The outbreak of Covid-19 has accelerated the trends from traditional in-class learning towards E-learning. There is no doubt that E-learning is beneficial towards educators and students in conveniency and efficiency. Students and educators no longer need to travel between institution and their house to attend physical class, time can be saved, and students can strengthen their knowledge anytime by replaying the recorded video. However, it is undeniable that E-learning through online classes also raised some problems such that some of the students do not manage to gain knowledge and complex information through flat device screen. As the class is not conducted face-to-face, the educators unable to track students' difficulty if they do not raise their problem. This situation would then affect students' academic performance indirectly. Hence, this project promotes an alternative learning method which is applying Augmented Reality (AR) technology in education system. The title of this project is "AR Application for Upper Parts of Digestive System Anatomy Learning Using 3D Reconstruction of Medical Image" which is to display complex human anatomy in 3D and integrate it with the real-world environment using AR technology. Thus, it eases the students in viewing and understanding human anatomy and motivate students to learn in interactive way. To increase the accuracy of human anatomy model, segmentation and visualization are carried out on medical image dataset. Also, to make the AR application more functional, the information gallery and quiz game modules is added into the application.

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CHAPTER 1 INTRODUCTION

1.1 Problem Statement and Motivation

Anatomy learning is one of the most prominent and crucial subjects of biology and medical education. In earlier years, students' main learning method of human anatomy is using traditional learning materials with 2D images with help of 3D human anatomy mannequin in the classroom. However, students have transitioned from face-to-face classes to online classes due to the COVID-19 pandemic. Studying from home caused the students no longer access to the 3D mannequin in biology lab. Hence, the motivation to develop this application is to provide an easily-access 3D human anatomy model in AR mode to students for effective learning. The following problems further increase the necessity of AR application using 3D reconstruction on medical image

I. Ineffective study on human anatomy in education system.

Human Anatomy learning is too complex to view and learn in graphical 2D images. During the time of in-person classes, students can still learn from the 3D mannequin in classroom with references to the 2D images on textbook under the supervision of teachers. However, during Covid-19 pandemic, students have been attending the online classes for a long period of time. As online class consideration is believed equal or superior to in-person learning, there might be high possibility that online education becomes one of the main education methods even though after the pandemic. The viewing of human anatomy by students through flat 2D screen on their devices is confusing and challenging.

II. Lack of reality and accurateness in existing 3D human anatomy applications.

The existing applications for 3D human anatomy learning are mostly developed by the 3D reconstruction of images that drawn in graphical design software and might have the differences with real human anatomy. Also, the 3D model that displayed in device screen looks virtual. Hence, the accurateness and sense of reality in displaying 3D human anatomy need to be modified and improved for better visualization.

III. Lack of interest and motivation towards traditional academic practices in student perspective.

The growing distance between students' technological way of life and the traditional teaching procedures has caused the students to loss their willingness and motivations towards the lesson.

The images of complex human anatomy in textbooks are unattractive towards the students, and the difficulty in understanding human anatomy in 2D contributes to the loss of motivation. This situation would then affect students' academic performance negatively.

1.2 Project Scope

In this project, a marker-based Augmented Reality (AR) application will be built for 3D visualization of upper parts of digestive system including oral cavity, tongue, pharynx, and salivary glands. Also, a quiz game module and information gallery module will be built to enhance user's knowledge on human anatomy. The AR application is prototyped for mobile devices to support portability and the dataset being used in this project is CT dataset.

This application is mainly developed for the biology subjects educators and for secondary or foundations students especially those who are taking biology or medical subject to enhance human anatomical knowledge. The proposed methodology in this project is applying 3D reconstruction on CT medical image which segmented using 3D Slicer and display the 3D anatomy object in AR using Unity with Vuforia SDK.

Firstly, the open-source 3D Slicer application will be used to process the raw CT data. The data is then undergone adjustment to increase the quality of image. After that, the next step to be applied is segmentation and 3D volume rendering, which is the major step to export the 3D model to Unity for visualization. Then, the application is developed with AR technology that can provide interactive function with user such as zoom in, turn around etc. At the same time, a quiz game module will be developed in C# script using the Unity Canvas with extension to Microsoft Visual Studio and being combined with the AR module.

After the application successfully developed, the users able to scan the marker through mobile device camera. Once the application successfully recognizes the marker, a 3D view of human anatomy will be display on the screen. Besides, users can play a quiz game by select the quiz game option in main menu or learn more about digestive system by reading the materials in information gallery.

1.3 Objectives

The main objective of this project is to display upper parts of digestive system anatomy in 3D from a dedicated CT using AR technology. Following are the sub-objectives that support the main objective.

- I.** To promote effective learning in human anatomy by providing a 3D anatomy that can be easily access by the students and educators anytime and anywhere. It can be a reference to the students when they are studying human anatomy in printed or online resources, or for the teachers to better explain human anatomy during online classes.
- II.** To increase the reality and accurateness of 3D human anatomy by applying 3D reconstruction of CT using AR to replace the normal 3D model of human anatomy which developed using graphical software. AR provide a real-time environment which increase the reality while 3D reconstruction of CT increases the accurateness of the model.
- III.** To increase student's motivation and interest in human anatomy learning by providing an interactive anatomy model in AR mode which enable the student to play around and adding a quiz game module into AR application for fun and attractive learning.

1.4 Impact, Significance and Contribution

This AR application promotes an effective education method on human anatomy. With the use of this application, an educator can better explain the complex human anatomy to the students by showing the high reality 3D anatomy model during online classes. Also, the students can easily access to the model in AR on their mobile devices, which is really convenience in compared to carrying the thin textbook everywhere.

Besides that, this application allows the interaction between students and the anatomy in AR. Students can feel, touch and play around the model with fingertips, and this will increase the students' interest towards human anatomy learning. The quiz game developed in this application serves the same purpose which enhance users' knowledge on human anatomy in an alternative fun and interesting way.

Moreover, the application of AR technology in education system is new and fresh to the students, this might cause their curiosity in exploring this new technology. Thus, the willingness and motivation to study human anatomy can be gained.

1.5 Background Information

1.5.1 Digestive System

Digestive system is a human body anatomy where the whole digestion process is carried out. Digestive system responsible in providing nutrients to the body for energy in undergoing daily life, growth, and cell repair. The digestive system is a complex system and can be mainly divided into three parts. The upper part of digestive system consists of oral cavity, tongue, Esophagus, pharynx and salivary glands. The middle part of digestive system involved liver, stomach, pancreas and gallbladder, while the lower part of digestive system included large intestine, small intestine, rectum, anus and appendix.

1.5.2 Medical Imaging

Medical imaging is techniques used to capture human body parts images for diagnostic and/or treatment purposes. There are several types of popular medical imaging widely used today such as Magnetic Resonance Imaging (MRI), Computed Tomography (CT), X-ray and positron emission tomography (PET),

1.5.3 Augmented Reality

AR is computed-generated content that overlaid on a real-world environment. AR hardware range from a handheld display to headsets and glasses. Nowadays, AR technology is commonly applied in video games and media display. AR and VR share the same basic. However, they are distinct in the way of displaying contents. AR augments reality but does not replace it while VR completely replaces surroundings with a virtual environment. In short, hardware that combines digital content with surrounding is known as AR while hardware that operates independently from the location and encompass vision is known as VR. Following are few main types of AR:

1.5.3.1 Marker-based AR

Marker-based AR requires markers to trigger augmented experience. The markers often made with unique patterns such as QR codes, colored dots or any other significance image. The role of the marker is as an anchor for the technology. When a marker in the physical world is recognized by an AR application, the digital content is placed on top of it.



Figure 1.5.3.1.1 Example of Marker-based AR.

1.5.3.2 Markerless AR

Marker-less AR is more adaptable than marker-based AR as it allows the user to decide where to put the virtual digital object. User can try different direction and locations via the markerless AR application, without moving anything in surrounding environment.



Figure 1.5.3.2.1 Example of Markerless AR.

1.5.3.3 Location-based AR

Location-based AR is one of the markerless AR. This type of AR adds digital content to geographical points of interest. The objects are mapped out so that once a user's location matches the predetermined spot, it is displayed on the screen. Basically, location-based AR relies on GPS, accelerometer, digital compass or other similar technologies that can identify a device's location and position with high accuracy (Paladini, M. 2018).

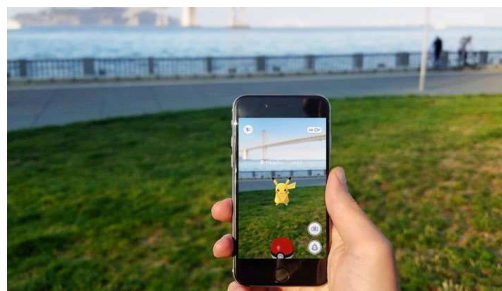


Figure 1.5.3.3.1 Example of location-based AR – Pokemon Go.

1.5.3.4 Superimposition-based AR

Superimposition-based AR is categorized under markerless AR. This AR recognizes an object and provides alternate view of the object, either by replacing the entire view with an augmented view of the object or by replacing a portion of the object view with an augmented view.

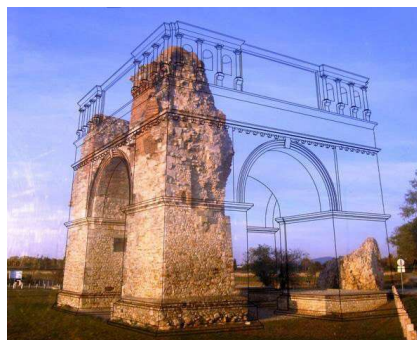


Figure 1.5.3.4.1 Example of Superimposition-based AR.

CHAPTER 2 LITERATURE REVIEW

2.1 Learning media for human digestive system based on augmented reality (Sonjaya and Fadlurahman, 2019)

Sonjaya and Fadlurahman Proposed an interactive AR-based teaching media which display the human digestive system anatomy in virtual. The application is created for Android OS mobile devices and the type of AR created is marker-based AR. The objective of this application of AR is to improve students' perception towards human anatomy learning material to avoid any potential misconception. The application is targeted for high school Biology teachers in illustrating the material presented in studying human digestive system.

Application follows Luther's multimedia development method. The first step in this application development is known as concept, which is problems identification by conducting interview with high school teacher. In design stage, the interface of design specifications and the AR-marker are created. The following stage is the material collecting which bring all the assets together. These assets undergo 3D modeling which conducted using the tools Autodesk Maya 2018, and texturing to color the component using UV Editor. Finally, the assembly stage is carried out using Unity 3D, all the assets are merged and the functional buttons is added using SceneLoader script.

The strength of this application is that the 3D components in virtual digestive system can be assemble and disassemble accordingly. Also, all the components are clearly labelled with its biological name which give a clear view to students in anatomy learning.

The limitation of this application is lack of accurateness as the developer collects individual components from different sources and organizes them together in own works. Hence, the components might be inconsistent in shape, size, etc. Moreover, it is lack of reality as the components is created based on the graphical resources online. The suggest resolution given to this application is replace the graphical resources with real medical resources to increase accurateness and reality.

2.2 3D Modelling Intestine Anatomy with Augmented Reality for Interactive Medical Learning (Andayani et al., 2019)

Andayani et al. proposed to creating AR in 3D intestines anatomy visualization to provide a virtual storage anatomy that can be learned at any time. The application was designed to be available on smartphone and can be studied without the needs of thematic tools. Labeling of structure and scenarios about the problems related to intestines anatomy are developed as additional features.

The first step in the development process is data collecting. All the information needed for anatomy labeling and description is collected, and the marker image were obtained from Prometheus book edition 3. In data collection process, 2D sketches from the lower parts of digestive system organs was collected from internet and served as the object to be built. 3D modeling process is carried out using digital Sculpting method and texturing is done on the object to increase reality. Finally, the 3D model was colored using photoshop and the labelling of each structure is pinned on each object. In post-production process, Model improvement was conducted to adjust lighting, camera position, etc. on the model. The strength of this proposed solution is that the application provides a user-friendly GUI to the user. Also, the clear labelling on the object displayed and the information that related to the anatomy provided are said to be fundamental to biology student.

The limitation of this application is that it lacks interactive as users can only view the anatomy model with its labelling, they are not allowed to resize, rotate or move the object. Hence, the suggestion of improvement given to this application is adding more interactive function such as resize, rotate etc. Also, the application can be improved in sense of reality by replacing the sketch data sources with real medical images.

2.3 “ARRES” Augmented Reality for the human respiratory system (Amalia and Suryani H, 2019)

Amalia and Suryani H Proposed a marker-based AR respiratory and blood circulation system with android platform uses game engine unity. The main objective of this project is to provide an interesting and interactive learning method to junior high school students. Also, it is developed to increase students' reasoning and imagination.

In analysis phase, the architecture of the system, device specifications and application storyboard were determined. The architecture of the system involved Android user which manage the use of device's camera to detect the marker and get the visualization of object in AR mode. The device specifications and tools included in the application development were Windows 7, Blender 2.77, Adobe Photoshop CS 6 and Unity 5.6. After setting up the device and software required, implementation step was carried out. The first step of implementation was building of the 3D object and the details of each structure such as the dust in alveoli was added onto the object. Then, marker images were created using Adobe Photoshop software. Black and white color are chosen in creating marker images to ease the recognition process. After that, implementation of 3D animation oxygen passes through nose, pharynx and trachea was carried out.

The strength of this application is that it provides useful and innovative function in creating educational AR application such as the displaying of oxygen pathway animation.

However, the 3D object displayed in AR looks fake and might need further improvements by searching for higher quality image sources or directly replace the graphical images by real medical image.

2.4 Human Anatomy Learning Systems Using Augmented Reality on Mobile Application (Kurniawan, Suharjito, Diana and Witjaksono, 2018)

Kurniawan, Suharjito, Diana and Witjaksono proposed the use of Augmented Reality to aid in learning complex respiratory and blood circulation system. The objective of this application is to help the students to gain a better understanding on human anatomy, while the displaying of model object in 3D is aimed to ease the student in memorize the anatomy structure. Also, the application would like to increase the interesting and interactive in student's perspective anatomy learning.

AR marker on mobile computing platform is proposed in this system. The marker is captured by taking a picture with access to the camera. Then, the captured image is separated into few sections and the marker patten is recognized and matched with the images stored in the database. The framework applied is Floating Euphoria Framework, it is combined with the SQLite database. The first section is camera vision which functioned as a tool in marker capturing, and marker size and position measuring. The second section is capture and tracking marker. The camera outputs are match to the position and fit to the size of images which determine the initial size of the 3D model to be displayed. The third stage is identification in which the applications will identify the marker, determine recognized or unrecognized markers, and then matched the recognized with the stored database. Also, the type of model to be displayed is decided in this stage Finally, the last stage is visual display in which the application displays the 3D models after retrieving the data stored in database.

This application provides a high interaction to the user, user can rotate and view the object in different angles. Also, there are sufficient information about the anatomy displayed for user to refer.

However, the application has some weakness such that it lacks some important details on anatomy displayed. For example, the heart model displayed on user screen do not have veins and arteries on it. Hence, the application is suggested to be improved by adding in more details which are essential in human anatomy learning.

2.5 Augmented Reality for Breast Tumors Visualization (Ghaderi, M.A. et al. 2016)

This project is to propose an improved method in showing 3D views of the breast internal composition, especially lumps and its tumors to doctors. The proposed system is a marker-based AR application that shows a 3D model of the breast tumors on a plastic model of the body. The main objective is to provide a better visualization for doctors, oncologist, and surgeons to lead to a better screening, less false positive tumor detection and also avoiding unnecessary biopsy. Furthermore, it can be utilized for surgery planning and navigation.

There are four modules in this system which are Pre-processing, marker finder, position estimator and graphic generation. Pre-Processing module input the image captured using camera and convert it into binary image

In marker finder module, a marker was created for the uses of registering the 3D model according to the scene.

The next step is position estimator which the angle that camera is looking at the scene is estimated so that the 3D model can be rendered in the correct angle.

Lastly, in graphic generation module, a pre-stored 3D model is rendered, and texture is added to the model for displaying. The processed image is available to on the screen of Android device, smartphone or head mounted display.

The proposed system has several potentials such as high-quality screening and effective surgery planning. Also, this application is useful as a tool that can be used for communication between radiologist and doctors.

The limitation for this application is that the accuracy of this model is uncertain. More tests and feedbacks from users are needed especially for the head-mounted displays. Also, the system needs to be improved from time to time to provide a stable and high accuracy as the detection of tumors is related to human health and live.

2.6 Comparisons of Reviewed Paper

	2.1 Learning media for human digestive system based on augmented reality (Sonjaya and Fadlurahman, 2019)	2.2 3D Modelling Intestine Anatomy with Augmented Reality for Interactive Medical Learning (Andayani et al., 2019)	2.3 “ARRES” Augmented Reality for the human respiratory system (Amalia and Suryani H, 2019)	2.4 Human Anatomy Learning Systems Using Augmented Reality on Mobile Application (Kurniawan, Suharjito, Diana and Witjaksono, 2018)	2.5 Augmented reality for Breast Imaging (Ghaderi, M.A. et al. 2016)
Type of anatomy/object	Digestive system	Intestine Anatomy	Respiratory system	Respiratory and blood circulation system	Breast tumor
Type of AR	Marker- based	Marker- based	Marker- based	Marker- based	Marker-based
Dataset	Graphical image	Graphical image	Graphical image	Graphical image	CT/MRI
Application	Mobile application	Mobile application	Mobile application	Mobile application	System

Table 2.6.1 Comparison of review paper

2.7 Summary of Literature Reviews

This chapter had reviewed the existing applications which were done by other researchers. Throughout the review, the strengths and weaknesses of the technologies used in these existing applications are identified and stated in each section. The suggestions of resolutions for each application are also provided. From the literature review conducted, the problems found will be the existing solutions on different parts of human anatomy learning apply same solutions which is applying 3D reconstruction on graphical images and displaying the 3D object using marker-based AR. Although all the applications have their strengths in different aspects, all of them share same weakness which is insufficient in sense of reality. The last review is conducted on different aspect which is the AR based breast tumor visualization to explore the methodology in applying marker-based AR with medical datasets. As currently it is hard to find similar application which is open-source and can be easily access, the development of AR application for upper parts of digestive system anatomy learning using 3d reconstruction of medical image is essential.

CHAPTER 3 PROPOSED METHOD/APPROACH

3.1 Design Specifications

3.1.1 Methodologies and General Work Procedures

3.1.1.1 Data Collection

The first step in this project will be search and collect upper parts of digestive system and oral cavity CT dataset. The raw datasets get is usually a DICOM format data. DICOM stands for Digital Imaging and Communications in Medicine and are represented as .dcm file.

3.1.1.2 Data Importing and Processing

The image dataset imported to 3D Slicer for further process. After importing CT data, the image might appear too bright or dark. Depending on which area of the scan is of interest, the brightness and contrast for that region needs to be optimized to gain better image quality.

3.1.1.3 Slices in 3D View

After the optimization of image brightness and contrast, the way of showing the data in 3D is to visualize the three visible slices which are coronal plane, axial plane, and sagittal plane in 3D view. Good overview of the position and the relation of the slices to each other can be obtained from these three planes. Further explanations of the planes are as following:

- Coronal/ frontal plane is a vertical plane that divides the object into front and back sections.
- Axial/ horizontal plane is a horizontal plane that divides the object into top and bottom sections.
- Sagittal/ longitudinal plane is a vertical plane that dividing the object into left and right sections (Libretexts 2020)

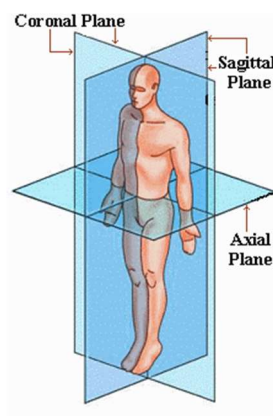


Figure 3.1.1.3.1 Three visible planes.

3.1.1.4 Segmentation and 3D Volume Rendering

The segmentation and 3D volume rendering is carried out using 3D Slicer. If only a specific part of the scan to be visualized, segmentation has to be done (Hemalatha, R.J. et al. 2018). The operator needs to trace the contours of the target regions on 2D slices manually. Segment is adjusted and applied when the operator satisfies with the segment. Operator needs to repeat the process until the segmentation of all slices are completed.

3.1.1.5 3D Model Exporting and File Conversion

After the segmentation is finished, volume rendering module and model maker module are applied to undergo 3D reconstruction. The object will now be displayed in the 3D view. The 3D model created is then exported as standard tessellation language (STL) format file. The next step is to export the 3D model as .obj file, as Unity can't directly import .stl files. Common software that being used to convert .stl file to .obj file is 3D Builder app.

3.1.1.6 AR Visualization

The .obj file is imported to Unity. As the AR to be built is a marker-based AR, a marker in JPG or PNG file type has to be created using Vuforia and being imported into Unity. The marker and the target object are matched and adjusted to the right position.

3.1.1.7 Application Development

Appropriate UI is created using Unity Canvas for interface display. The features such as rotate, zoom in, etc. will be added to create interactive user interface. C# scripts is created in Unity to perform application function. Also, the quiz game module will be developed using C# script in Unity extension Visual Studio. Finally, the application is exports as APK file.

3.1.2 Tools to use

3.1.2.1 Hardware

The hardware involved in this project is a laptop and an android mobile device. The laptop is used to develop the whole application from image segmentation, 3D reconstruction and applying AR technology. The mobile device is for testing and deploying the application.

The specification of each of the hardware are as shown following:

Laptop

Description	Specifications
Name	Dell Vostro 5471
Processor	Intel(R) Core(TM) i5-8250U CPU @ 1.60GHz 1.80 GHz
Operating System	Windows 10
Graphic coprocessor	AMD Radeon 530 Graphics
RAM	8GB
Hard Drive	128GB SSD, 1TB HDD 5400rpm
System Type	64-bit operating system, x64-based processor
Interface	2x USB 2.0 ports
Battery Capacity	3500 mAH

Table 3.1.2.1.1 Laptop specifications

Mobile Device

Description	Specifications
Name	Xiaomi Poco X3 NFC
Model Number	M2007J20CG
Processor	Qualcomm Snapdragon 732G
Operating System	Android 10, MIUI 12
GPU	Adreno 618
RAM	6GB
Memory	64GB
Network	2G,3G,4G/ LTE
Sensors	Fingerprint (side-mounted), accelerometer, gyro, proximity, compass
Battery Capacity	5160 mAH

Table 3.1.2.1.2 Mobile device specifications

3.1.2.2 Software

The software involved in this project are 3D Slicer, 3D Builder, Unity, Vuforia and Microsoft Visual Studio

- 3D Slicer

3D Slicer is an open source and multi-platform software for image analysis and scientific visualization which is widely used for medical and biomedical imaging.



Figure 3.1.2.2.1 3D Slicer logo.

- 3D Builder

3D Builder is a open source Windows app that enables user to view, capture, customize, repair, and print 3D models. 3D Builder is used to convert the .stl file type to .obj file in this project.

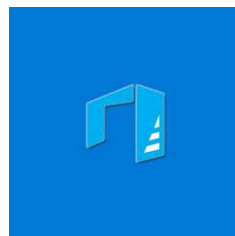


Figure 3.1.2.2.2 3D Builder logo.

- Unity

Unity is a cross-platform game engine that can be used to create both 2D and 3D games, as well as interactive simulations. The engine is popular and has been adopted by industries others than video gaming, wide ranging from film, automotive to architecture, engineering and construction. In this project, Unity 3D with Vuforia SDK installed is used to develop AR.



Figure 3.1.2.2.3 Unity logo.

- Vuforia

Vuforia Engine is a software development kit (SDK) that commonly used in creating Augmented Reality and other related app. It is added into the Unity and being set up to create the AR in this project.



Figure 3.1.2.2.4 Vuforia logo.

- Microsoft Visual Studio

Microsoft Visual Studio is an integrated development environment (IDE) which function in developing computer programs, as well as websites, web apps, web services and mobile apps. It is used as the extension of Unity to create quiz game in C# script in this project.

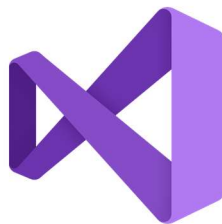


Figure 3.1.2.2.5 Microsoft Visual Studio logo.

3.1.3 Functional Requirements

Marker Tracking Module

- The application should allow user to scan the marker images.
- The application should detect and recognize the marker image scanned with mobile device camera.

AR Displaying Module

- The application should display the 3D model object on respective marker image.
- The application should display object in the real-time environment which tracking by the mobile device camera.
- The application should allow user to drag and resize the object according with fingertips gesture.
- The application should show rotate the object horizontally when user presses rotate button.
- The application shall show information gallery window when the user presses information button.

Information Gallery Module

- The application should show respective structural labelling anatomy pictures.
- The application should show information and knowledge about respective anatomy in words.

Quiz Game Module

- The application should display multiple-choice question.
- The application should let the user to answer the question by clicking a selection.
- The application should display result on the correctness of answer.
- The application should display correct answer when user answers the question wrongly.
- The application should display next question when previous question is completed.

3.1.4 Non- Functional Requirements

Operational

- The application should operate on Android environments.
- The application should be able to access the mobile device camera.
- The application should be able to access the mobile device sensor.

Performance Requirement

- The application should redirect user into correct features within short time.
- The application should detect and recognize the correct marker scanned within short time.

Usability Requirement

- The application should appear easy to use, rather than intimidating, demanding or frustrating.
- The application should respond on any button click.
- The application should allow user to close or return a feature.

3.1.5 Verification Plan

The test plans to be conducted are functional testing and acceptance testing. Functional testing is to be conducted on the complete and integrated application to evaluate the functions with its requirements. The following table shows the functionality test case with the test step and its expected output.

- Functional Testing

Test Case	Input	Expected Output
1. User able to download the marker.	User pressed “Download the marker” in main menu.	System directs user to a link with marker images to download.
2. User able to get into “Upper Parts of digestive system” AR interface.	User pressed “Upper Parts of Digestive System” button in main menu.	System directs user to AR interface for showing upper part of digestive system.
3. User able to get into “Oral Cavity” AR interface.	User pressed “Oral Cavity” button in main menu.	System directs user to AR interface for showing oral cavity.
4. User able to view upper parts of digestive system 3D anatomy in AR.	User scanned the marker for upper parts of digestive system.	System shows the 3D anatomy for upper part of digestive system above the marker in AR mode.
5. User able to view oral cavity 3D anatomy in AR.	User scanned the marker for oral cavity.	System shows the 3D anatomy for oral cavity above the marker in AR mode.
6. User can play around both upper part of digestive system and oral cavity objects.	User dragged, enlarged, or contracted the object displayed with fingertips.	System resize or drag the object according to user’s fingertips gesture.

7. User able to read more about both upper part of digestive system and oral cavity anatomy.	User clicked the information gallery button in AR interface of respective anatomy.	System pops up the information gallery window for respective anatomy.
8. User able to rotate both upper part of digestive system and oral cavity objects.	User clicked the rotate button in AR interface of respective anatomy.	System rotates the object displayed horizontally.
9. User able to play a quiz game.	User clicked the “Quiz Game” button in main menu.	System directs user to quiz game interface.
10. User able to answer questions and get the correct answer in quiz game.	User read the question and click on one of the selections.	System checks the user’s selection and return result on whether the selection is correct. If not, system displays the correct answer.

Table 3.1.5.1 Functional testing

- **Acceptance Testing**

In this testing process, the application developed will be distributed to 10 to 20 existing secondary or pre-university biology students. Their feedbacks are to be collected using Google Form questionnaire to evaluate the functionality, usability, performance, etc. of the application.

3.2 System Design/ Overview

3.2.1 System Block Diagram

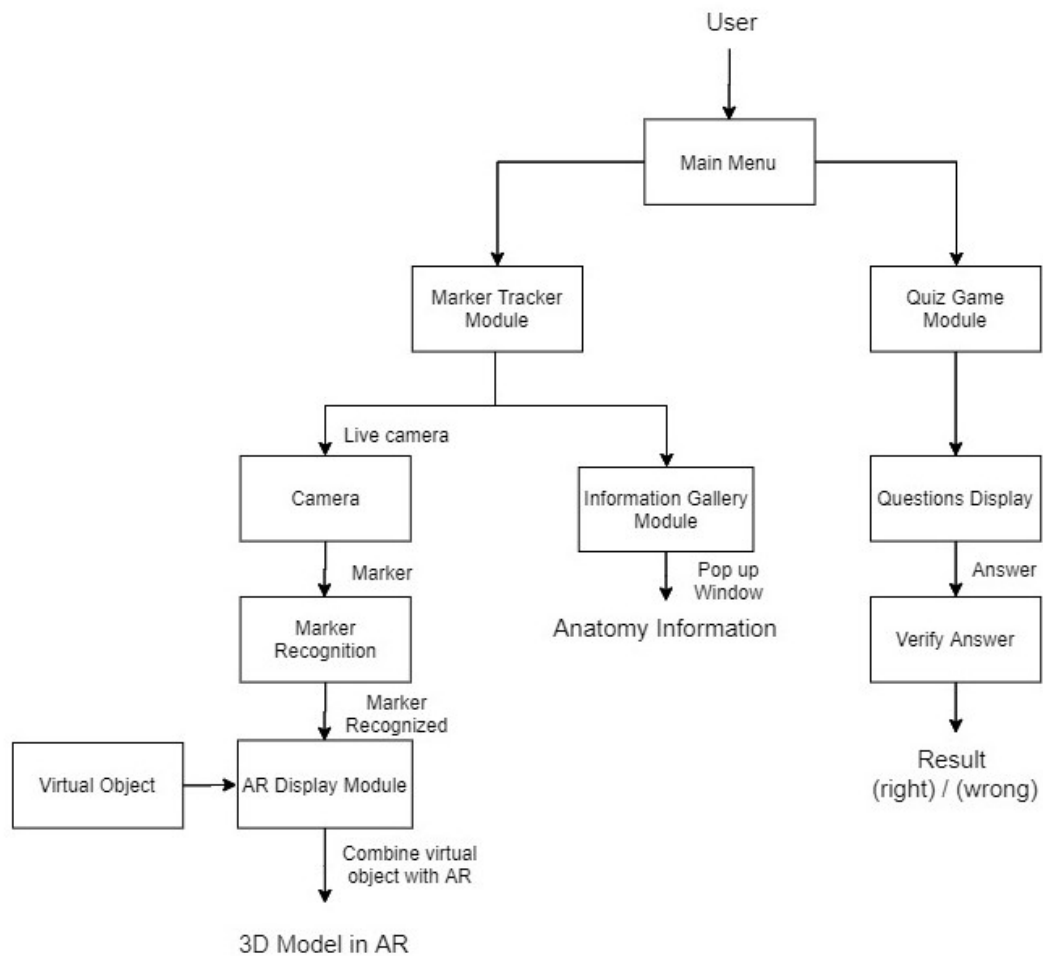


Figure 3.2.1.1 System Block Diagram.

There are four main modules involved in this AR application:

Marker Tracking Module

This module access user's mobile device camera and detect the object scanned by the user. When an available marker successfully recognized, the respective human anatomy object will be displayed above the marker on mobile device screen.

AR Displaying Module

This module allows visualization on 3D human anatomy model objects in real environment. User can view the object in 360 degree and play around the object with the fingertip gestures to visualize explore the anatomy structures in different angle.

Information Gallery Module

This module provides information about involved anatomy. The information provided is related to digestive system and oral cavity such as structural labelling of digestive system and oral cavity, the procedures of food being digested and other relevant information. Therefore, this will be convenience to the users as they can have an instant reference at the same time of viewing 3D anatomy in AR, without the needs to searching for other resources on books or Internet.

Quiz Game Module

This module consists of multiple-choice questions related to digestive system. Users can click on the selection based on their knowledge, the system will then justify user's answer and provide the correct answer if the student answer the question wrongly.

3.2.2 Use Case Diagram

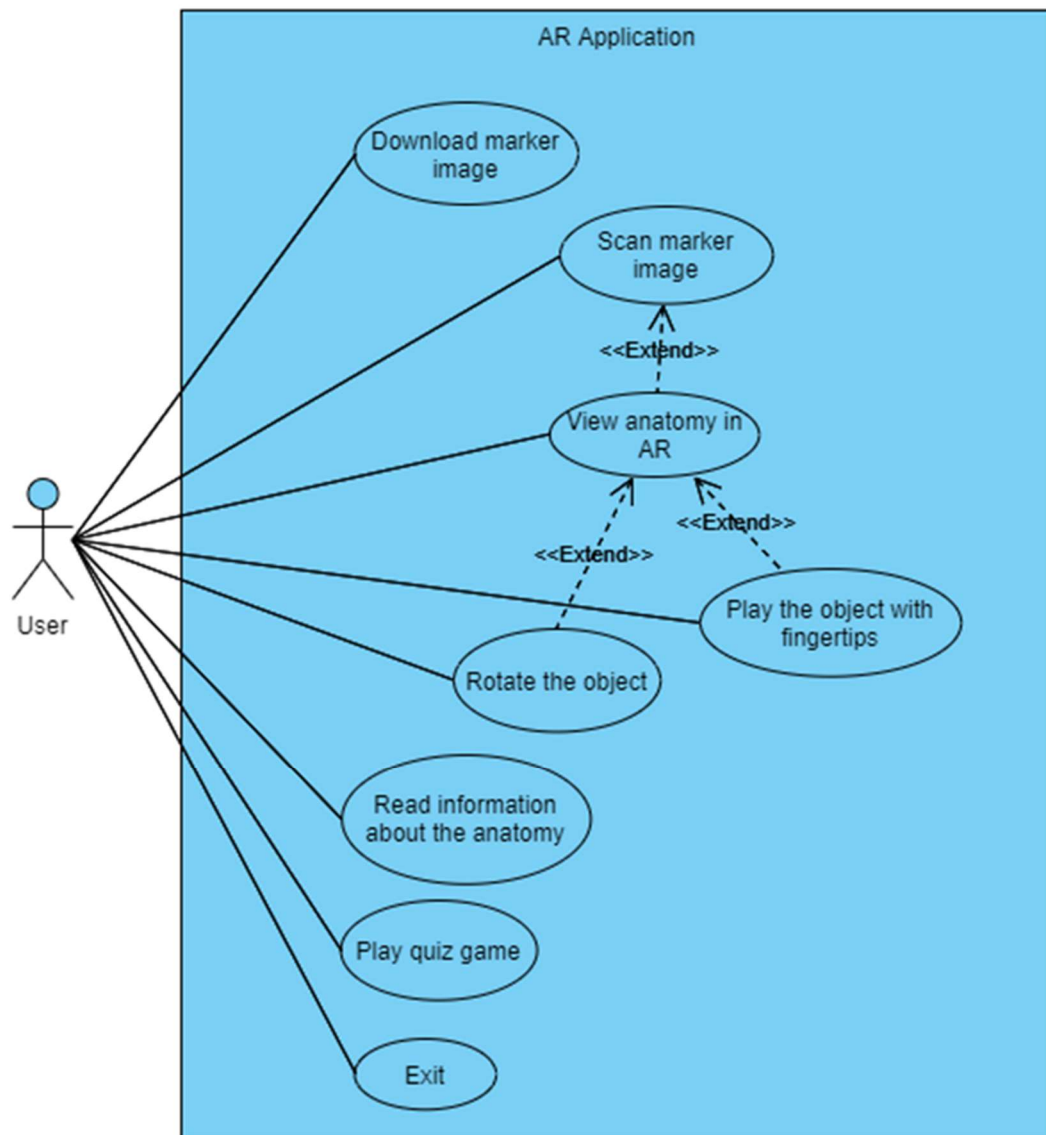


Figure 3.2.2.1 System Use Case Diagram.

The use case diagram above shows all the functions that can be carried out by users in using this AR application. Firstly, user can download the marker image through a link provided. Then, the user can scan the marker to view respective 3D anatomy in AR mode. Once the object is displayed on user's screen, user can drag or resize it with fingertips. Additional features in this AR application are information gallery which showing related anatomy information and quiz game which allow user to play with.

3.2.3 Sequence Diagram

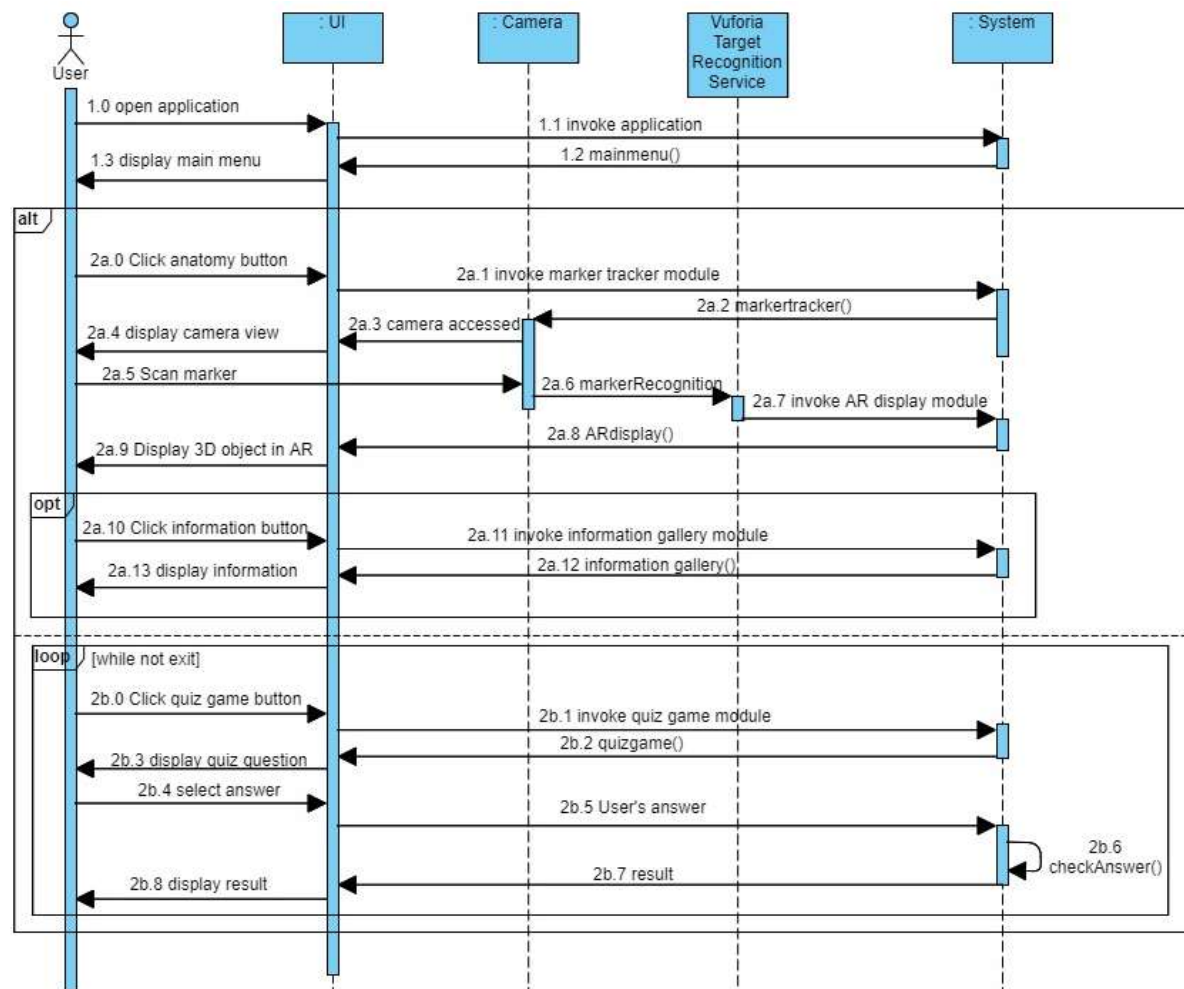


Figure 3.2.3.1 System sequence diagram.

The sequence diagram above shows the interaction between different objects. When the user opens the application, the main menu interface is firstly display. From main menu, use can select either to view 3D anatomy in AR mode or play the quiz game. If the user selects to view anatomy model in AR, the marker tracker module would be call, the module access to the mobile device camera and show camera view in user interface. Then, the user can start scanning the marker. Once the marker is recognized, the 3D anatomy model will be displayed in AR. In marker tracker module, if user press information button, the information gallery module will be called and the window displaying anatomy related information will pop out. If the user selects quiz game in main menu, quiz game module will be called. The question is displayed and wait for user answer. Once the user selects an answer, system will check the answer and return a result, either correct answer or wrong answer with display of correct answer.

3.2.4 Activity Diagram for Marker tracking, AR displaying and information gallery module

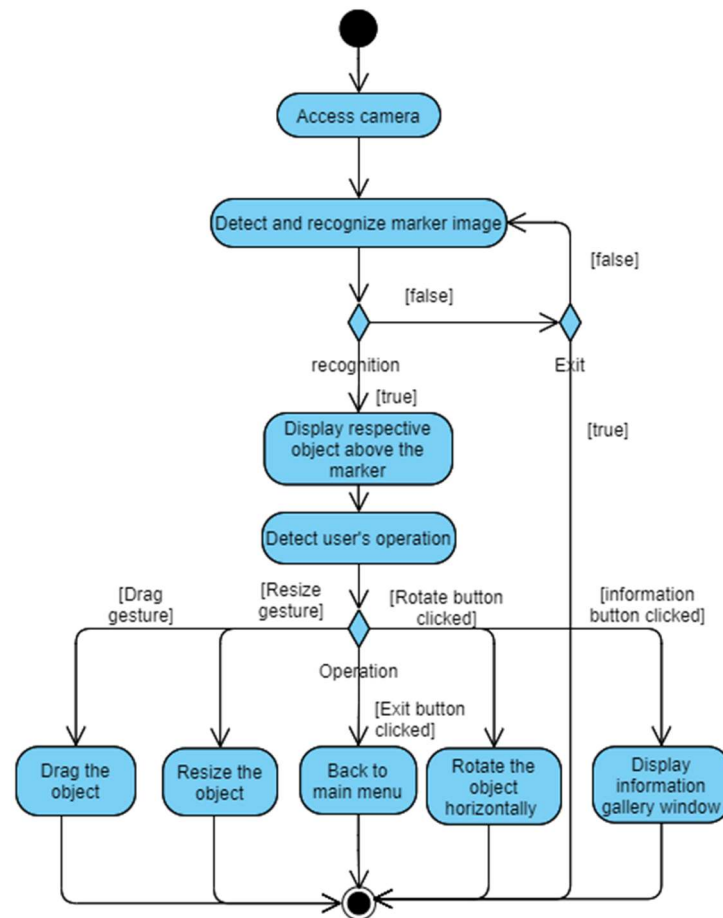


Figure 3.2.4.1 Activity Diagram for Marker tracking, AR displaying and information gallery module.

After entering the AR interface, user let the application to access the mobile device camera. The application will detect and recognize whether there is a valid marker image. If the application cannot detect a valid marker image, it will scan repeatedly until the user presses the exit button. Once the application successfully detects a marker image, it will display the respective anatomy object at the position above the marker. Then, the user able to operate different function onto the object. The application detects the user's fingertips gesture from time to time and perform respective functions intermediately. If user presses the rotate button, the application rotates the object horizontally with moderate speed. If user presses the information button, the application will pop up the information gallery window, else if the user presses exit button, the application will direct user to main menu.

3.2.5 Activity Diagram for Quiz Game module

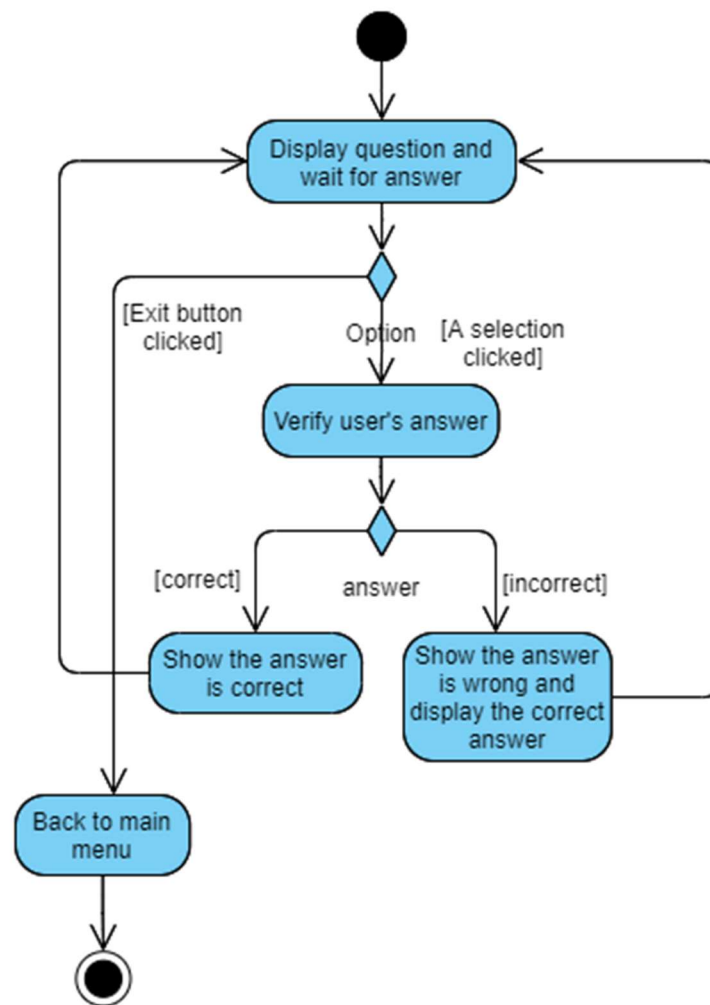


Figure 3.2.5.1 Activity Diagram for Quiz Game Module.

After entering the quiz game module, the application will randomly display a question and pause waiting for option from user. If the user clicks the exit button, the application will direct user back to the main menu. If the user clicks one of the selections, the application checks whether the selection is correct. If user's selection is correct, the application will show the answer is correct, else if the user's selection is incorrect, the application shows the answer is wrong and display the correct answer. Then, the application continues to next question and wait for user's option again.

3.2.6 Application GUI Design

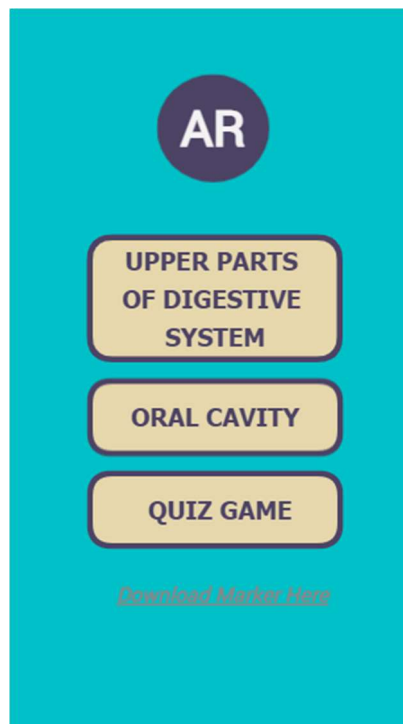


Figure 3.2.6.1 Main menu interface

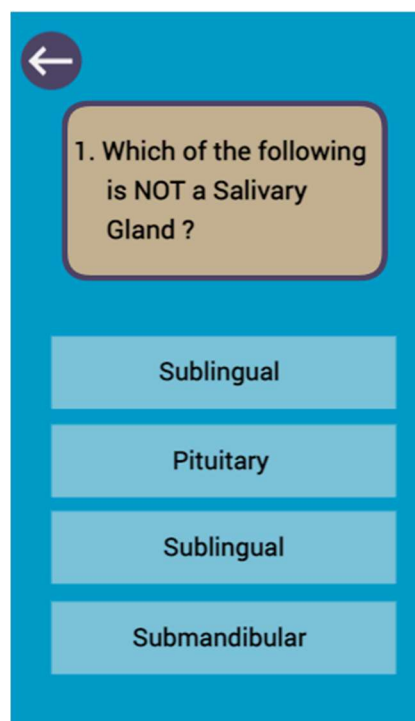


Figure 3.2.6.2 Quiz interface



Figure 3.2.6.3 AR display interface

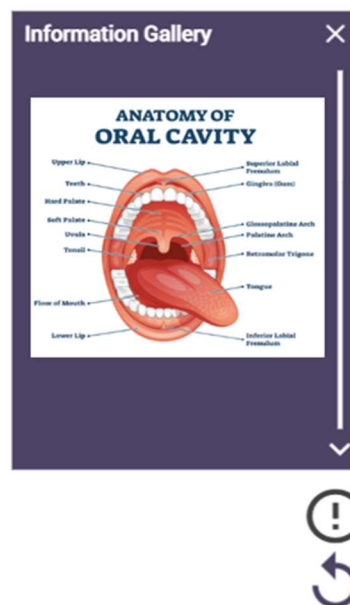


Figure 3.2.6.4 Information gallery interface

3.2.7 Implementation Issues and Challenges

There are several implementation issues and challenges in conducting this project as shown following:

- Difficulties in finding medical images datasets of human anatomy. Most of the medical images provided by medical institution or medical university is blocked and require purchase of license due to patient's privacy. Hence, it is hard to find high quality open-source medical images datasets.
- A lot of research is required to provide accurate information. As the developer of this application is not from medical or biology background, more studies on human anatomy must be conducted to provide precise information and knowledge to the user.

3.2.8 Timeline

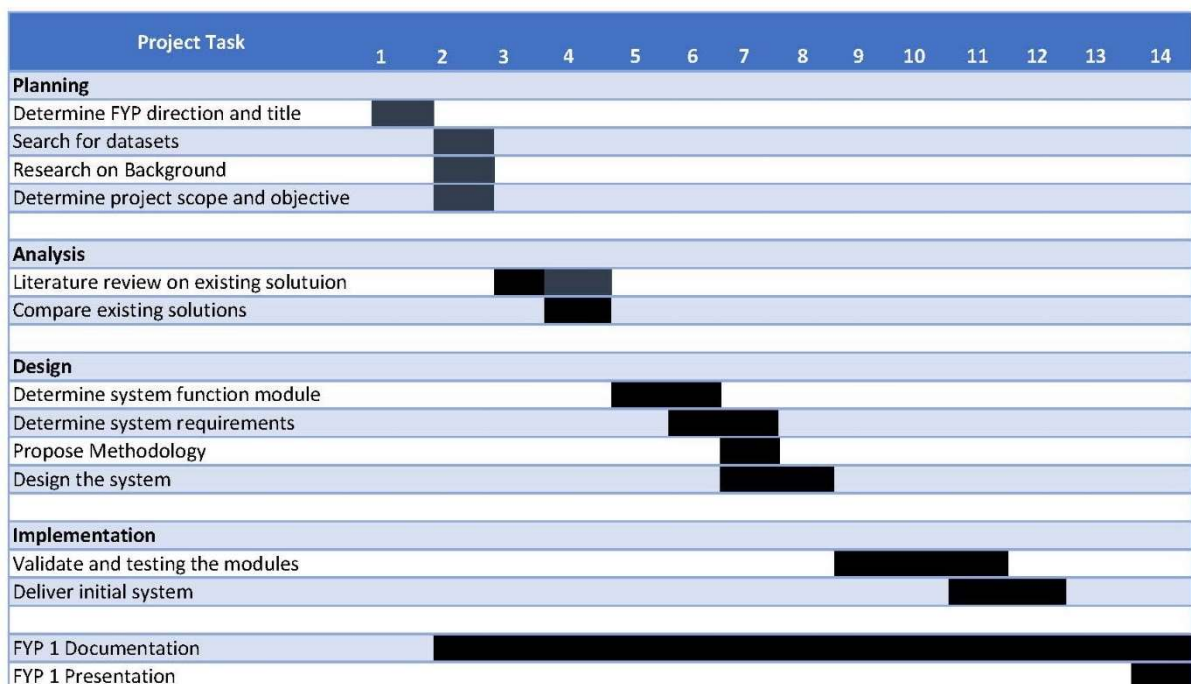


Figure 3.2.7.1 FYP1 Gantt Chart

3.2.9 Milestone of project and its key deliverable.

#	MILESTONE	KEY DELIVERABLE	DATE TO BE COMPLETED
1	Week 1		
	Complete the determination of project title.	1. Title	13 June 2021 (Sun)
2	Week 2		
	Complete the research on related works.	1. Project Background	18 June 2021 (Fri)
	Complete the selection of suitable dataset	2. Project Scope and objective	
3	Week 5		
	Complete the literature review.	1. Literature Review	5 July 2021 (Mon)
	Compare the literature review		
	Week 6		
	Complete the determination of functional module	1. Functional Module with description	17 July 2021 (Sat)
4	Week 8		
	Complete system requirements	1. System Specifications	31 July 2021 (Sat)
	Complete in Proposing methodology		
5	Week 9		
	Complete design of system	1. A draft for the report	2 August 2021 (Mon)
	Complete the draft of report		
6	Week 12		
	Complete the full report.	1. Final report.	26 August 2021 (Thu)
	Complete the implementation of preliminary work.	2. Preliminary Work	
7	Week 14		
	Complete the presentation of project and demo of system.	1. Presentation.	31 August 2021 (Tue)

Table 3.2.7.1 FYP1 milestones

CHAPTER 4: PRELIMINARY WORKS

4.1 3D Slicer Application Installation

There are two open-source applications involved in preliminary work which are 3D Slicer and 3D Builder. The 3D slicer application version 4.11.20210226 is firstly installed. As the 3D builder installation package including Qt plugin and Cmake folder by default, no extra environment setup needs to be done. The following figure shows the interface of initial 3D slicer workspace upon installation.

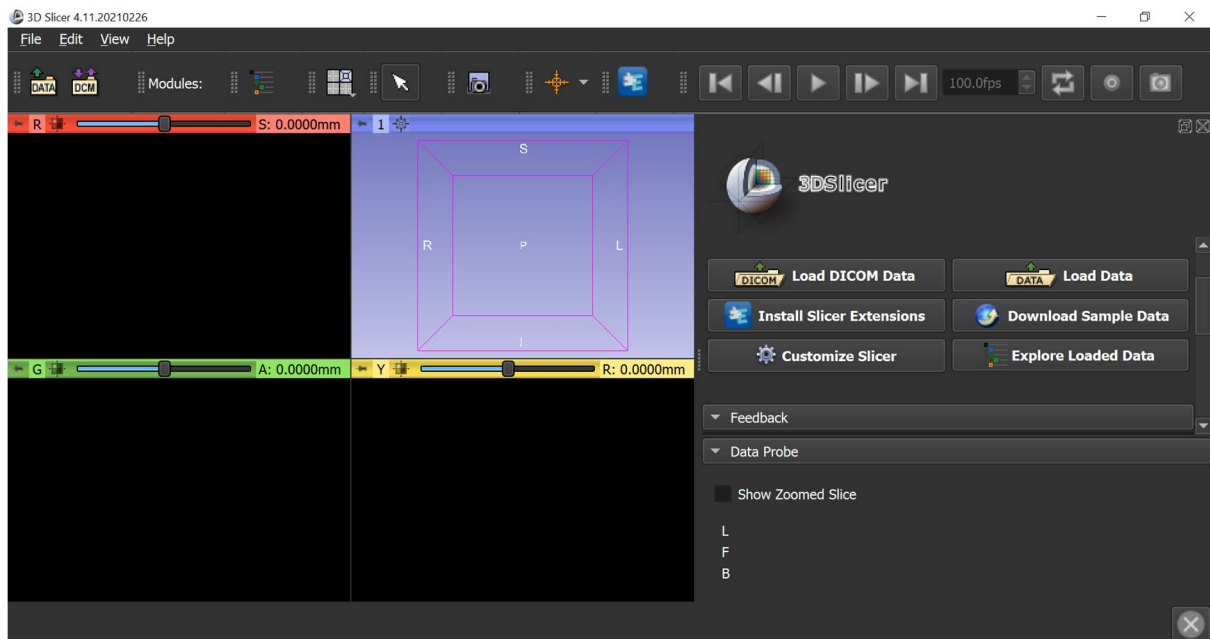


Figure 4.1.1 3D Slicer workspace.

4.2 Data Importing

There are two medical datasets which are CT imaging datasets being used in this project, the CBCT Dental Surgery is used for oral cavity 3D reconstruction while the SX Eagle skull, head and neck CT dataset is used for upper parts of digestive system 3D reconstruction. The source of each dataset is as following.

- i. CBCT Dental Surgery

Source: <http://slicer.kitware.com/midas3/slicerdatastore/view?itemId=137839>

- ii. SX Eagle 1.0.0

Source: <https://www.embodi3d.com/files/file/47712-sx-eagle/>

4.3 Image Segmentation

After the data is installed and loaded into the 3D Slicer workspace, the segment editor menu is selected from the top navigation bar.

4.3.1 Segments Creations

The segments are created and the colour for each segment is selected to separate each segment. For the oral cavity datasets, two segments which are skull and teeth are created, while for the upper parts of digestive system datasets, four segments which are esophagus, glands, lips and tract are created. Each segment is edited one by one, when a segment is being edited, all other segments are set to be invisible.

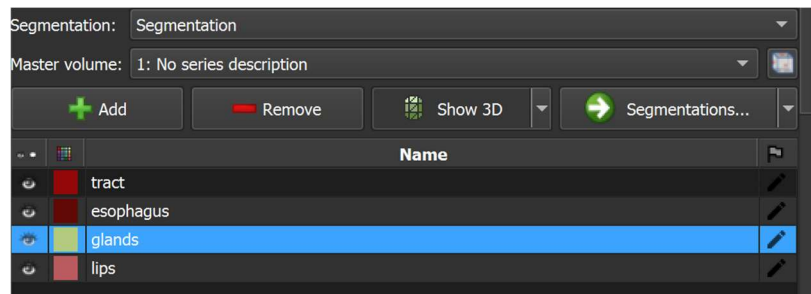


Figure 4.3.1.1 3D Segments of upper parts of digestive system.

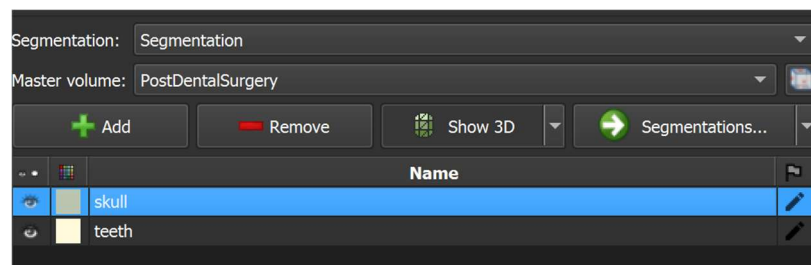


Figure 4.3.1.2 3D Segments of upper parts of digestive system.

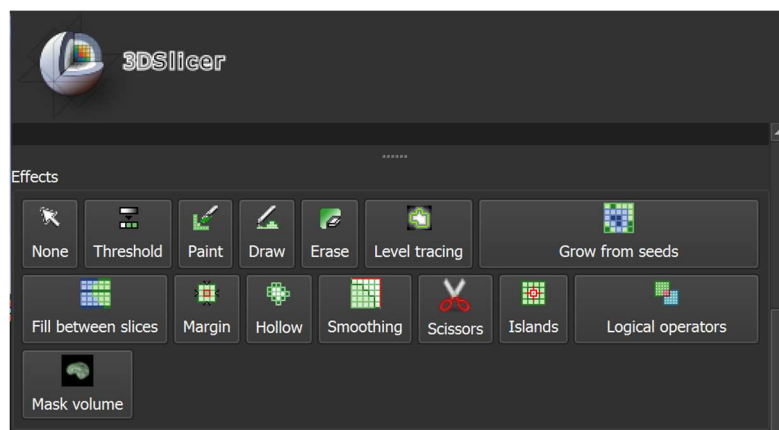


Figure 4.3.1.3 3D Slicer effects options.

4.3.2 Otsu's Thresholding

Otsu's thresholding is used to retrieve the important features of the images, the minimum and maximum threshold value is adjusted until the 3D model built with the features extracted showing overall shape of the model to be displayed. For skull segment thresholding, the range of threshold value is set as 188.29 to 14060.70.

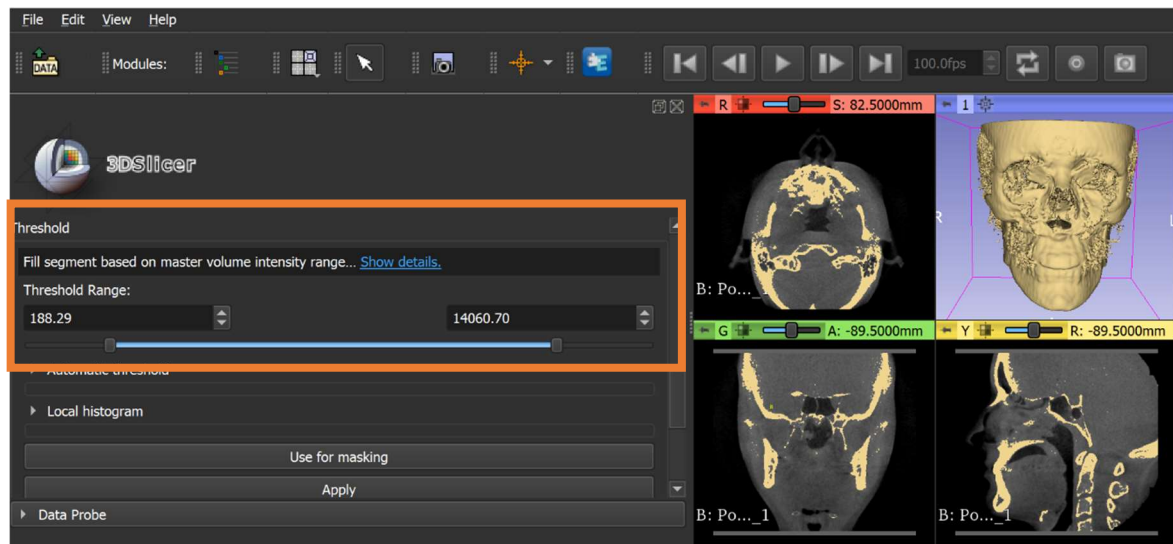


Figure 4.3.2.1 3D Skull segment thresholding

4.3.3 Contours Adjustment

The contours of each segment in all coronals, axial and sagittal 2D plane are adjusted manually using the paint, erase and cut function to enhance the main features and remove the external features.

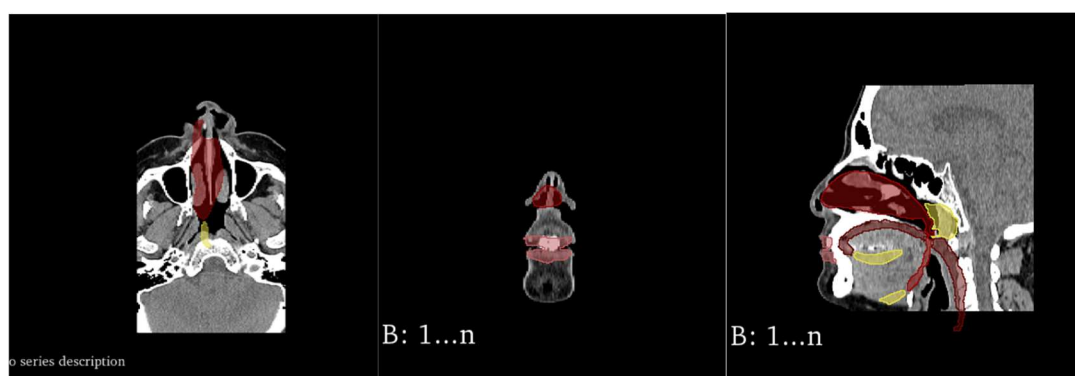


Figure 4.3.3.1 Coronals, axial and sagittal view of segmented upper part of digestive system

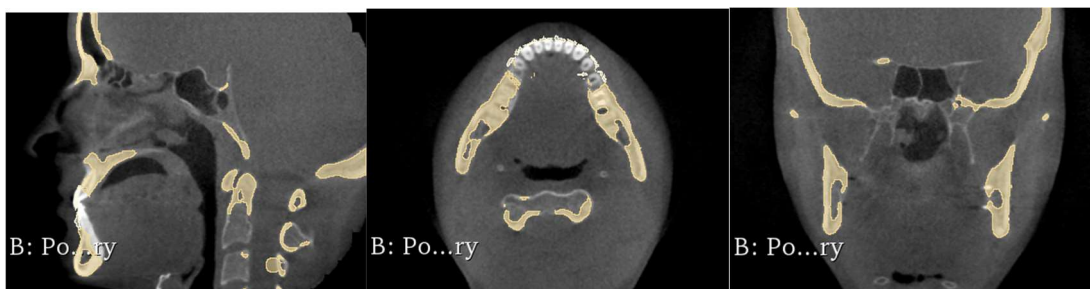


Figure 4.3.3.1 Coronals, axial and sagittal view of segmented oral cavity

4.3.4 Segment Island

The islands function in segment editor is utilized to remove the outliers. The minimum size is set to 1000 voxels and the selection “remove the small islands” is selected, which means any feature that having size smaller than 1000 voxels will be removed.

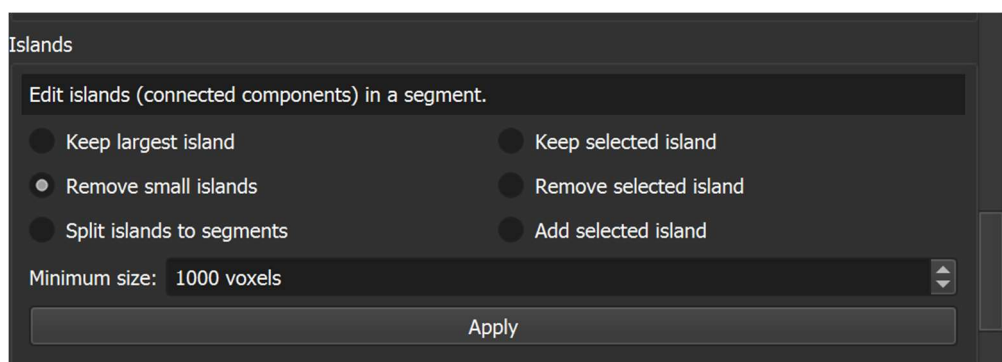


Figure 4.3.4.1 Islands settings

4.3.5 Segment Smoothing

The surface area of each segment is flattened and smoothed by setting a suitable smoothing method and kernel size. For example, the following smoothing method is saved as median, and the kernel size is set to 3.00mm.

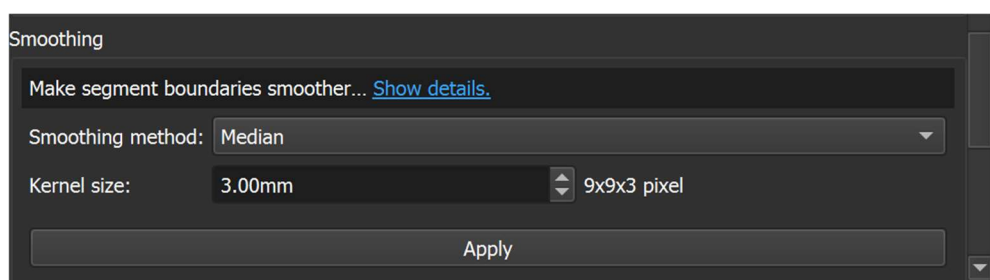


Figure 4.3.5.1 Smoothing settings

4.3.6 Segments Merging

After all the segments for a model is finished editing, the grow from seeds effect is used to merge all the features together. All the segments are set to be visible and the initialize button in grow from seeds function is clicked. When all the segments are loaded and updated, show in 3D button is clicked. Now, the 3D model of all segments combined is shown in 3D.

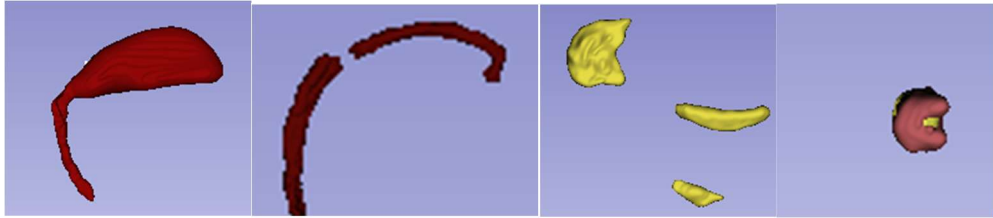


Figure 4.3.6.1 Segments isolation

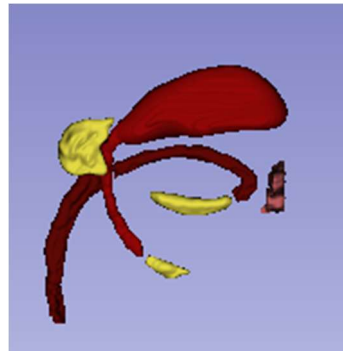


Figure 4.3.6.2 Combined segment

4.4 3D Volume Rendering

For upper parts of digestive system model, 3D volume rendering is applied to shows segments positions in human. The segment editor menu is selected from the top navigation bar. Then, a preset volume rendering is selected among the templates given.

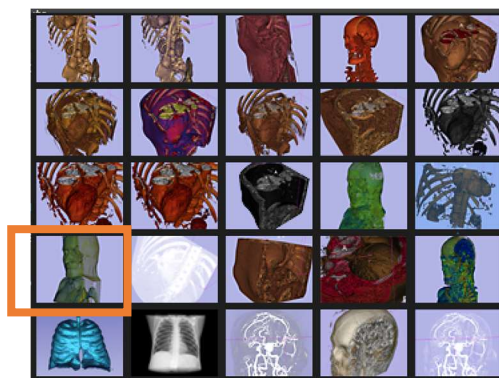


Figure 4.4.1 Volume rendering templates

The intensity of the volume rendering is adjusted, and the volume is set to be visible. Now, 3D model with volume rendering can be visualized.

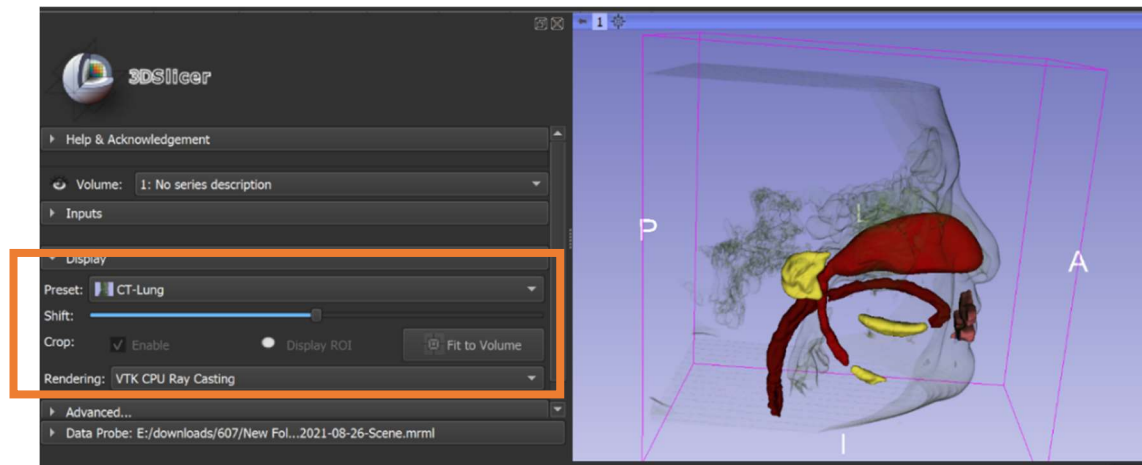


Figure 4.4.1 3D model with volume rendering

4.5 3D Model Exporting

After satisfied with the 3D model, the model is exported to STL file and to be further processed in 3D Builder application.

4.6 3D Model Customization

As the STL file do not support colour attributes, the colour of the segments need to be set again in 3D Builder application. As the datasets that used for upper part of digestive system 3D reconstruction only display the head and neck parts, it's loss of some essential parts which is the long esophagus that connected oral cavity to the stomach. Hence, a 3D model of esophagus from the online source is edited and combined with the model built. Then, the model is exported to Unity supported OBJ file.

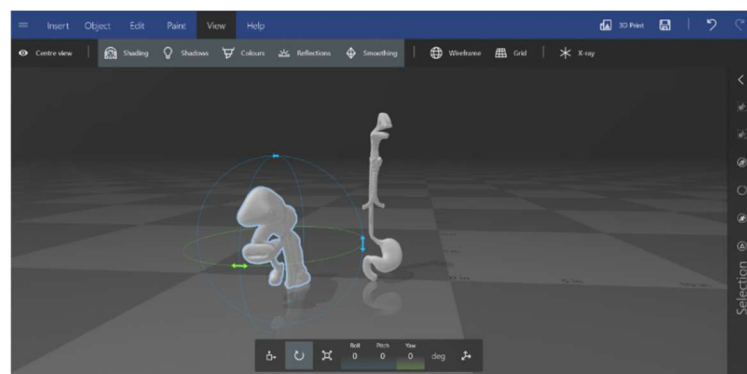


Figure 4.6.1 3D Builder workspace

4.7 3D Model Visualization

The final 3D model in OBJ file which are ready to be imported to Unity to further implement with AR are as shown as following,

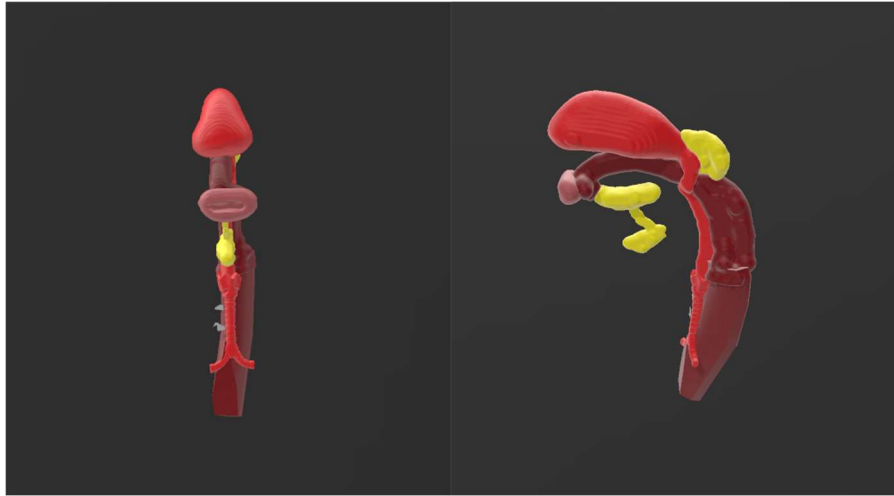


Figure 4.7.1 3D Model of upper parts of digestive system in OBJ file

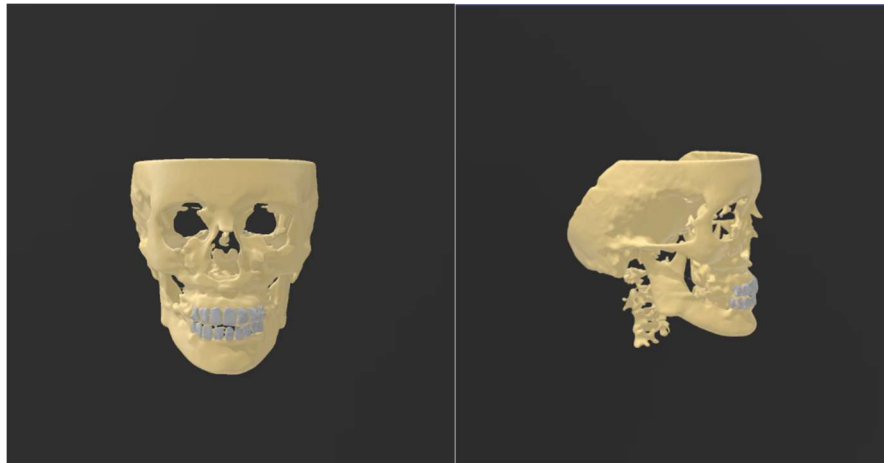


Figure 4.7.2 3D Model of oral cavity in OBJ file

CHAPTER 5 CONCLUSIONS

In medical and biology subjects, human anatomy learning is necessary. Traditional education method on human anatomy is ineffective as human anatomy is too complex to be represented in just a 2D image. As an aid to this, some of the educators explain the human anatomy using a 3D mannequin with reference to the resources on textbook, so that the students can have a clearer view and better understanding on human anatomy. This method is useful previously, but it is unavailable recently due to the transition from physical classes to online classes during the period of Covid-19 pandemic. The learning of human anatomy through flat screen on devices is challenging.

The proposed solution in this project is development of AR application with 3D reconstruction of CT image dataset. Making use of AR technology in displaying 3D anatomy model provides an alternative method of education which helps students to learn effectively and efficiently. Also, the interactive model of anatomy and the quiz game designed in this application is attractive and able to motivate students in learning human anatomy. Besides that, this application provides convenience for students to learn and revise instantly with just a mobile device instead of carrying thin reference book.

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Appendices

APPENDIX A: Weekly Report

FINAL YEAR PROJECT WEEKLY REPORT

(Project I / Project II)

Trimester, Year: May, 2021	Study week no.:1&2
Student Name & ID: Ng Che Qin 18ACB02123	
Supervisor: Dr Sayed Ahmad Zikri Bin Sayed Aluwee	
Project Title: AR Application for Upper Parts of Digestive System Anatomy Learning Using 3D Reconstruction of Medical Image	

1. WORK DONE

- Title Refinement
- Search for suitable dataset
- Research Project Background
- Determine project Scope and objective

2. WORK TO BE DONE

- Search and select for similar application or paper to be reviewed


3. PROBLEMS ENCOUNTERED

- Face some difficulties in searching open-source and high quality DICOM datasets.

4. SELF EVALUATION OF THE PROGRESS

- Need to conduct more research to better implement the application development.

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project I / Project II)

Trimester, Year: May, 2021	Study week no.:3&4
Student Name & ID: Ng Che Qin 18ACB02123	
Supervisor: Dr Sayed Ahmad Zikri Bin Sayed Aluwee	
Project Title: AR Application for Upper Parts of Digestive System Anatomy Learning Using 3D Reconstruction of Medical Image	

1. WORK DONE

- Determine 5 papers to be reviewed.
- Read through all the papers.

2. WORK TO BE DONE

- Complete the literature review with the papers selected.
- Determine application functions

3. PROBLEMS ENCOUNTERED

- Hard to find papers that develop AR application which made use of medical image for 3D reconstruction.

4. SELF EVALUATION OF THE PROGRESS

- Need to conduct more research to better implement the application development.

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project I / Project II)

Trimester, Year: May, 2021	Study week no.:5&6
Student Name & ID: Ng Che Qin 18ACB02123	
Supervisor: Dr Sayed Ahmad Zikri Bin Sayed Aluwee	
Project Title: AR Application for Upper Parts of Digestive System Anatomy Learning Using 3D Reconstruction of Medical Image	

1. WORK DONE

- Complete the literature review with methodology, strength, weaknesses, and suggestions for each reviewed paper.
- Complete the determination of functional modules

2. WORK TO BE DONE

- Determine system requirements.
- Proposed methodologies.


3. PROBLEMS ENCOUNTERED

- Spend long time in proposing system methodologies.

4. SELF EVALUATION OF THE PROGRESS

- Need efficient time management to avoid the delayed of progress.

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project I / ~~Project II~~)

Trimester, Year: May, 2021	Study week no.:7&8
Student Name & ID: Ng Che Qin 18ACB02123	
Supervisor: Dr Sayed Ahmad Zikri Bin Sayed Aluwee	
Project Title: AR Application for Upper Parts of Digestive System Anatomy Learning Using 3D Reconstruction of Medical Image	

1. WORK DONE

- Complete the system requirements sections in report.
- Complete Methodology sections in report.

2. WORK TO BE DONE

- Propose System design.
- Complete all necessary sections in reports such as timeline, Gantt Chart, Verification Plan, etc.

3. PROBLEMS ENCOUNTERED

- Currently no problem to be encountered.

4. SELF EVALUATION OF THE PROGRESS

- Need efficient time management to avoid the delayed of progress.
- Modifications of project need to be done from time to time.

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project I / Project II)

Trimester, Year: May, 2021	Study week no.:9&10
Student Name & ID: Ng Che Qin 18ACB02123	
Supervisor: Dr Sayed Ahmad Zikri Bin Sayed Aluwee	
Project Title: AR Application for Upper Parts of Digestive System Anatomy Learning Using 3D Reconstruction of Medical Image	

1. WORK DONE

- Submission of report draft without preliminary works
- Obtained the advice from supervisor.

2. WORK TO BE DONE

- Modify the reports according supervisor's advice.
- Install and setup required tools for system implementation.
- Start preliminary work.

3. PROBLEMS ENCOUNTERED

- Rush through the reports writing and preliminary work.

4. SELF EVALUATION OF THE PROGRESS

- Need to put in efforts on preliminary work.

Supervisor's signature



Student's signature

FINAL YEAR PROJECT WEEKLY REPORT

(Project I / Project II)

Trimester, Year: May, 2021	Study week no.:11&12
Student Name & ID: Ng Che Qin 18ACB02123	
Supervisor: Dr Sayed Ahmad Zikri Bin Sayed Aluwee	
Project Title: AR Application for Upper Parts of Digestive System Anatomy Learning Using 3D Reconstruction of Medical Image	

1. WORK DONE

- Complete and submit the fyp1 report.
- Complete the preliminary work.

2. WORK TO BE DONE

- Prepare the powerpoint slide for oral presentation.
- Continue implement the application.

3. PROBLEMS ENCOUNTERED

- Spends long time in medical image segmentation and 3D visualization.

4. SELF EVALUATION OF THE PROGRESS

- The works done need to be modified and improved from time to time.

Supervisor's signature



Student's signature

AR Application for Upper Parts of Digestive System Anatomy Learning Using 3D Reconstruction of Medical Image

Made By: Ng Che Qin | Supervisor: Dr. Sayed Ahmad Zikri Bin Sayed Aluwee | Moderator: Prof. Dr. Leung Kar Hang | Universiti Tunku Abdul Rahman

Introduction

The outbreak of Covid-19 has accelerated the trends from traditional in-class learning towards E-learning. Anatomy learning is one of the most prominent and crucial subjects of biology and medical education. Human anatomy is too complex for some students to gain knowledge and information through flat device screen during online classes. This project is to develop a mobile application which provide an easily-access 3D human anatomy model in AR mode using 3D reconstruction of medical images. Also, Interactive function, information gallery and quiz game are added to develop a more functional application.

Problem Statement

- I. Ineffective study on human anatomy in education system.
- II. Lack of reality and accurateness in existing 3D human anatomy applications.
- III. Lack of interest and motivation towards traditional academic practices in student perspective.

Objectives

- I. To promote effective learning in human anatomy.
- II. To increase the reality and accurateness of 3D human anatomy.
- III. To increase student's motivation and interest in human anatomy learning

Tools

- 3D Slicer
- 3D Builder
- Unity with Yuforia SDK
- Microsoft Visual Studio

Methodology

Image Segmentation

3D Visualization

AR Implementation

Application Development

System Block Diagram

```

graph TD
    User --> Main Menu
    Main Menu --> Customizer Module
    Main Menu --> Information Gallery Module
    Customizer Module --> Live camera
    Live camera --> Marker
    Marker --> Marker Recognition
    Marker Recognition --> AR Overlay Module
    Information Gallery Module --> Propag. Information
    Propag. Information --> Anatomy Information
    Anatomy Information --> AR Overlay Module
    AR Overlay Module --> Virtual Object
    Virtual Object --> Combine virtual object with AR
    Combine virtual object with AR --> 3D Model in AR
    
```

Medical Image Dataset

- CBCT Dental Surgery
<http://slicer.kitware.com/midas3/slicerdataset/view?itemId=137839>
- Upper parts of digestive system CT image
<https://www.emboof3d.com/files/file/47712-sx-ea4e1e>

Image Segmentation and 3D Visualization

Conclusion

Making use of AR technology in displaying 3D anatomy model provides an alternative method of education which helps students to learn effectively and efficiently. Also, the interactive model of anatomy and the quiz game designed in this application is attractive and able to motivate students in learning human anatomy. Besides that, this application provides convenience for students to learn and revise instantly with just a mobile device instead of carrying thin reference book.

APPENDIX C: Plagiarism Check Summary

8/27/2021

Turnitin

<p>Turnitin Originality Report</p> <p>Processed on: 26-Aug-2021 23:30 +08 ID: 1636205785 Word Count: 7304 Submitted: 2</p>	
<p>Similarity Index</p> <p>10%</p>	<p>Similarity by Source</p> <p>Internet Sources: 6% Publications: 4% Student Papers: 6%</p>
<p>AR Application for Upper Parts of Digestive System Anatomy Learning Using 3D Reconstruction of Medical Image By Che Qin Ng</p>	
<p>1% match (student papers from 26-Oct-2016) <u>Submitted to UT, Dallas on 2016-10-26</u></p>	
<p>1% match (Internet from 02-Dec-2020) https://learn.g2.com/augmented-reality</p>	
<p>1% match (publications) Michael H Kurniawan, Suharjito, Diana, Gunawan Witjaksono. "Human Anatomy Learning Systems Using Augmented Reality on Mobile Application", Procedia Computer Science, 2018</p>	
<p>1% match (publications) E L Amalia, D Suryani H. ""ARRES" Augmented Reality for the human respiratory system", Journal of Physics: Conference Series, 2019</p>	
<p>< 1% match (student papers from 12-Jun-2018) <u>Submitted to Universiti Malaysia Pahang on 2018-06-12</u></p>	
<p>< 1% match (Internet from 18-Sep-2020) https://techterms.com/definition/augmented_reality</p>	
<p>< 1% match (publications) I Sonjaya, R Fadlurahman. "Learning media for human digestive system based on augmented reality", Journal of Physics: Conference Series, 2019</p>	
<p>< 1% match (student papers from 25-Jun-2020) <u>Submitted to CSU, Dominguez Hills on 2020-06-25</u></p>	
<p>< 1% match (student papers from 27-Apr-2011) <u>Submitted to Republic Polytechnic on 2011-04-27</u></p>	
<p>< 1% match (Internet from 07-Aug-2021) https://b2fc5faf-3a51-4493-beb0-dd8aba69eab0.filesusr.com/ugd/189545_05eaa54cf4a24e6db44d27e13ea323a4.pdf</p>	
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Universiti Tunku Abdul Rahman			
Form Title : Supervisor's Comments on Originality Report Generated by Turnitin for Submission of Final Year Project Report (for Undergraduate Programmes)			
Form Number: FM-IAD-005	Rev No.: 0	Effective Date: 01/10/2013	Page No.: 1 of 1



FACULTY OF INFORMATION AND COMMUNICATION TECHNOLOGY

Full Name(s) of Candidate(s)	Ng Che Qin
ID Number(s)	18ACB02123
Programme / Course	BACHELOR OF COMPUTER SCIENCE (HONS)
Title of Final Year Project	AR Application for Upper Parts of Digestive System Anatomy Learning Using 3D Reconstruction of Medical Image

Similarity	Supervisor's Comments (Compulsory if parameters of originality exceeds the limits approved by UTAR)
Overall similarity index: <u>10</u> % Similarity by source Internet Sources: <u>6</u> % Publications: <u>4</u> % Student Papers: <u>6</u> %	
Number of individual sources listed of more than 3% similarity: <u>0</u>	
Parameters of originality required and limits approved by UTAR are as Follows: (i) Overall similarity index is 20% and below, and (ii) Matching of individual sources listed must be less than 3% each, and (iii) Matching texts in continuous block must not exceed 8 words <i>Note: Parameters (i) – (ii) shall exclude quotes, bibliography and text matches which are less than 8 words.</i>	

Note Supervisor/Candidate(s) is/are required to provide softcopy of full set of the originality report to Faculty/Institute

Based on the above results, I hereby declare that I am satisfied with the originality of the Final Year Project Report submitted by my student(s) as named above.

Signature of Supervisor

Name: _____

Date: _____

Signature of Co-Supervisor

Name: _____

Date: _____



UNIVERSITI TUNKU ABDUL RAHMAN

FACULTY OF INFORMATION & COMMUNICATION TECHNOLOGY (KAMPAR CAMPUS)

CHECKLIST FOR FYP1 THESIS SUBMISSION

Student Id 18ACB02123
Student Name Ng Che Qin
Supervisor Name Dr Sayed Ahmad Zikri Bin Sayed Aluwee

TICK (✓)

DOCUMENT ITEMS

Your report must include all the items below. Put a tick on the left column after you have checked your report with respect to the corresponding item.

- ✓ Title Page
- ✓ Signed form of the Declaration of Originality
- ✓ Abstract
- ✓ Table of Contents
- ✓ List of Figures (if applicable)
- ✓ List of Tables (if applicable)
- ✓ List of Symbols (if applicable)
- ✓ List of Abbreviations (if applicable)
- ✓ Chapters / Content
- ✓ Bibliography (or References)
- ✓ All references in bibliography are cited in the thesis, especially in the chapter of literature review
- ✓ Appendices (if applicable)
- ✓ Poster
- ✓ Signed Turnitin Report (Plagiarism Check Result – Form Number: FM-IAD-005)

*Include this form (checklist) in the thesis (Bind together as the last page)

I, the author, have checked and confirmed all the items listed in the table are included in my report.

Supervisor verification. Report with incorrect format can get 5 mark (1 grade) reduction.

cheqin

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Date:

(Signature of Supervisor)
Date: