# 3D MODEL RECONSTRUCTION OF HUMAN KNEE JOINT BASED ON MEDICAL IMAGES FOR EDUCATION PURPOSE

BY

CHOY CHEE MUN

A REPORT

SUBMITTED TO

UNIVERSITI TUNKU ABDUL RAHMAN

In partial fulfillment of the requirements

for the degree of

BACHELOR OF COMPUTER SCIENCE (Honours)

Faculty of Information and Communication Technology (FICT)

(Kampar Campus)

JAN 2021

**UNIVERSITI TUNKU ABDUL RAHMAN**

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**Date**: 14TH APRIL 2021

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## DECLARATION OF ORIGINALITY

I declare that this report entitled "**3D MODEL RECONSTRUCTION OF HUMAN KNEE JOINT BASED ON MEDICAL IMAGES FOR EDUCATION PURPOSE**" 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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## ACKNOWLEDGEMENT

I would like to express my sincere thanks and appreciation to my supervisor, Dr Sayed Ahmad Zikri Bin Sayed Aluwee for giving me the opportunity to engage this project entitled “3D Model reconstruction of human knee joint based on medical images for education purpose. It is a great blessing for me to able to learn and acquire the knowledge of medical image processing and 3D modelling. A bless and million thanks to you.

I would also like to thank Dr Dylan Choy Siew Fen, a veterinarian, and a sister, and Dr Hafizah Zaharah Bt Ahmad, oncologist in Sunway healthcare, who had helped me throughout the process of understanding the medical images and acknowledge my project.

Finally, I would like to thank my family and friends who had given me love and supports throughout the course.

# ABSTRACT

The medical images are the fundamental equipment that will help the medical students or even specialists on finding the problems and diseases in the body. The objective of this project is to develop 3D reconstructed anatomy structure based on real medical images of the patient to allow students to study the 3D anatomy structure from actual medical images. Segmentation techniques are the methods which helps on detecting the anomalies or the diseases inside the bodies. The 3D slicer workbench is a software which provides different type of the modules and systems that will help to generate a 3D models of the anatomy and the problems from the medical images. Along with the workbench, a new module can be created to help on solving the problems as well as easing the studies for the medical students. Image segmentations consist of few methods that can be used to do the image processing onto the DICOM image so that to create a 3D model according to it, but proper method must be chosen wisely. Moreover, the 3D slicer workbench project template had provided basic 3D slicer modules and can be used to create a new model for the project. The model was done so by using some segmentation techniques and smoothing techniques. Once the process was done, the 3D model visualization can be seen. The 3D model was then printed out with the software called Snapmaker Luban along with the 3D printing machine. During the project, the waterfall development method was used.

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| | |
|---|---|
| MRI | Magnetic Resonance Imaging |
| GPU | Graphical Processing Unit |
| VTK | Visualization Toolkit |
| ITK | Insight Segmentation and registration Toolkit |
| CTK | Common Toolkit |
| ACL | Anterior Cruciate Lateral |
| PCL | Posterior Cruciate Lateral |
| LCL | Lateral Collateral Ligament |
| MCL | Medial Collateral Ligament |

**LIST OF TABLES**

# Chapter 1: Introduction

## 1.1 Problem Statement and motivation

The 3D reconstruction of human organ based on medical images segmentation is a technique that allows the doctors to study the anatomy and the functions of the organs in living things. It is an important task in many clinical applications as it will influence the outcome results of the analysis. Furthermore, the medical-based segmentation allows specialists to detect the location of the disease and enable the doctor to diagnose quickly on the patients' situation. In addition, segmentations also had helped to ease the studies on anatomy of living things, allowing all medical students to understand better on living things' complexity. However, some parts of the anatomy of the bodies can be hard to be seen through the image itself and often the specialist will need to detect it manually using the manual segmentation.

In Malaysia medical student had a hard time practicing on detection region of the organs infected from the disease by studying the 2D images. Visualization on the medical images is difficult for fresh medical students who do not have the experience on understanding the medical images and will need the guidance from the lecturer. However, even with the advice, some students may not be able to visualize the images, and many of them may not be able to sketch out the images in 3D volumetric shape. It was challenging to understand the anatomy of the organs only by using the textbook or 2D atlases. Moreover, students need to virtually construct the structures in their mind which is very inefficient to them (Kong et al. 2016). Additionally, such a task is nearly impossible for all fresh medical students who are not experienced to do so or cannot do so. It will be time-consuming to study anatomy from a textbook and to map out the anatomy structure of the organs manually based on the 2D images. Moreover, other parts of the body anatomy like the knee joints have the complexity of visualization on the ligaments; under the medical images, it is still likely impossible to see the ligament parts.

Even though some 3D organs are modelled were used for learning purpose, but it still lacks 3D anatomical structures based on the original medical images, especially in Malaysia. Most of the models are created based on the book, pictures, or atlases. The problem with these models was the accuracy, whether it is similar to the actual organs with diseases.

Other problem is the performance of an inexperienced doctors on the surgery practice. New doctors had a hard time performing well in their surgery practice, especially when it comes to diagnosing the disease of the patients by referring to the images. The procedure such as examine the condition of the patient, then followed by diagnosing the disease; once done, they will need to make a right decision on whether if the patients need to perform a surgery. Although they may have diagnosed the disease correctly the first time, there is a high chance risk of mistakes. Some may not have been able to examine or visualize appropriately due to the position of the diseases in the images which may not be clear and easy to be detected. In fact, action, determination, and precision of the surgeons are the keys when it comes to saving the lives of the others.

Therefore, our purpose is to generate a 3D reconstruction and segmentation of human knee joints based on actual medical images to help a medical student to learn more effectively, especially in Malaysia. Furthermore, in a distant future, we can enhance our work to support (second opinion) the doctors to improve disease diagnosis results, especially for the new doctors.

## 1.2 Project Scope

This project will develop a new module with different segmentation technique and will be implemented into the 3D slicer workbench to give improvements on the 3D views after the segmentation process for improvements on education purpose. This new module allows the 3D slicer user to do auto-segmentation so that to save time on pre-processing the medical images into a 3D model. Moreover, the auto-segmentation module is also an attempt to give a better accuracy of the views on the anatomy of the knee joints, which is the current project data that will be used.

Additionally, in this project scope the Visual studio 2017 software will be suggested for the development of the module and implementation as well. The visual studio 2017 is suggested as such that it is needed to build a new module that is not found in the current workbench. Moreover, the software itself allows any plugins which able to improve the functionality with different level. In visual studio, many built-in tools have been also provided such as the designer for GUI application build, web designs, class designs, database schema designer and many more. Besides that, the Visual Studio is an error-sensitive code editor which then be easier to prevent any of the errors, misused of the operators or finding redundancy of the class relations and functionality.

### 1.3Project objective

1) To develop 3D reconstructed anatomy structure based on real medical images of the patient.
   - The reconstruction of the organs with every detail of the anatomy structure of organs will be able to help medical students to have better understanding on the condition of the parts of an organ from a patient.

2) To allow students to study the 3D anatomy structure from actual medical images
   - Allows user, especially medical students to ease their studies on the anatomy by using a 3D view of the medical image's segmentation.
   - Allows to improve the inexperienced doctors' or surgeons' judgment on disease detection.

### 1.4 Impact, significance, and contribution

The significance of this project is that using auto segmentation modules to create a 3D model of the knee joints. The anatomy of the knee joints is not easily to be seen or visible enough under the medical imaging screening although semi-auto segmentation can be done as well. But even with the semi-auto segmentation, human errors can also occur during the segmentation process, giving a low accuracy of the image information. Moreover, the workbench in this project has not been implemented with the auto segmentation modules as it is. Besides that, this project will eventually give bigger impacts on medical education as it will provide the need of help to them on giving the exact description of the anatomy and perhaps letting the medical students to understand and learn more of the auto segmentation system. This is because the auto segmentation module is a technique that can clearly give a better result of the 3D models with greater accuracy as well as the precision. This technique will then be used as learning purpose for medical educations.

They were solving medical imaging studies problem by helping to reduce making any mistakes after graduating as a medical specialist, as it can give negative impacts towards their career and the company that they are working. Furthermore, lecturers of the medical field have now begun to take in on teaching the fundamentals of the programs regarding on the segmentation process which will be a game-changer as the medical students will then understand better on the functionality.

## 1.5 Background information

Manual segmentation is the first module which was used frequently by the doctors and specialists where they will need to make labels and segments the medical images by hand, only by referring to a spectrograms or waveforms. To this date, medical doctors, specialists and even the medical students are still using manual segmentation as a practice as it is said that the manual segmentation method is the most accurate because of the difficulties to create and align the structures of the images accurately. Moreover, it will be much more difficult for the experts to do segmentations if the quality of the related image is too low (Despotovic et al, 2014).

Even with a well-trained expert, the fact about the manual segmentation is that it is a very time-consuming task such that an expert, or operator, will need to go through every slices of the medical images to do segmentation process and extracting out the contour of the structures which the operators target to segment it. Additionally, it is very likely to be prone on making a lot of mistakes or errors and most of the time the results will be impossible to reproduce. Therefore, experts are now currently practicing on the semi-auto segmentation technique and auto segmentation technique.

Auto segmentation is the latest generation of segmentation algorithm development in which this technique have been clustered with 3 generations of algorithms along with the multi-atlas based and hybrid technique (Carlos et al, 2019). Knee joint was used for the project purpose as the anatomy of the knee joint on the medical image is quite a challenge for the experts or medical students to create the models out especially when segmenting the ligament parts in the knee joint.

## 1.6 Report Organization

In chapter 1, background information, problem statement and motivation to develop this AR application for learning human anatomy is discussed and stated. Then, the project objectives and scopes are identified based on the problem statement. Next, project impact, significance and contribution are discussed.

Chapter 2 will discuss about the literature review on the research paper or the existing system and the technologies to identify and analyze the strength, weakness, and the recommendation for improving of each of the reviewed system. Besides that, a comparison table among the reviewed existing system is created and classified.

In chapter 3 the type of development model of system methodology is chosen, system requirement and functional requirement is stated. Besides that, system design including use case, activity and sequence diagrams are drawn. Project timeline expected challenges and expected system testing and performances are discussed in this chapter also.

# Chapter 2: Literature Review

A research on similar systems or algorithms can be useful on designing a functionality of the programs for 3D reconstruction on medical images as it helps to know what the problems are, weaknesses that the researchers had encountered and what solutions have they contributed to solve the problems of our life. In this chapter, there are few researched articles reviewed regarding on the studies of the anatomy using the 3D reconstructed models along with the introductions of the medical images.

## 2.1 Anatomy study using 3D scanning.

Anatomy education is the study of the structures of the human body which requires undergoing of dissection to study or visualize on how the body is made up. The learning of the anatomy will provide knowledge for medical students to understand the structure of the human body which allows them in need for understanding the pathology and surgical problems along with the basic tools needed in practices. However, some complexity structures like the cerebral structure of the brains, the tissue structures of the muscles or even the architectural of the bones can be very tedious and hard to comprehend if to be referring on the radiography 2D images only. Therefore, an idea of using the 3D scanning was proposed to give a better visualization of the anatomy of the organs.

3D scanning is a support technology which is vital for medical field as it helps to capture the external measurement of the body within a shorter time with better manner and save cost. Moreover, it helps to check the body status and allows medical students on research of health improvements. In fact, 3D is much more accurate, flexible, and manipulative merely with low operational cost and it is mostly suitable and used for preclinical testing, medical training and physical education. 3D scanning had been useful in the modern era technology on medical fields as it began to be useful on teaching the engineering of the organ tissues for transplantation, where medical students are able to learn on reconstructing a model of a functional organ to transplant along with the materials which are harmless towards humans.

The problem of the anatomy studies using the 3D scanning is that it can only provide the information on measurement of the outer part surface of the organs from the medical images but could not scan the internal information of the body. In fact, the technology could not scan any transparent or reflective objects which give trouble for medical students on accident case study. However, these limitations can be resolved by coupling the 3D scanning technology with virtual reality (VR) technology as it helps in teaching purposes and gives improvement on communication between the medical students and patients during the placement session (Haleem & Javaid, 2019).

## 2.2 3D reconstruction

A 3D reconstruction is an approach of processing the medical image and transforming it into a 3D volumetric shape of a model. To these days, it has also been used in different variant of the fields such as the civil engineering field, architecture, automobile engine construction and many more. In medical fields, 3D reconstruction is used to generate a model of an anatomy of the organs with better precision of the shape rather than using hand-drawn image. For 3D reconstruction it is mostly used for detection of the disease in the body parts, and it is purposed to help radiologist in diagnosis and treatment planning. In fact, 3D reconstructions can generate an actual yet accurate 3D model amount of time and gives a better perspective of the 3D graphics on shape and size of the anatomy of the body parts, making more efficient diagnosis possible.

However, the drawback of the 3D reconstruction is that it requires a high demand on Graphical Processing Unit (GPU) for the purpose of rendering the 3D images with a better quality on the visualization of the model. In fact, different parts of the body will have different variant size of the anatomy and which will have different size of the dataset as well. Bigger the dataset, the slower the time efficiency on 3D reconstructing process.

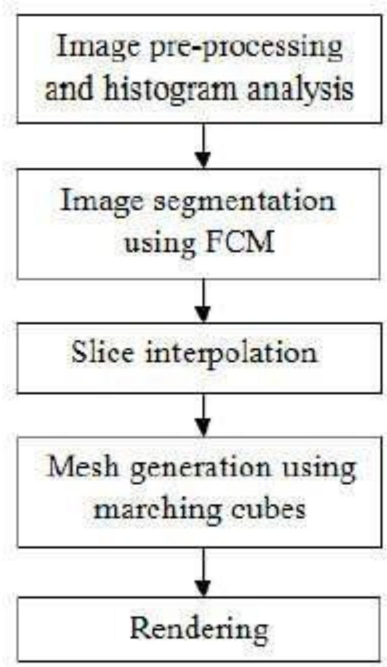



**Figure 1: the flowchart of 3D reconstruction**

### 2.3 Medical imaging segmentation

The purpose of medical imaging segmentation is to improvise the visualization process on handling the detection process with better effectiveness and efficiency. Moreover, imaging segmentation may also help medical students to practice and study on navigating the disease that affects the anatomy function of the organs. With this practice, they will then also able to make practice on analyzing, diagnosing, and quantifying the disease.

However, there are weaknesses that arise for medical image segmentation which limits the progress of the medical students to advance their studies properly. One of the weaknesses is that there is noise in images which will give difficulty on making the classification of the image. This is simply because the pixel intensity value is altered due to the noises behind the image. Therefore, the pixels intensity value disturbs the consistency in the image's intensity range. Additionally, the noise can exist in the image due to the motions in the medical image, blurring effect and diverse features deficiency. Eventually, this partial volume averaging can be a problem as it may causes inconsistency problem in the image pixels intensity value. Therefore, there are many methods that had been proposed by other researchers to overcome the limitations of the medical image segmentation.

### 2.3.1 Thresholding method

Thresholding is a method that has been used frequently for image segmentation, as it is very effective on analyzing the foreground context by reducing the background of the image. This method usually depends on the image pixel's intensity value. The process of the method is such that the background image was compared using the threshold value with the forefront image to see if there is a difference in intensity value in order to classify the image (Masood et al, 2015). Additionally, a few operations are needed to reduce the noise factor from the image and to achieve more effective results in the segmentation process. Therefore, the image was converted into a binary image and a defined threshold value was used to differentiate the regions of the image.

Another thresholding approach on imaging segmentation is by using the watershed segmentation. The watershed segmentation was made used to transform the segment of the gray and white matter from the Magnetic Resonance (MR) images. Additionally, the watershed segmentation can produce a complete division of the image in separated regions even if the contrast is poor and thus there is no need to perform any post-processing work such as the contour joining.

#### 2.3.1.1 Strength

The strength of the thresholding method is that this method is able to reduce the complexity of the medical image data and can simplify the process of the recognition and classification. Moreover, there is no requirement of a prior knowledge about medical images.

#### 2.3.1.2 Limitation

Thresholding method does not work very well if there is too many edges of the medical images are present, or it doesn't fit for the flat valley. In fact, thresholding methods are very responsive to any artifacts. Additionally, piecewise continuity cannot be assured by the method as well (Masood et al, 2015).

### 2.3.2 Region growing

Region growing is another technique of image segmentation that is mostly used in MRI segmentation for analysis of brain vessels, brain tumor segmentation or extraction of brain surface. It is a technique for extracting connected regions of the image which consist of groups of pixels with similar intensities. The process of the technique is such that the region growing will start with a seed point (or simply pixel) that belongs to the object of interest. Next, the seed point can be manually selected by an operator or even automatically initialized with a seed finding algorithm. The region growing will then check all of the neighboring pixels; if the intensities are similar such that it satisfies a homogeneity criterion, then the pixels will be added to the growing region. The process will be repeated until there are no pixels left can be added to the region (Despotovi´c et al, 2014).

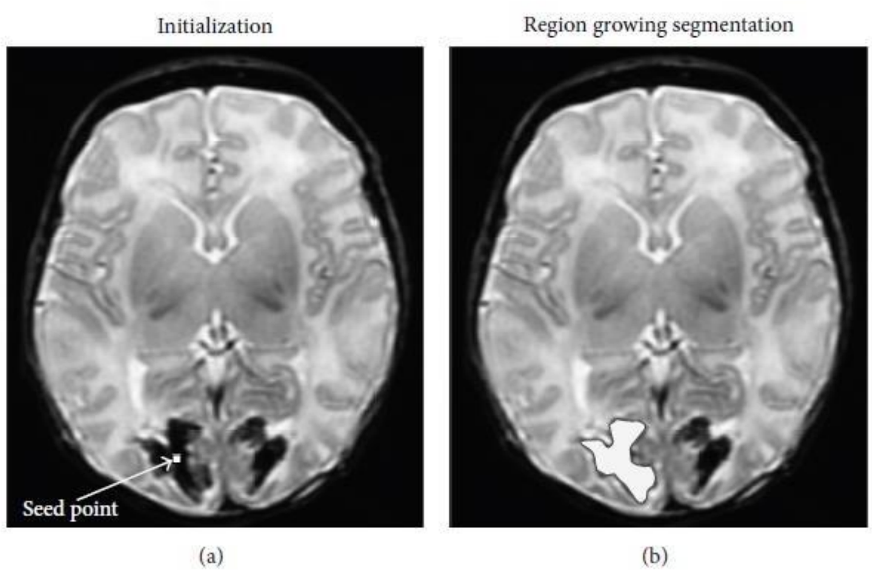



**Figure 2: The process of segmentation using the region growing technique**

The region growing technique is suitable for segmentation of volumetric image which are mostly composed of large connected homogenous regions. Therefore, it is successfully used in medical image analysis to segment different parts of the tissues, organs, or lesions from the MRI.

#### 2.3.2.1 Strength of region growing.

Region growing method works in such that it focuses on the gradients of the medical images and the variables with the boundaries, and the edge information is kept for the usage of anisotropic filter. The advantage of this method is that it takes only a short amount of time for manual post processing process and it is a multi-stage processing approach. Moreover, region growing method cooperate will when region homogeneity criteria can be easily defined and is less sensitive to noises.

#### 2.3.2.2 Limitation of region growing.

The only limitation of the region growing method is that it consumes some time and a lot of memories as this method consist of double segmentation. This also means that more memories will be needed when there is more addition of new projects. Furthermore, region growing method has a difficulty on deciding the stopping criteria for the segmentation and the scan order dependencies may give a considerable impact to the minute regions.

### 2.3.3 Clustering

Clustering approach performs similar function like classifier methods without using any training data and this approach are known as the unsupervised method. In fact, clustering approach change iteratively between the segmentation of the image and characterization of properties of each class. Thus, the clustering method can be said able to train itself using available data. Most common use of the clustering algorithms is usually the K-mean algorithm, fuzzy-c algorithm, or the expectation maximization (EM) algorithm (Dzung, 2000).

#### 2.3.3.1 K-means algorithm

The K-means algorithm is an algorithm that carries out the clustering process by calculating the means of the intensity values of separated class or cluster of images iteratively. Once finish computing the mean calculation, each pixel with the nearest obtained mean of the image will then be categorized for segmentation purposes.

#### 2.3.3.2 Fuzzy c-means algorithm

The fuzzy c-means algorithm also can be known as the generalization of the k-mean process, is slightly different from the k-means algorithm, which k-means process categorizes the points in every separate class while the fuzzy c-means allows the point to connect with more than one class.

#### 2.3.3.3 Expectation maximization (EM)

It is a statistical approach which was used to find out the parameter of statistical models from MAP or ML. In fact, the methods function on the iteration basis which firstly performs the estimation step followed by the maximization step which utilized for the next estimation step and repeats. Additionally, the EM algorithm uses the same concept or principles of the clustering with underlying assumption which the data follows a Gaussian mixture model.

#### 2.3.3.4 Strength of the clustering method

The clustering method allows performing all of the segmentation process without any supervision of the user as it had utilized with a trained data. Moreover, the methods are easy implemented and can be used as a starting point for the next type of approaches. With enough dataset to be trained, it is possible to reduce the time consumption for the users as this method can provide a fast computation. Lastly, the clustering method also improves the robustness of the clustering algorithm towards the intensity inhomogeneity in the MR images.

#### 2.3.3.5 Limitation of the clustering method

However, due to reasons of getting different cases of the medical images in daily life, the datasets for the training purpose will need to be updated which will eventually consumes the memory usage as well as reducing the performance of the computer devices. Moreover, the clustering method can be sensitive to noises and also the intensity inhomogeneity if the algorithms do not incorporate directly with the spatial modeling. In fact, the clustering method usually only work for the MR images but not to the CT images and it also requires spatial constraints to perform better.

### 2.3.4 Atlas Guided approach

The atlas guided approach is a process of analyzing image by labeling the targeted structure or framework which commence images made through the modalities of medical images. This process purpose is such that to help radiologists on finding and identifying the diseases in the body and it worked by identifying a significant anatomy in the images. Here, segmentation was performed by preparing atlas with compiled information of the anatomy. Then, the atlas was used for segmentation of the images and it take account of the registration problem to handle the segmentation process (Masood et al, 2015).

#### 2.3.4.1 Strength of the atlas guided approach

One good thing of using the atlas guided approach is that these methods allow transferring both of the labels and the segmentation and it provides a standard system for the purpose of studying the morphometric properties (Dzung, 2000).

### 2.3.4.2 Limitation of the atlas guided approach

One problem about the atlas guided approach is that although the nonlinear registration methods are provided but finding the accurate segmentation of the complex structure can be difficult to the anatomical variability. That said, one method which helps in the model anatomical variability is by using the probabilistic atlases, but it requires more time and interaction to collect and accumulate the data.

# Chapter 3: Proposed method/approach

## 3.1 Design specification

Tools/software that will be used for project:

- Visual Studio 2017
- Cmake

The reason of using visual studio 2017 for this project is to create a new module for the 3D slicer project workbench and the software is widely recognizable worldwide for programmers to create programming projects, especially for any new updates or new software that needs to be made; Cmake is used for this software in purpose of managing the build process of the software. In this project, a setup of the 3D slicer workbench project template will need the assistant of the Cmake tool.

Visual studio 2017 is a tool which allows developers to have a plugging of the functionality which was coded as the visual studio package. Moreover, since the visual studio is an integrated development environment (IDE), the visual studio can handle different kinds of programming language. Additionally, the visual studio can show disassembly if the source code is unavailable, otherwise, the code will be displayed when it runs. Furthermore, whenever there is an error while building the code, visual studio provides a breakpoint check to see at what line of the source code is having a problem or errors.

For the verification plan the project will be tested with a DICOM image of the knee joint base. In this case, the project will be using the MRI image of the patient's knee joint for a moment. Once it is successfully read, the project will be further tested with a different type of an image such as CT scan image or even X-ray images.

### 3.2 System Design

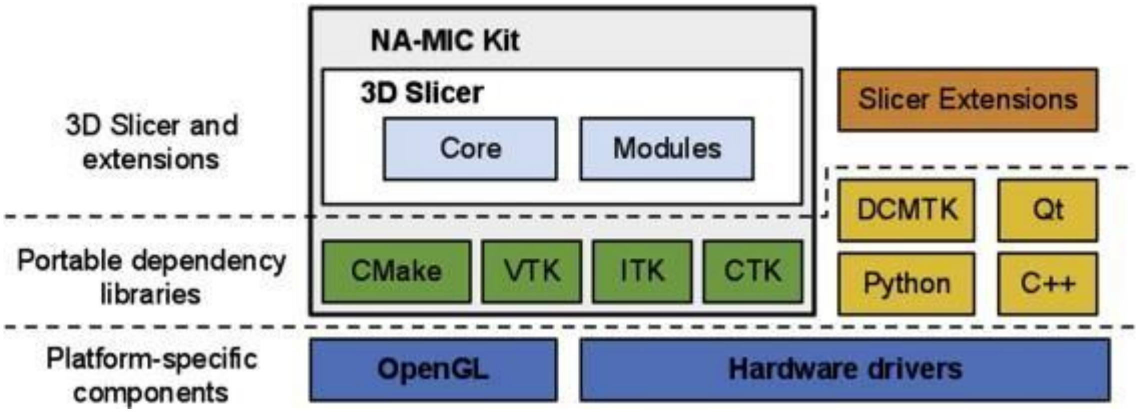



**Figure 3: System architecture design of 3D slicer workbench**

The Figure 3 above shows the system architecture design of the 3D slicer workbench. The 3D slicer workbench consists of different frameworks and toolkits integrated. The 3D slicer modules are the linkers which provide the functionality for the purpose of the segmentation in the system. As the matter of fact, these workbenches can be used to implement any other new sorts of open-source application which are cross-platform for further future purposes. This project will be focusing on creating on a new module for the 3D slicer workbench.

### 3.2.1 ITK

Insight Toolkit (ITK) is a cross platform library which provides the developer a software tools for the image analysis. In fact, this toolkit also gives registration and segmentation algorithms, however, the toolkit was not meant for visualization or interaction purposes.

### 3.2.2 VTK

Visualization Toolkit (ITK) is an open-source software which helps in manipulating and displaying all scientific data. The software is important as to shows the outcome of the results with a tool of 3D renderings, providing with the help of the widgets for 3D interaction as well as extensive 2D plotting capability.

### 3.2.3 CTK

The Common toolkit (CTK) is another software which helps in biomedical images computing. In this project, the CTK serves the purpose on the plug-in's framework so that other different type of the frameworks will be able to be easily implemented and not intercept each other.

### 3.2.4 3D slicer modules

The 3D slicer modules are a file which contains the modules for the system to work along with the functionality and the library of the module. For this project, some 3D slicer modules will be used to create a 3D models of the knee joints image and as well as supporting on creating the new module on the next project.

### 3.3 Timeline

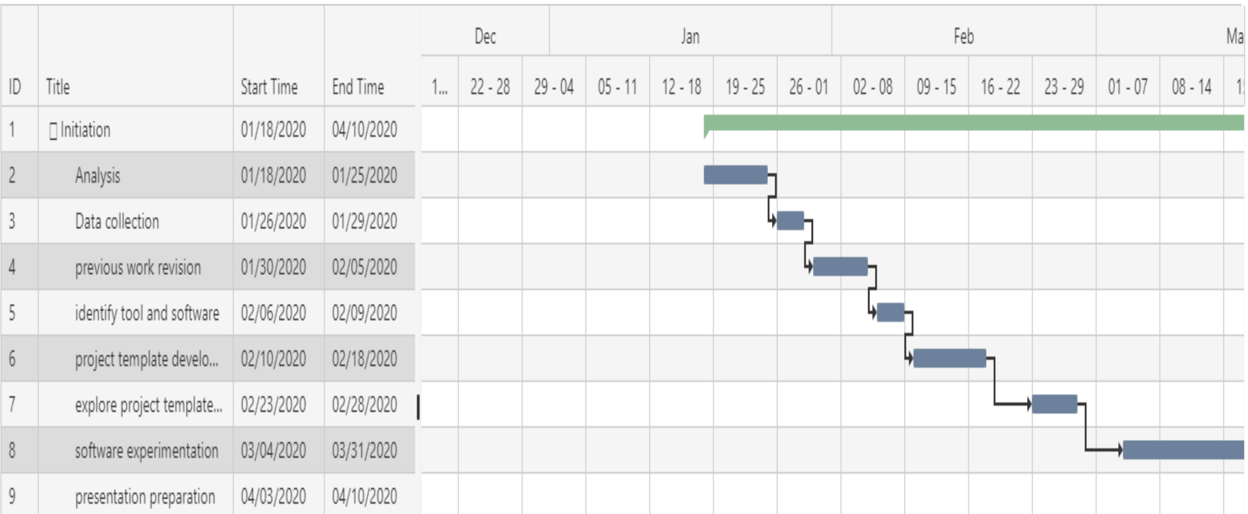



**Figure 4: Gantt chart for previous semester (Jan to May 2020)**

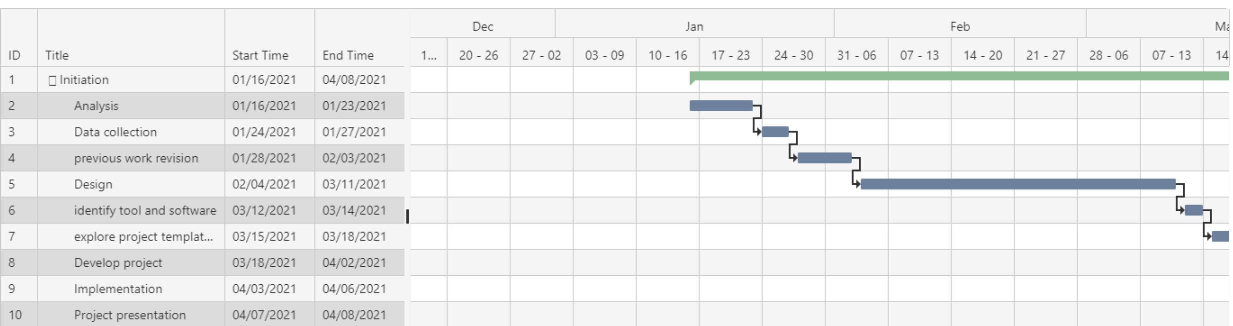



**Figure 5: Gantt chart for current year (Jan to May 2021)**

Figure 4 shows the Gantt chart of the previous semester where the phase requires about full 3 months for this project to complete. This project will be focusing on the studies of the project workbench and the way of writing the code based on the 3D slicer format which takes up about a month to understand the algorithm. Furthermore, the setup of the workbench takes up about a week of that month to finish. The implementation phase will then take about a week to set up and the very last week was used for the presentation preparation.

Figure 5 shows the Gantt chart for current year semester. The analysis phase will be taking about a week time to finish. Next, design phase will be using about a month to complete. The implementation phase will take about 3 to 6 days to finish, and the last few days will be used for the presentation for Project 2.

## 3.4 Waterfall Development model

Waterfall development is one of the project models that will be included in the methodology to develop the 3D reconstructed model since the process of development consist of consistency and completeness of the documentation. In fact, the progress of the project can be measured much easier, as the full scope of the work is fully known in advance. Moreover, it provides a better understanding and clear requirements to the developer to complete the platform of the project since it is a step-by-step approach.

In waterfall development model, the project can be developed or designed completely and more carefully, depending on the complete understanding of the project deliverables. Because the design is completed early in the development cycle, this approach of development model will lend itself to the projects where multiple software components must be designed for integration with external system. In addition, each phase of the development cycle must be completed before proceeding to the next step and no overlapping of phases in the development model, the outcome of the phase acts as an input of the next phase. The following of the sequential phases in the waterfall development model are requirement analysis, design, implementation and installation, testing, deployment, and maintenance.

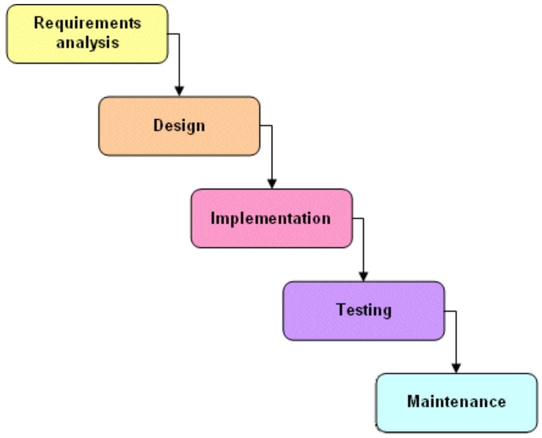



**Figure 6: Waterfall development model.**

**Requirement Analysis**

The waterfall development model begins with the requirement analysis phase, where requirements from the users are defined. Then requirements for designing the 3D model for study purpose are then gathered through several journals and research papers and interviewing some users. Next, collected requirements need to be defined to understand the demands of the user for the 3D models. Here, the data for the models are also gathered for the next phase of the project.

**Design**

The design phase is the second phase of the waterfall development model, where data are collected and is ready to make the 3D model based on the image. During the design phase, certain modules are chosen and needed to perform the task of creating the 3D model. The functionality of the module is included and able to meet the criteria.

**Implementation**

The implementation phase is where the execution of the project on creating 3D model meets. Information from the previous stage will be used to create the 3D model product. The coding of the modules will be taken place to get the right requirement of creating the 3D product which then integrated with the software later.

**Testing**

Once the coding was done, the testing of the software product will begin and be used. If there is any serious issues arise during the 3D model product creation, report and problems will be taken place.

**Maintenance**

The 3D product was delivered to the client and was used. From here, problems that were raised during the production will be solved and any issues that cannot be solved in short time will be iterated to the first phase of the waterfall method.

## 3.5 System requirement

### 3.5.1 Hardware

The hardware that will be used in this project is a computer and a 3D printed. Computer was used for the purpose of processing the 3D visualization and segmentation from the MRI imaging so that to obtain the 3D model object and converting the 3D model to STL format. A 3D printer was used for printing out the STL format of the 3D models so that to learn a proper and accurate human anatomy. The specification of the hardware is shown as below:

**Computer**

| **Description** | **Requirements** |
|---|---|
| **Name** | **Nitro AN515-54** |
| **Processor** | **Intel core i5-8300H CPU @2.30GHz 2.30GHz** |
| **Operating System** | **Windows 10** |
| **Graphic Processor** | **NVIDIA GeForce GTX1050** |
| **RAM Size** | **16GB** |
| **Hard Drive** | **500GB** |
| **System Type** | **64-bit Operating system, x64-based processor** |
| **Interface** | **2 USB port, 1 USB 2.0 port, HDMI port** |
| **Audio** | **Speakers (Realtek(R) Audio)** |

**Table 1: computer specification**

**3D printer**

| **Description** | **Requirement** |
|---|---|
| **Product name** | **Snapmaker 2.0 A350** |
| **Work area** | **345 x 360 x 334 mm** |
| **Controller version** | **V1.8.0 1_20200603** |
| **Touchscreen version** | **V1.8.0.0** |
| **Core** | **Quad core A7 CPU @1.1 GHz** |

**Table 2: 3D printer Specification**

### 3.5.2 Software

The software that was included in this project is the 3D Slicer toolkit and Snapmaker Luban.

#### 3.5.2.1 3D Slicer

In this project, the 3D slicer was used to import the DICOM files or DCM file of the MRI, CT, and PET scans datasets to do the visualization and segmentation to get the accurate and precise 3D model of the anatomy part.

**3D Slicer GUI overview**

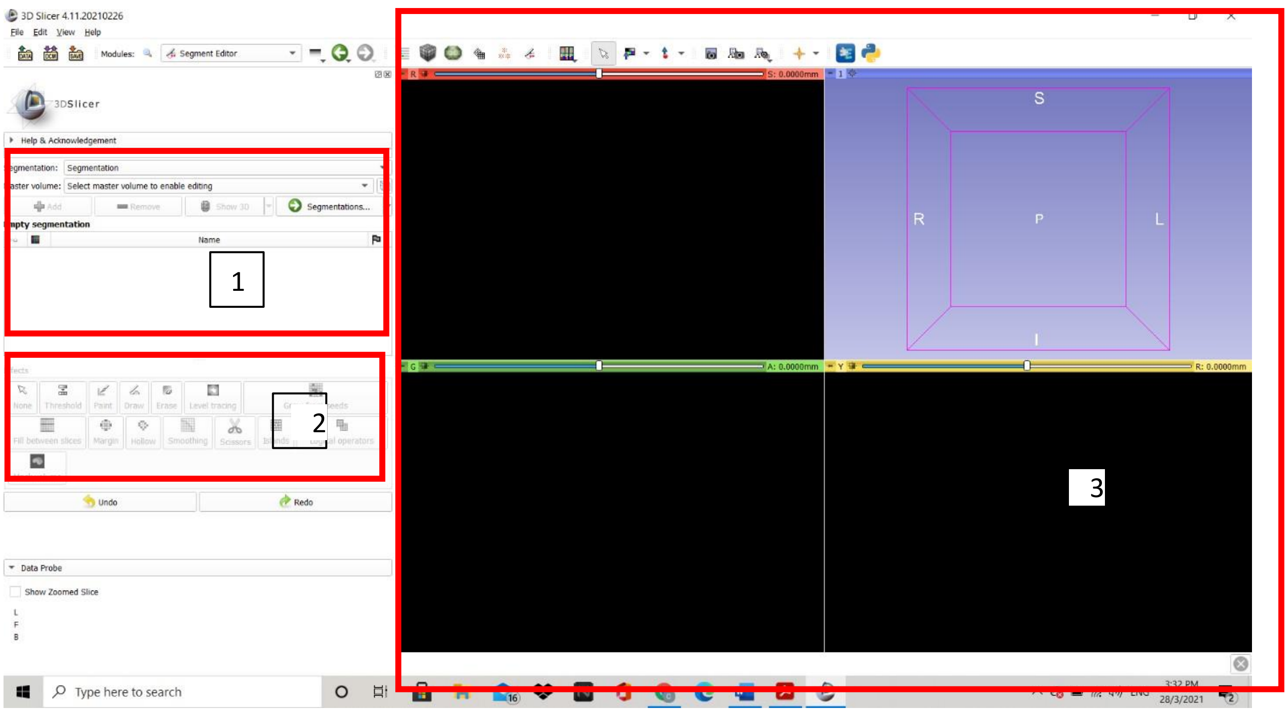



**Figure 7: 3D Slicer**

the left box labeled 1 of the Figure 7 is the editor manager of the layers which shows the different parts of the layers to make the segmentation easier to read and not interfering on other parts of the model. The 3D Slicer supports file formats such as DCM, MRML, MRB, NRRD, VTK, STL, and h5. In fact, all these files can be displayed to the 4-view displays in box labeled 3.

The box 3 shown in Figure 7 can displays both 2D and 3D views of the image. As shown in figure 8 below, the top left shows the 2D view of the axial position, bottom left windows show the 2D view of the coronal position, and the bottom right windows shows the 2D view of the sagittal position. Top right window shows the 3D views of the overall positions shown in the other windows.

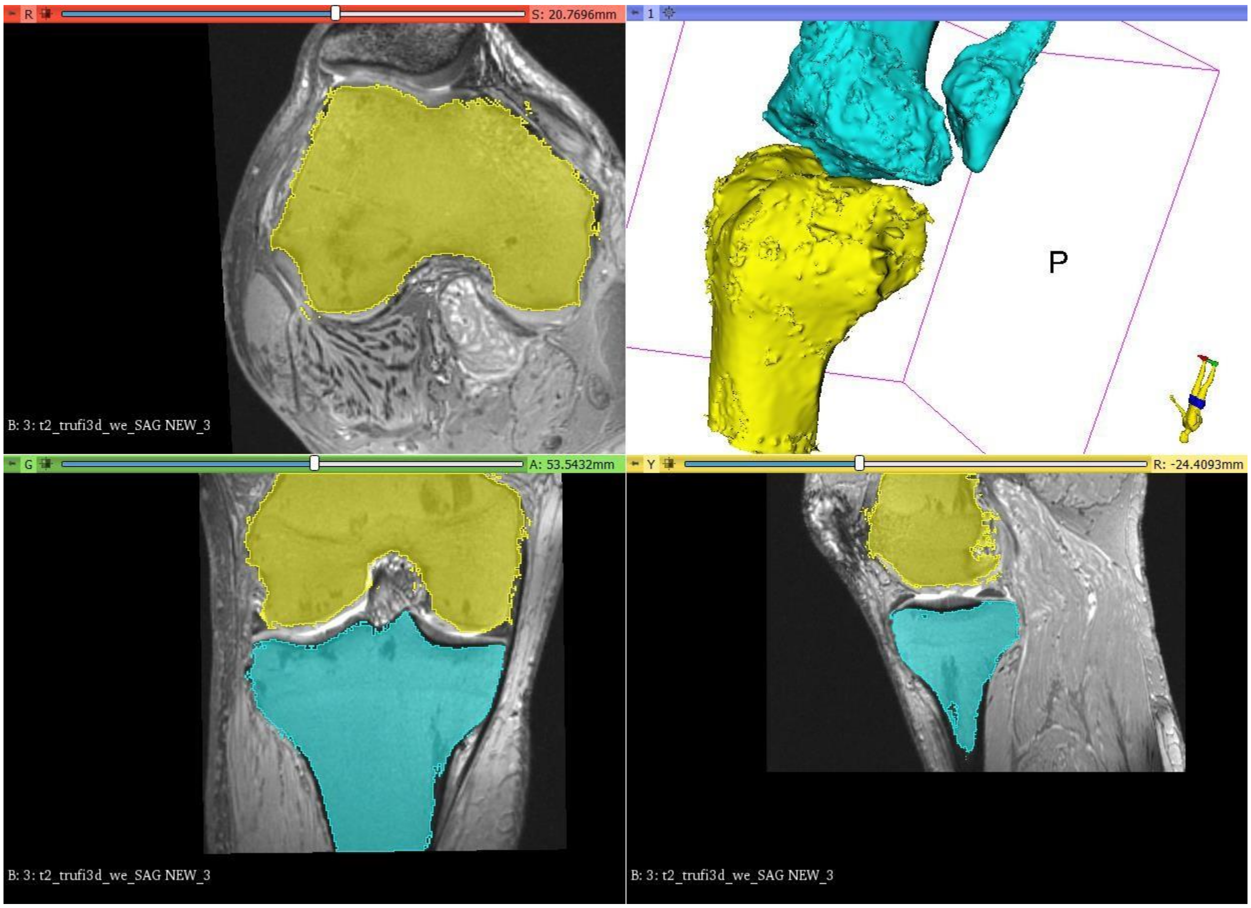



**Figure 8: 4-views of the window display on the segmentation of a subject's knee**

The red box labeled 2 is the segmentation tools which consist of both 2D and 3D tools. 3D tool that was used for segmentation is the level tracing, grow from seed (region growing) and the smoothing modules (Gaussian smoothing). 2D tools that are used was the paint tool which to paint the region of the wanted segmentation part, eraser to remove any unwanted anomaly part, and scissors to quickly remove huge, segmented parts of the MRI images.

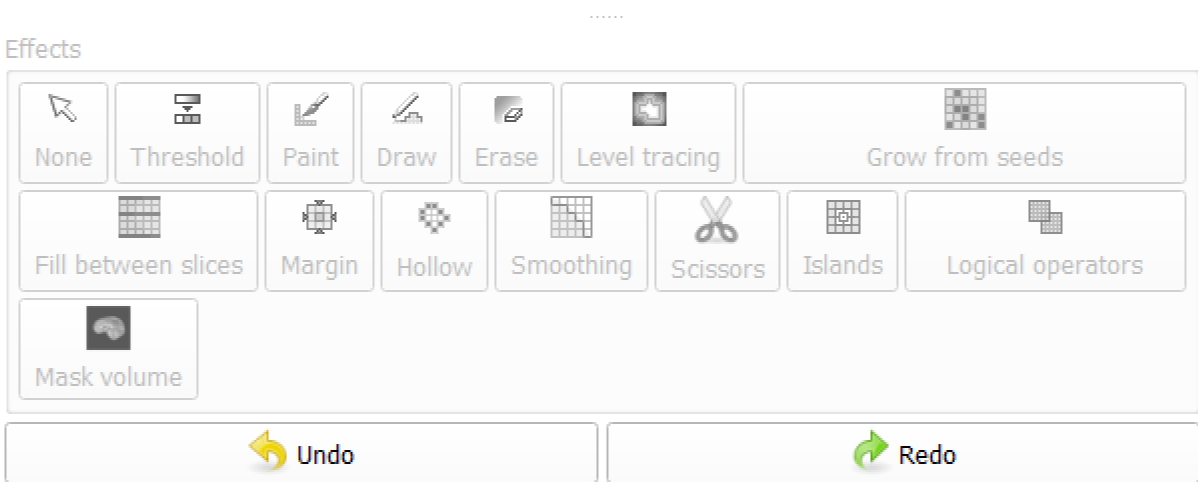



**Figure 9: Modules and tools for 3D modelling**

**Anatomical plane**

The anatomy of the body was captured with 3 different point of views plane to scan and capture the image of the human body anatomy – the coronal, sagittal and axial plane. Consider the anatomical plane as the eyes to view the map of the body.

The coronal, or the frontal plane is a vertical plane which divides the body from the front to the back section.

Axial plane or the transverse plane is a horizontal that "cuts" the view vertically down and divide the body from the top to the bottom.

Sagittal plane or longitudinal plane is a vertical plane that "cuts" the view horizontally and divide the body from left to right sections.

### 3.5.2.2 Snapmaker Luban

Snapmaker Luban is a software application that was needed in this project to print out the 3D model of the human anatomy parts.

**Snapmaker Luban GUI overview**

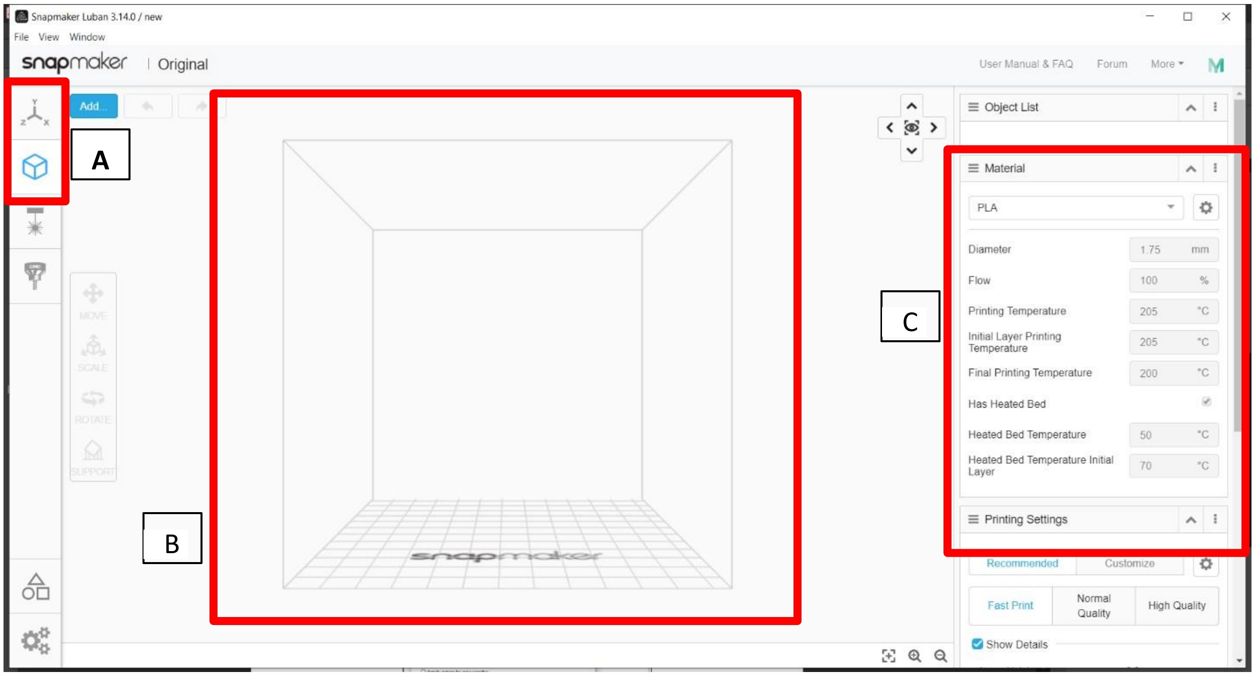



Figure 10: Snapmaker Luban

The A red box of the Figure 10 is the task workspace that will be used to navigate the printing of the 3D models or to import the STL file format of the model. The B red box is the 3D view windows that allows user to know the shape of the models. Lastly, the C red box is the settings for the filament materials to print out the model.

## 3.6 Expected Challenges

There are few of challenges that was found during the progress of the project:

- Difficulties on finding accurate and clear MRI scan of the human anatomy. The MRI scans datasets are mostly provided by the hospital or medical universities that has licensed on taking the patient's data for research purpose and the datasets are mostly confidential for experienced doctors or medical students. Furthermore, majority of the datasets that was found in the open source needs to be paid before getting the source.

- Accuracy of the models can be difficult for any programmers to achieve that are unfamiliar to knowledge of the human anatomy. More information is needed for the programmers to do research and understand the MRI image anatomy parts. Furthermore, the clearance of the datasets can be difficult for programmers too to make the models. Better quality of the dataset is needed in the future to have better accuracy of the models.

- Some functionalities of the module did not give out the proper outcome of the segmentation due to the similar intensity of the pixel in the MR image datasets. In addition, another module will need to be added into the software to implement better segmentation process.

## Chapter 4: preliminary Work

### 4.1 Setting up 3D Slicer.

The first step of the project is to setup the 3D Slicer workbench project template. To do that, the project will need to get an existing project template from the source of Github repository. This can be done by using the Git software or by accessing into the Github webpage.

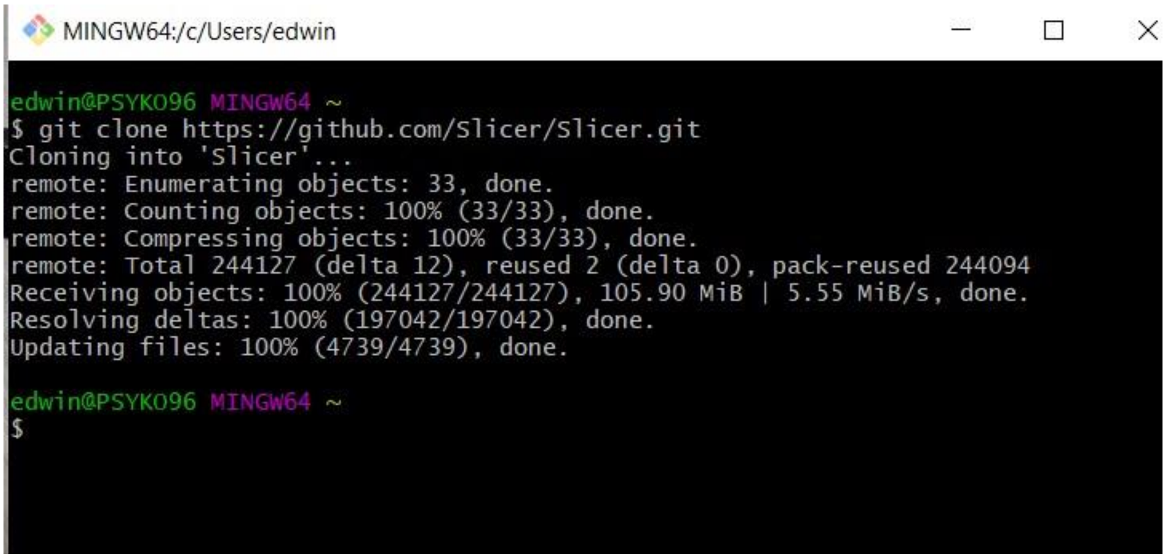



**Figure 11: result of getting the project template from the repository.**

The next step is to generate the files of the project template using the Cmake. A new source file was created, and the name of the file must be short so that to prevent the Visual Studio to do long path searching. The source directory will be the project template that was downloaded recently, and the build directory will be the file that was recently made. Once the path has been determined, a variable pointing to Qt5 folder was also added. Then, the Cmake configures the project template, and a list of the necessary files are prompted out.

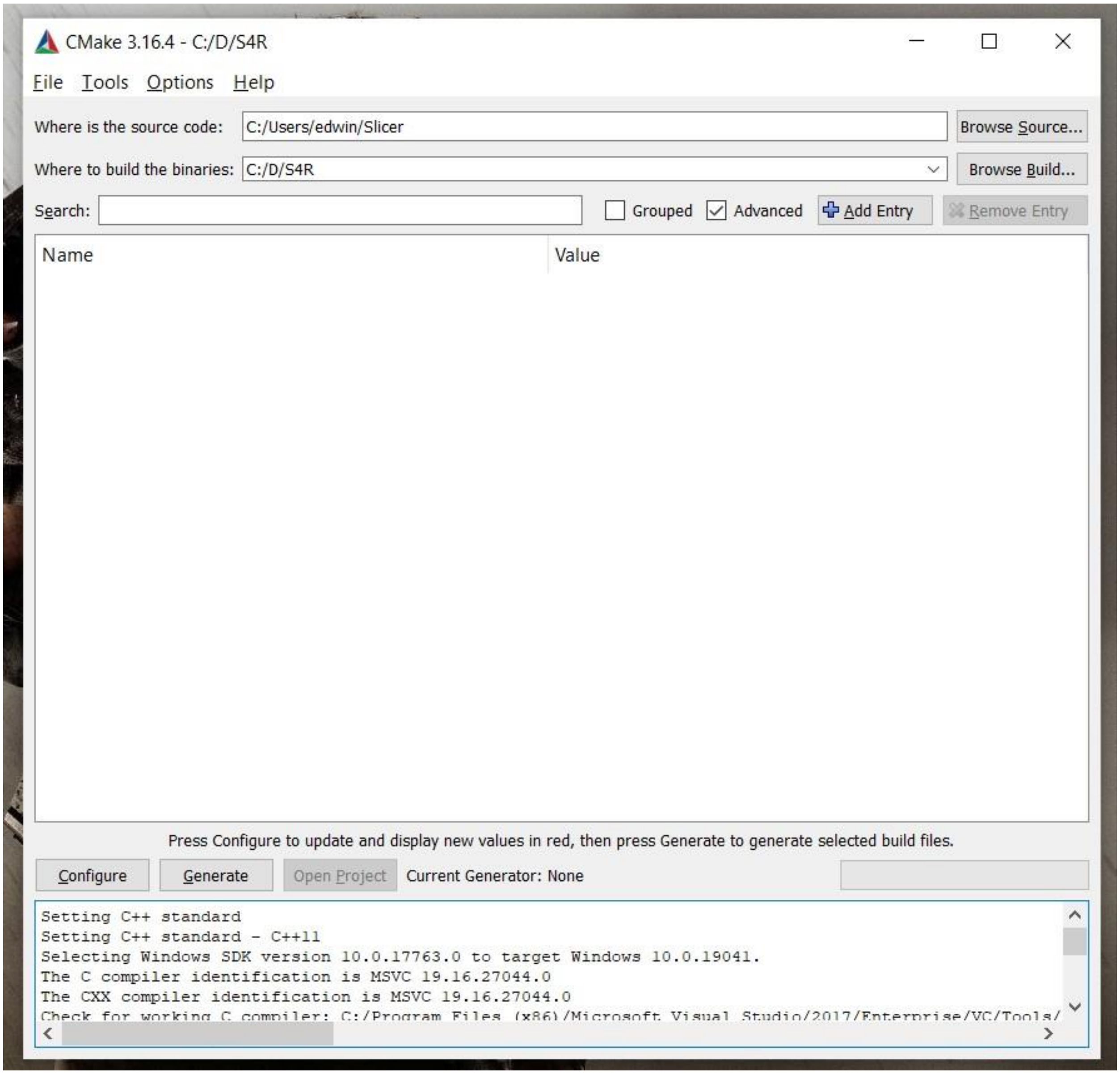



**Figure 12: file directory configuration setup.**

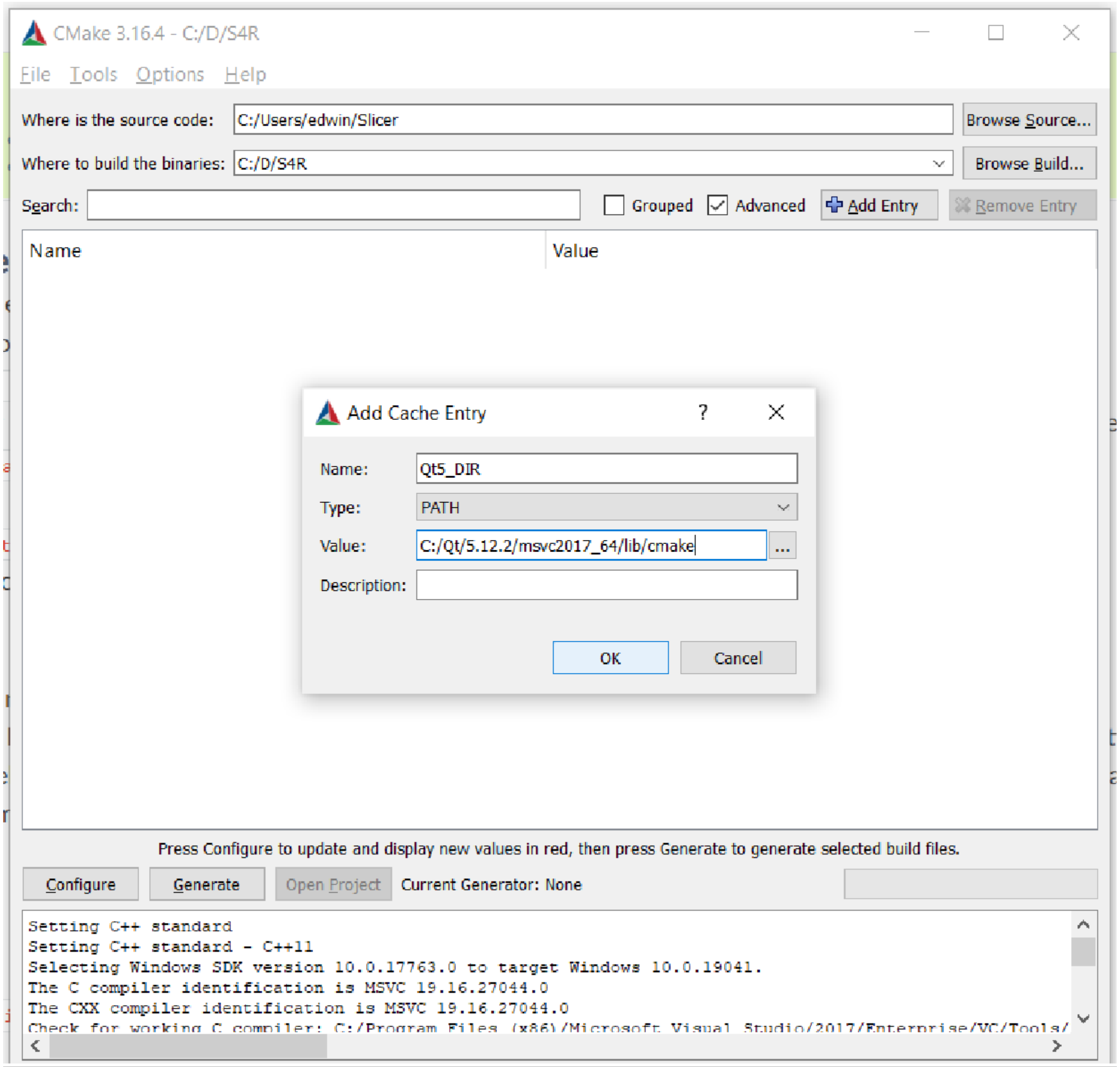



**Figure 13: Qt 5 folder variable points.**

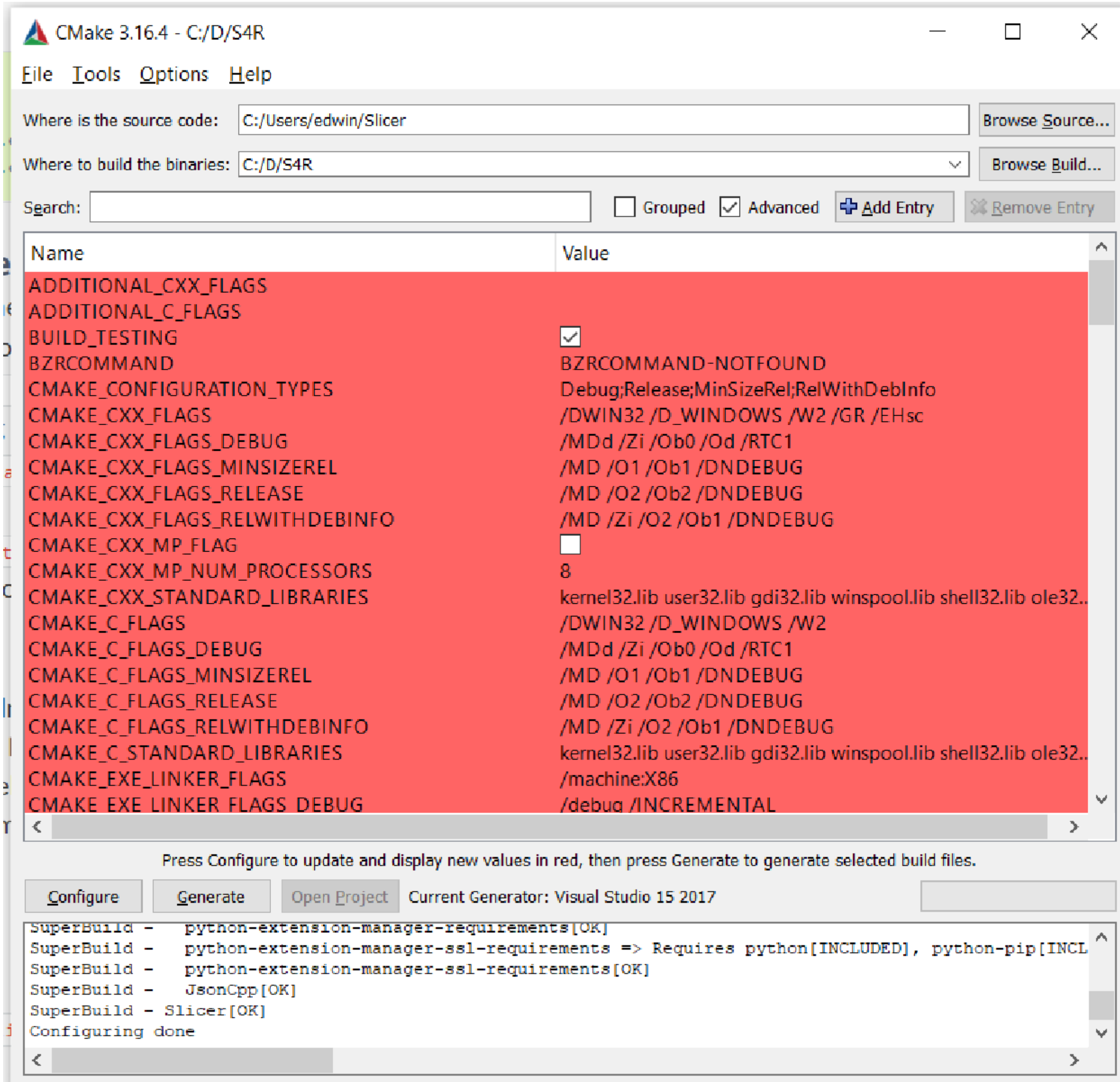



**Figure 14: Cmake configuration of the project template.**

The next step is to build the 3D slicer project. Once the Cmake had configured the project template, all necessary files are added into the file that was previously made. There, a project file named Slicer.sln can be found. The process of the build will take out about 3 hours depending the speed of the processor. After the build is done, an execution file for 3D slicer was made and can be runned.

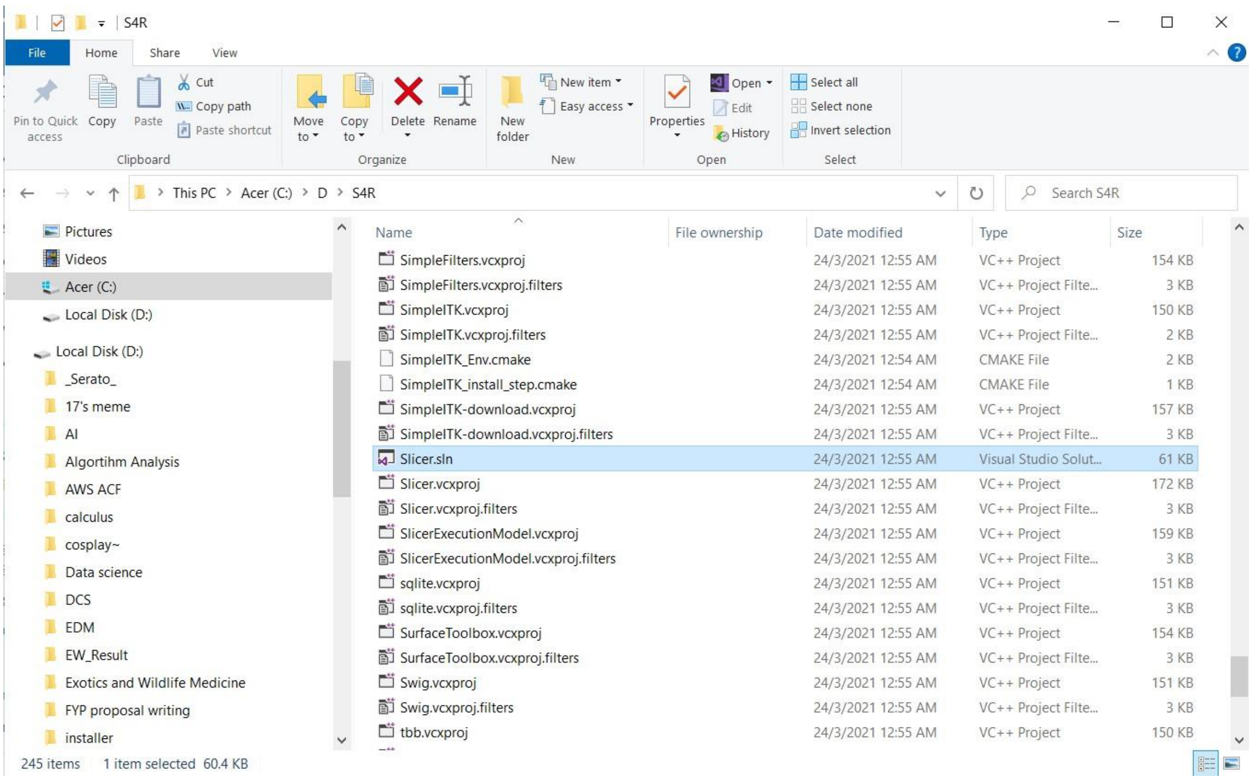



**Figure 15: generation of the project**

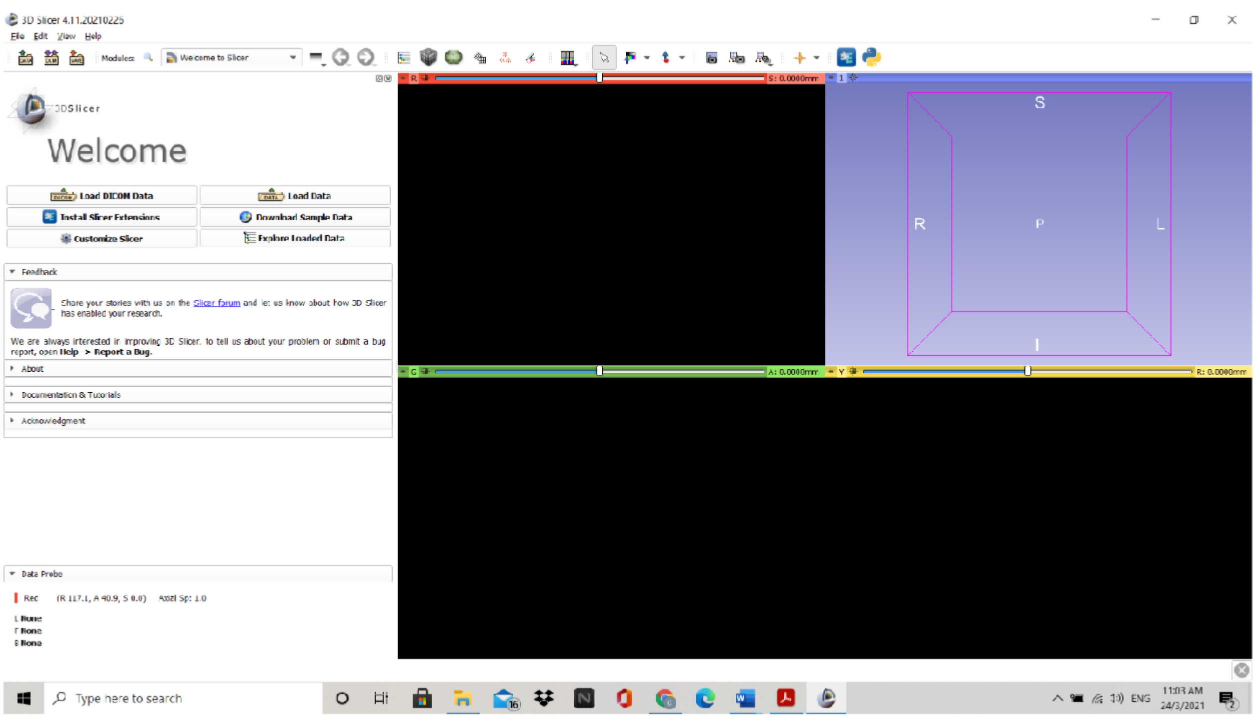



**Figure 16: 3D slicer Workbench**

### 4.2 Visualization and segmentation with 3D Slicer

The following instructions below are the steps on segmentation process:

- Import DCM file of the anatomy images.
- Create the segmentation with the file name and use different color code to indicate and differentiate the segmented parts along with different names.
- Start the segmentation process until is satisfied.
- Use the 3D views to visualize the model and save it as STL file format.

#### 4.2.1 Importing MRI dataset file.

One MRI datasets of the knee part has of 192 DCM files while the CT datasets has 251 DCM files that are used to segment and modelled into 3D models. The dataset information is shown as below:

Natural knee MRI data:

https://digitalcommons.du.edu/natural_knee_data/1/

provided by: University of Denver Centre for Orthopaedic Biomechanics

- MRI acquisition details: 192 slices; thickness: 0.6 mm; in-plane pixel spacing (mm): 0.53125 x 0.53125; in-plane resolution: 320 x 320.
- CT acquisition details: 251 slices; thickness: 0.6 mm; In-plane pixel spacing (mm): 0.390625 x 0.390625; In-plane resolution: 512 x 512; Tube Current: 186 mA; Peak kV: 120.

#### 4.2.2 Images segmentation

The datasets of the knee are segmented using the semi-automatic method and visualized in 3D using the surface rendering based on the 3D Slicer. the MRI of the knee parts was segmented based on the “slice-based” segmentation along with the 3d interpolation.

**Beginning of the Segmentation**

The segmentation of the knee parts will take a lot of layers with different name parts; therefore, the process of segmentation was done by firstly to partially fill the parts that was needed to segment with different colours. After doing so, the background was painted in red colour to make the region growing process easier on detecting the pixels with similar intensity around the region of the colours. Thresholding was not used as some the intensity value of some part of the anatomy of the knee was similar. After the region growing was complete, the eraser tool was used to remove any extras outline that was affected so that to give a better accuracy when doing the smoothing process. The following process, however, must be done manually. The following figure below shows the anatomy of the knee segmentation:

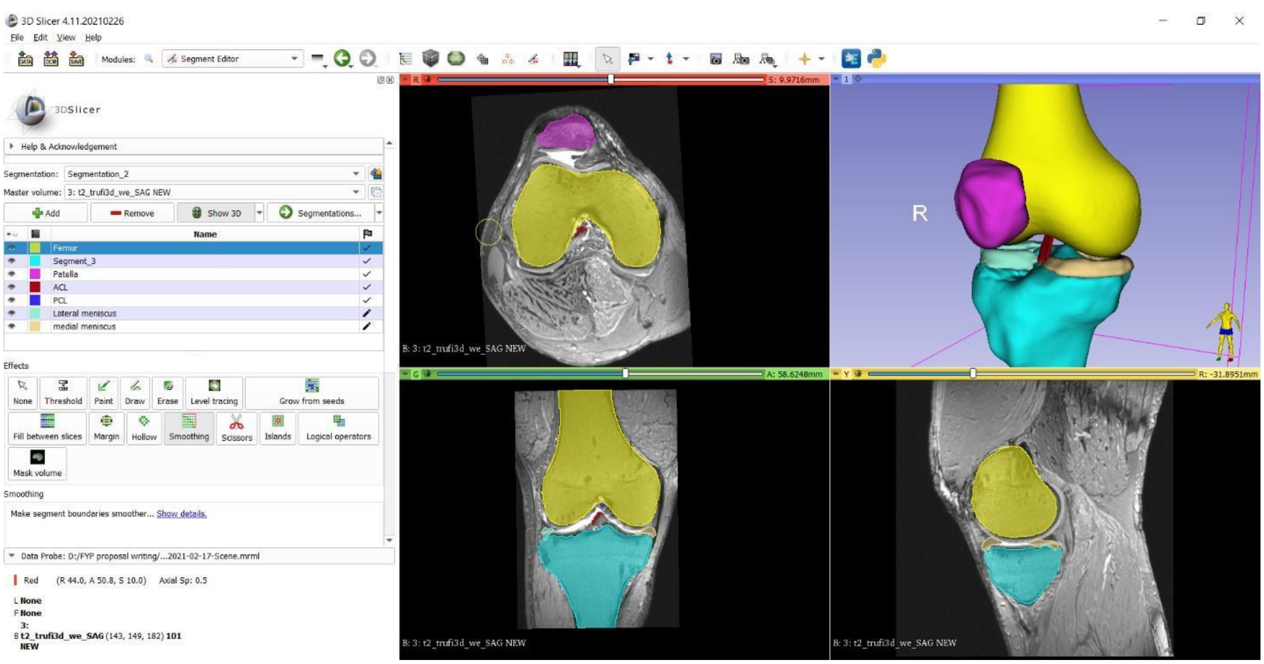



**Figure 17: segmentation of the knee**

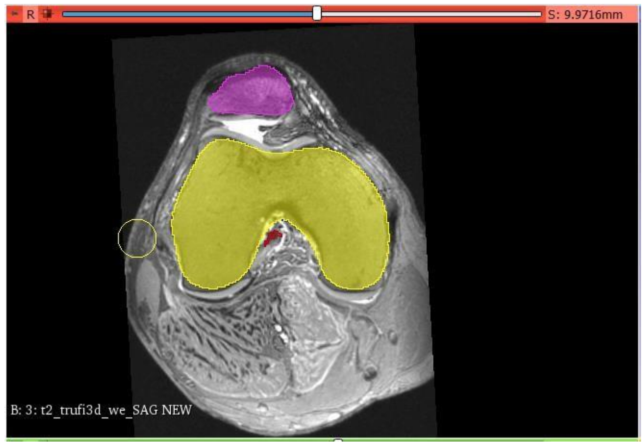



**Figure 18: Axial view of the knee segmentation**


**Figure 19: Coronal view of the knee segmentation**

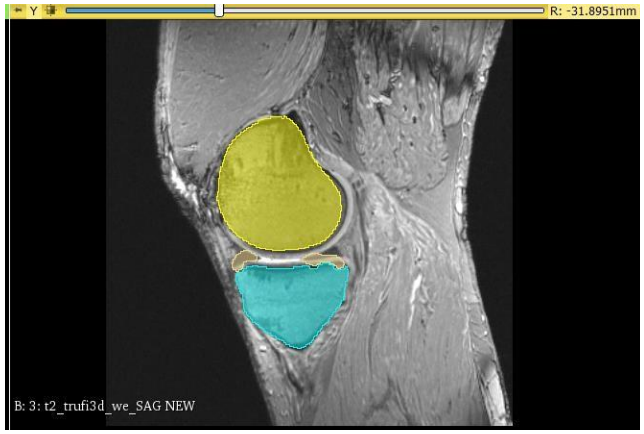



**Figure 20: Sagittal view of the knee segmentation**

### 4.2.3 3D visualization

After finishing the segmentation of the knee, the segmented part of the knee will be then visualized with surface rendering technique. The technique was done with the help of the algorithm called the marching cube algorithm, which helps to give the highest quality of the image by creating a polygonal mesh of the iso-surface from the 3D voxels with smoothing technique. After the smoothing process, the file was saved as STL format file. The following figure below shows the after effect of the rendering and smoothing process.

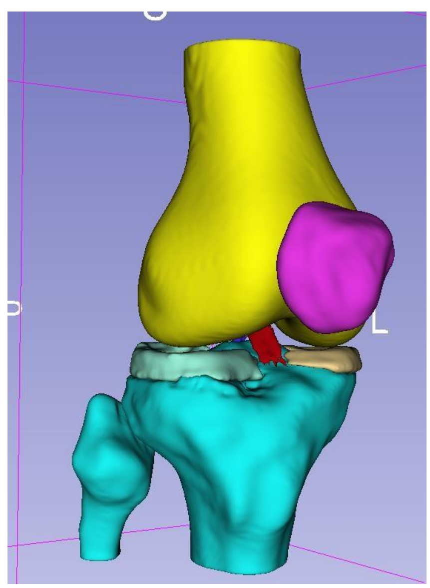


**Figure 21: 3D view of the segmented knee**

### 4.3 printing the 3D model with Snapmaker Luban

After the 3D segmentation was complete and the 3D model views are satisfied, the model is then converted to STL format file so that the Snapmaker Luban will be able to read it since Snapmaker Luban do not support the mrml format of the file. Then, open the STL file of the 3D knee from snapmaker Luban. The following instructions below shows the steps on converting the mrml format file to STL:

1) In the modules drop down box, select the segmentations modules.

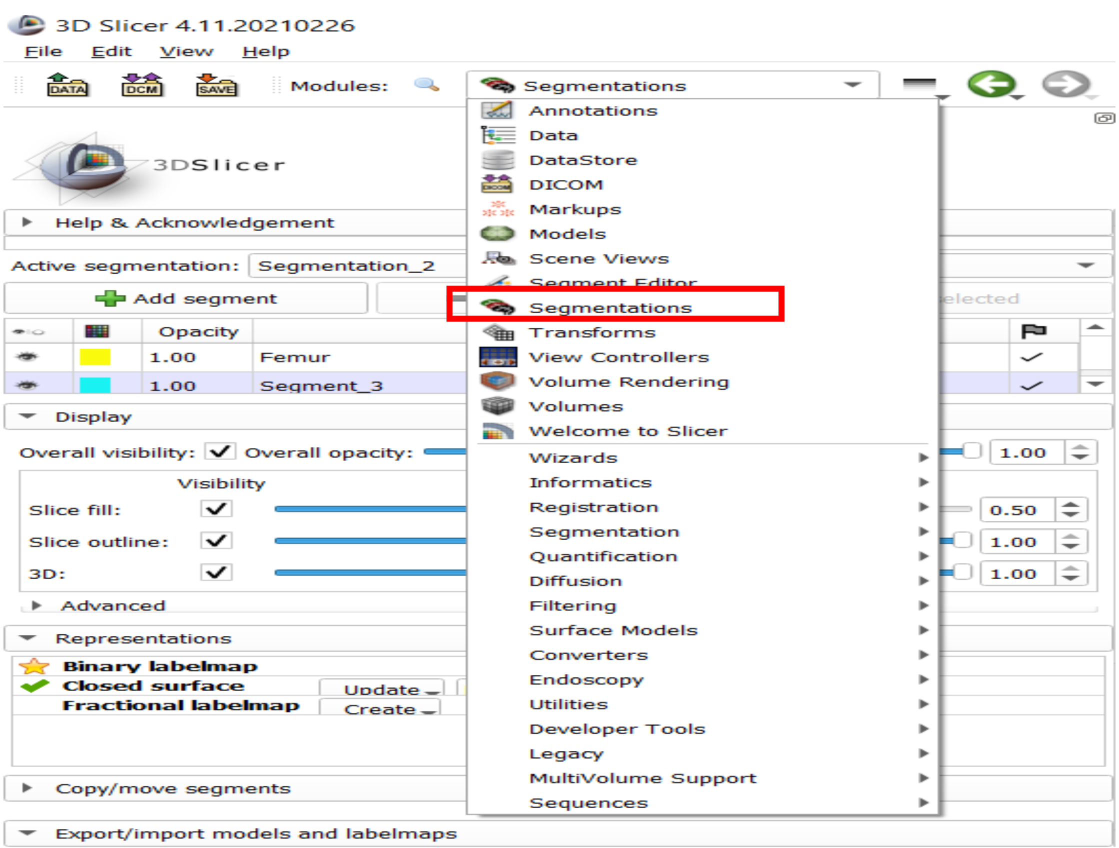



**Figure 22: Module selection**

2) At the task bar, scroll down to exports to files. Choose the destination folder that needs to save the file into and at the file format drop box select STL. Since the knee anatomy parts are separated and difference in shape, the "merge into single file" checkbox needs to be unticked.

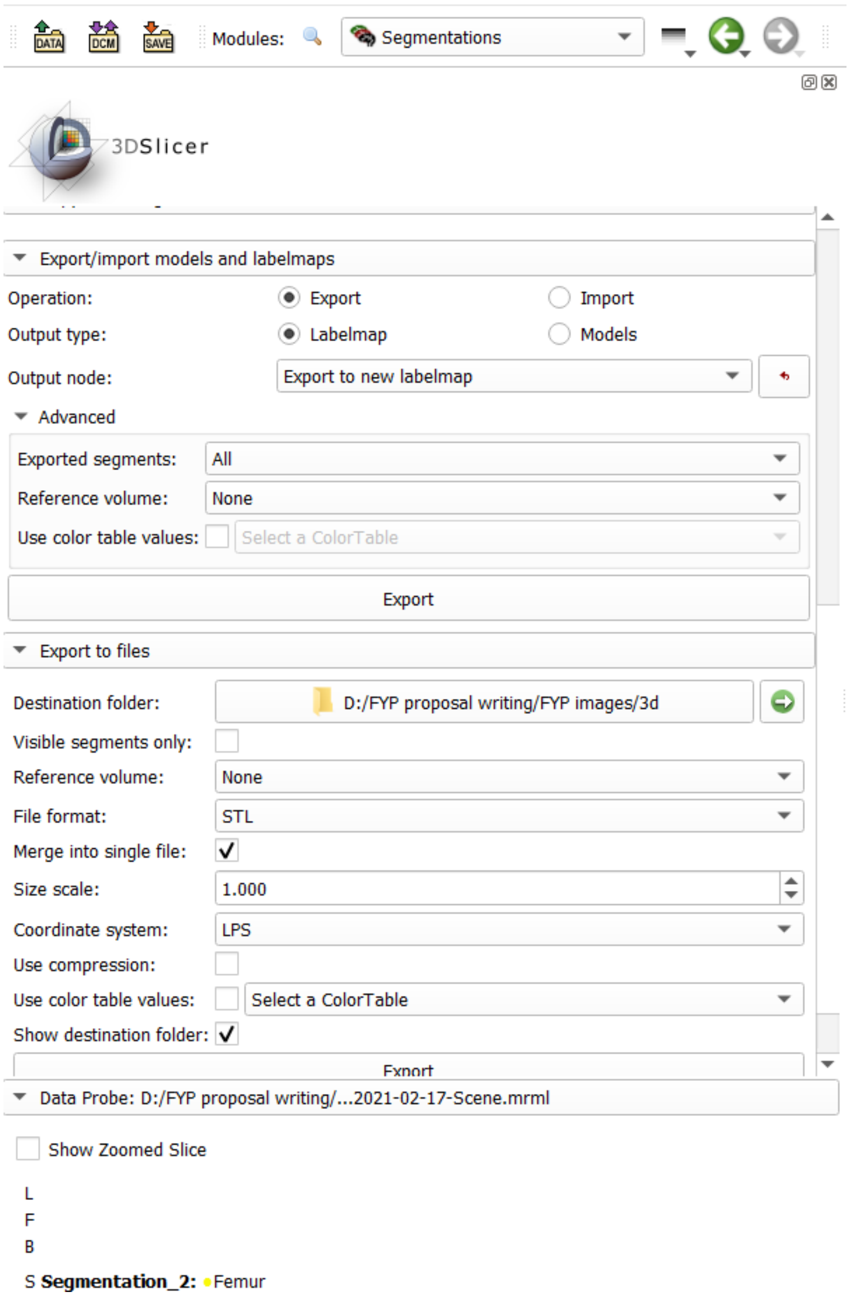



**Figure 23: Process of STL format file conversion**

3) Open and read the STL file from the snapmaker Luban by clicking the add button.

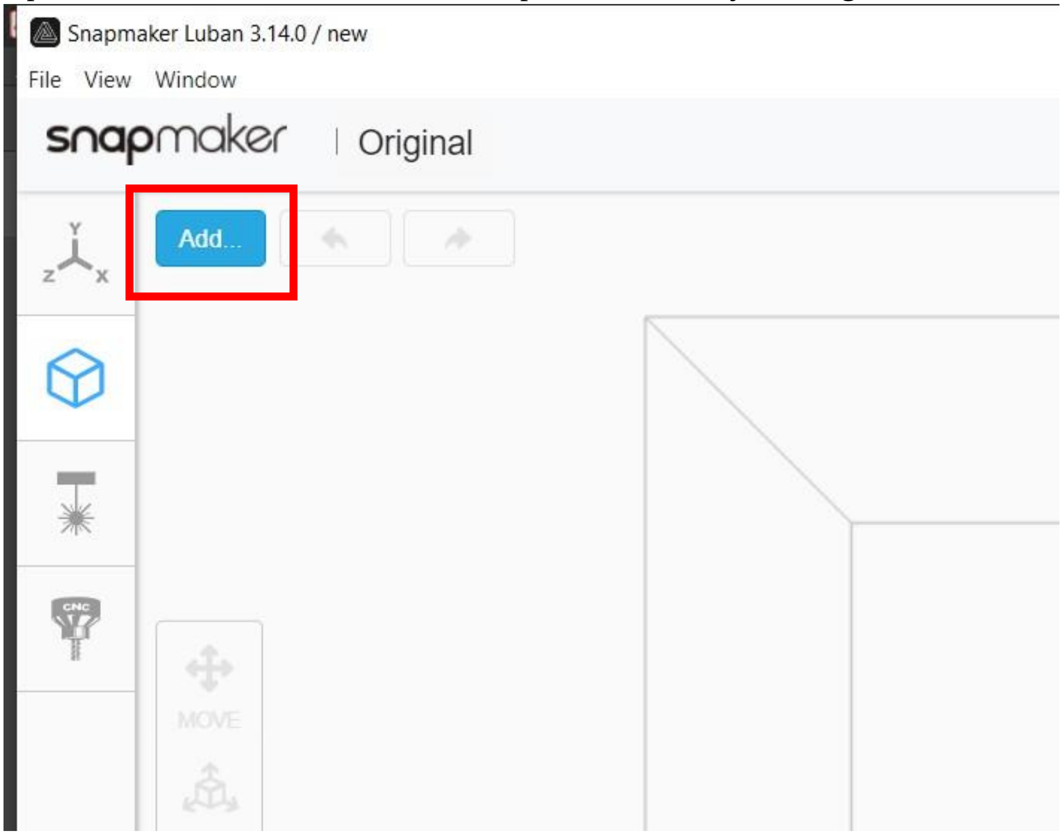



**Figure 24: open file**

4) Once the file was open, select the type of materials to be used for the 3D printing, and check printing setup. To save time, the printing setup for the project has gone to fast print process. Once the setup is complete, the 3D model can be printed.

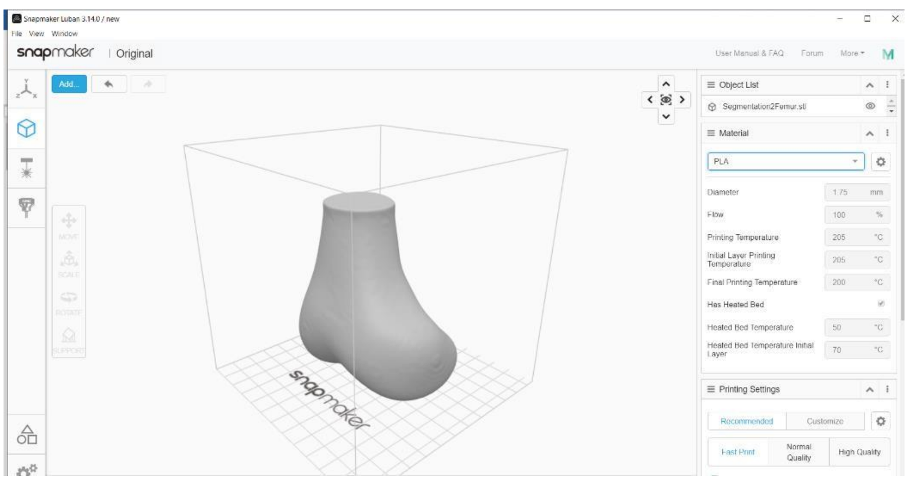



**Figure 25: STL format of the Femur**

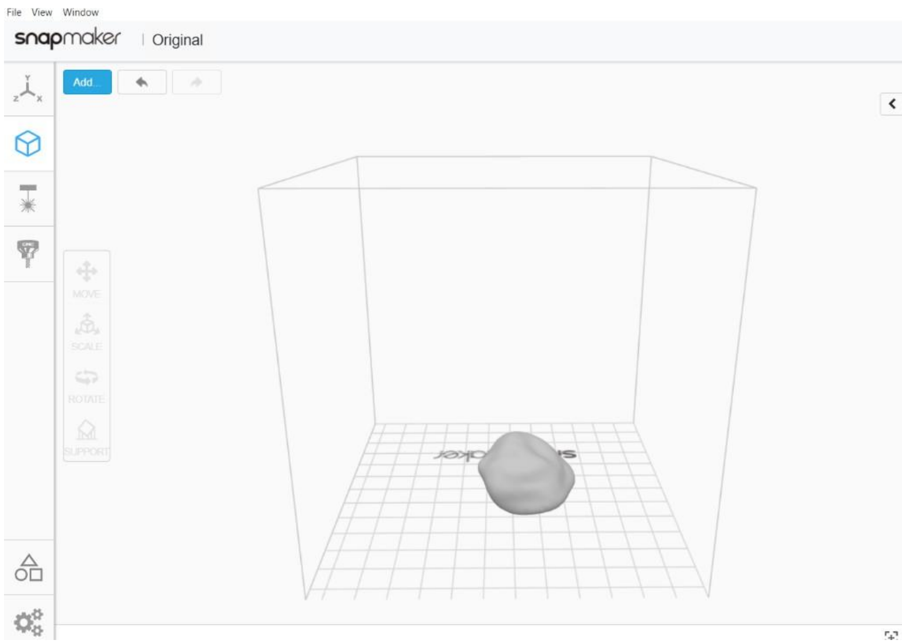



**Figure 26: STL format of the Patella**

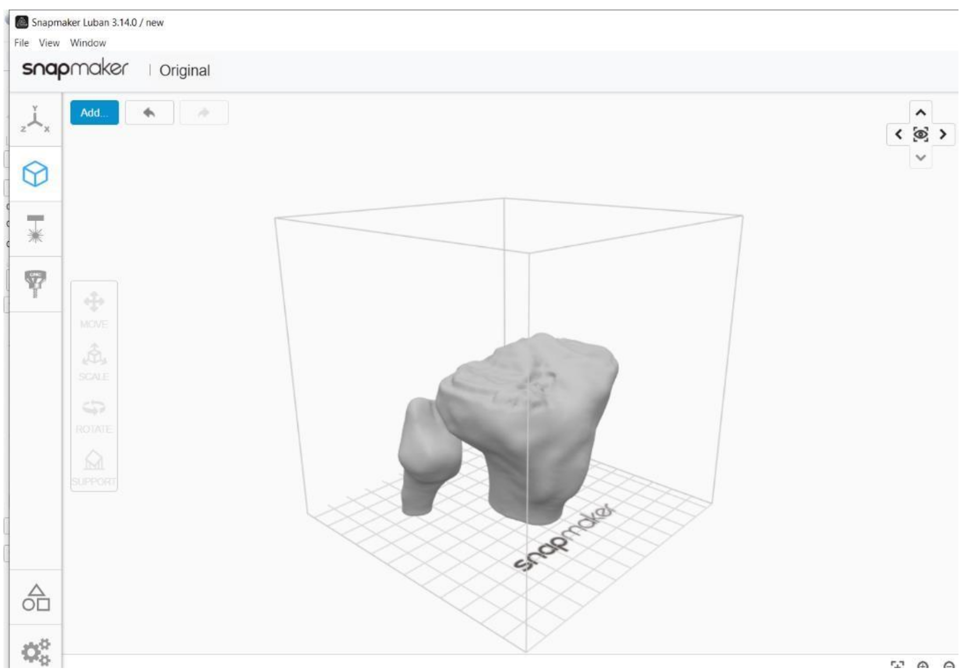



**Figure 27: STL format of Fibula and Tibia**

### 4.4 Detail printings and implementation

The details of the 3D model of the knee anatomy plays the important role on giving out the presentation to the medical students so that the medical students can know how it is like before going into any practical. Therefore, the implementation of the printing is such that the settings of the printing must be set properly. The melting point of the PLA material can be very sensitive when melting therefore the details of the material printing such as the printing temperature, diameter of the PLA materials (to control the flow), and final printing temperature must be checked before starting to print the 3D model. The following figures below shows the presets of the fast printing set up and the materials checklist setup respectively:

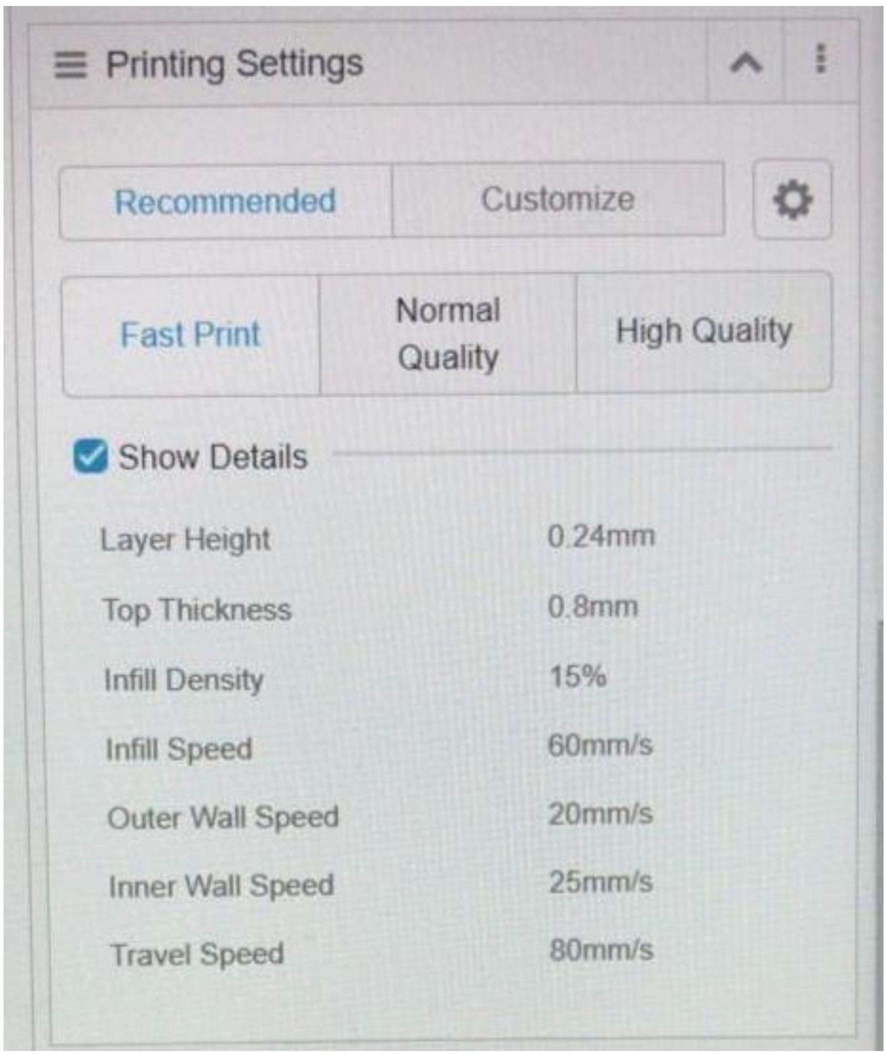



**Figure 28: fast printing setup**

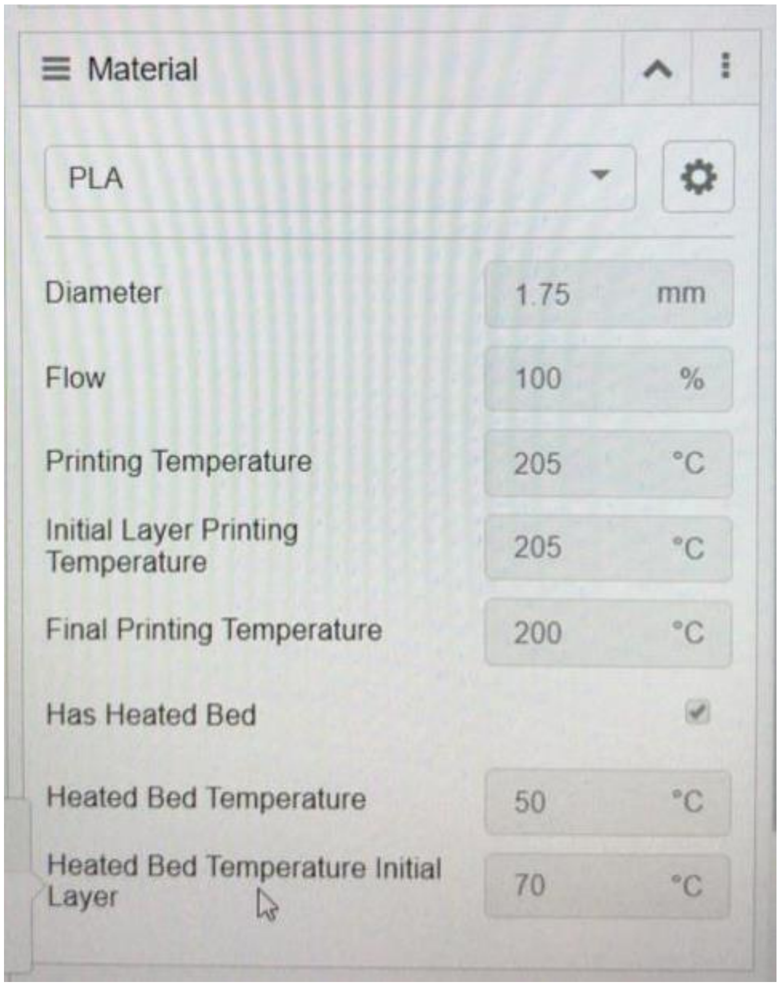



**Figure 29: Material checklist setup**

## Chapter 5: results

### 5.1 Segmentation results

The segmentations of the knee consist of 5 parts – Femur, Tibia & Fibula, Lateral and Medial Meniscus, ACL and PCL, and Patella. The process was done by using the region growing method. After the segmentation was complete, the results of the region growing module of the 3D slicer had given out a good and promising result although a slight modification must be done manually with the eraser tool. During the segmentation, some parts of the anatomy are not visible enough to do the segmentation like the collateral ligaments which was not able to find at all. The following figures below are the results of the singular part segmentations:

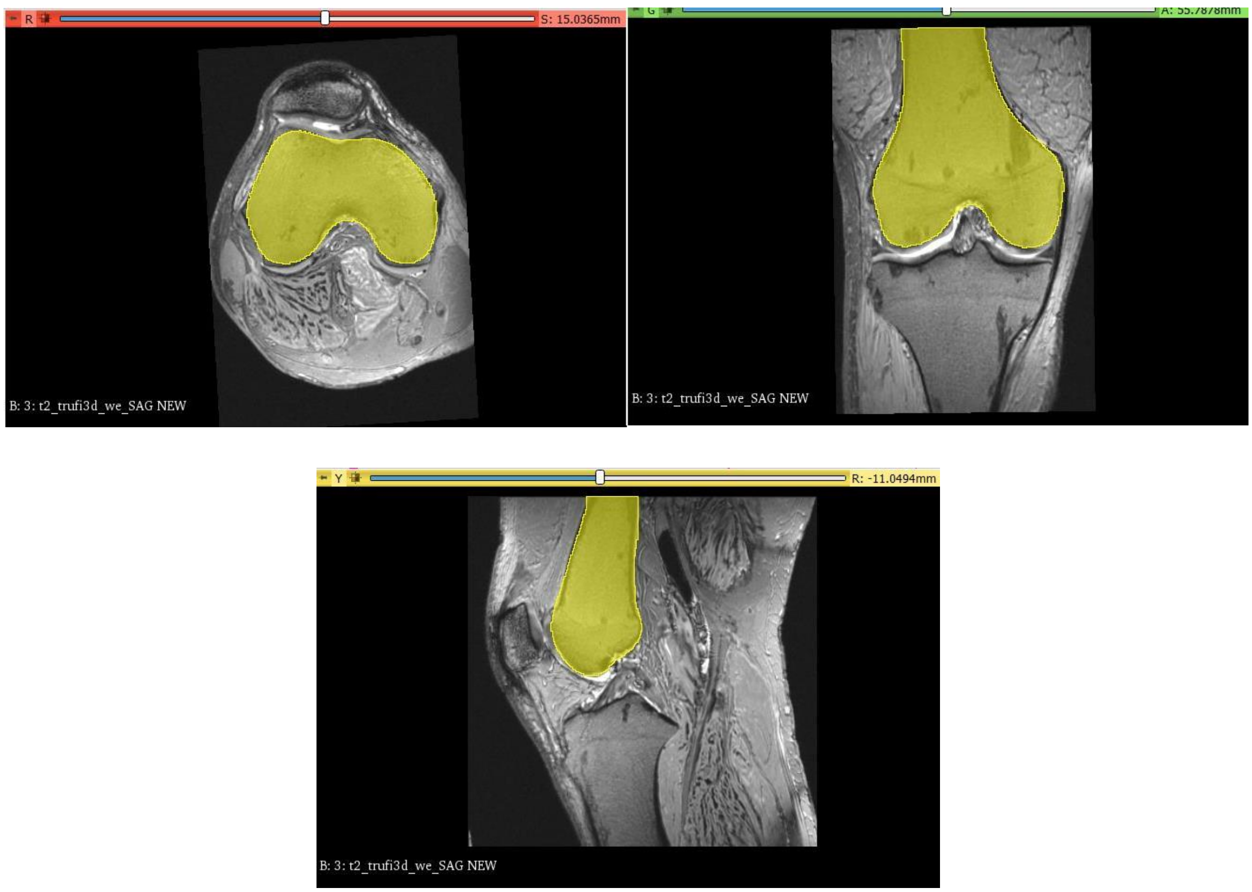



**Figure 30: Segmentation of the Femur**

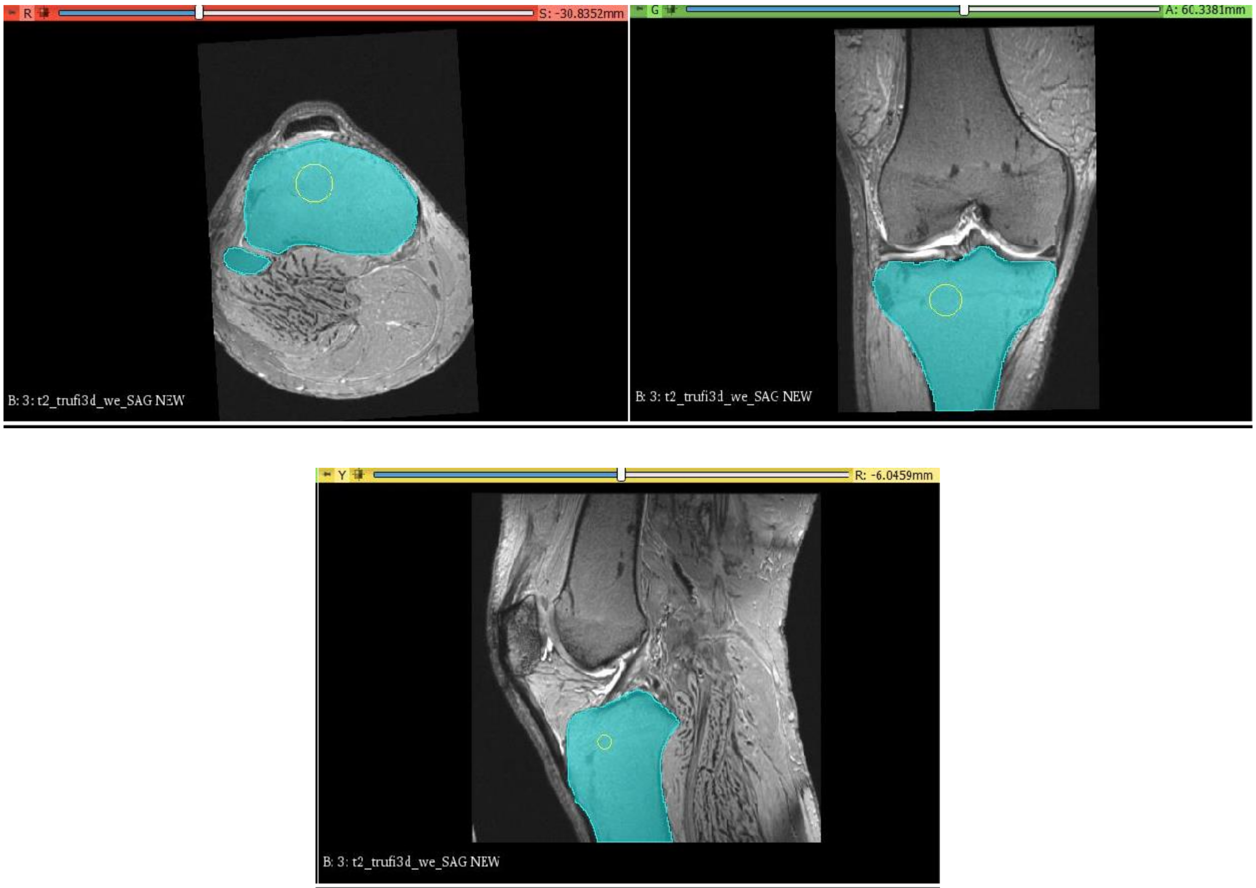



**Figure 31: Segmentation of the Fibula and Tibia**

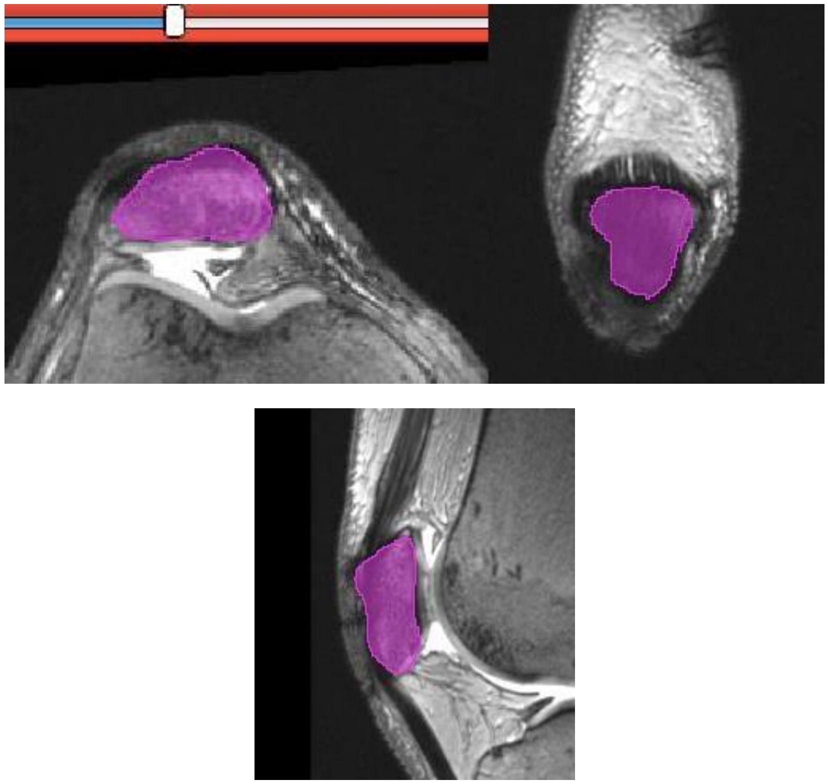


**Figure 32: Segmentation of the Patella**

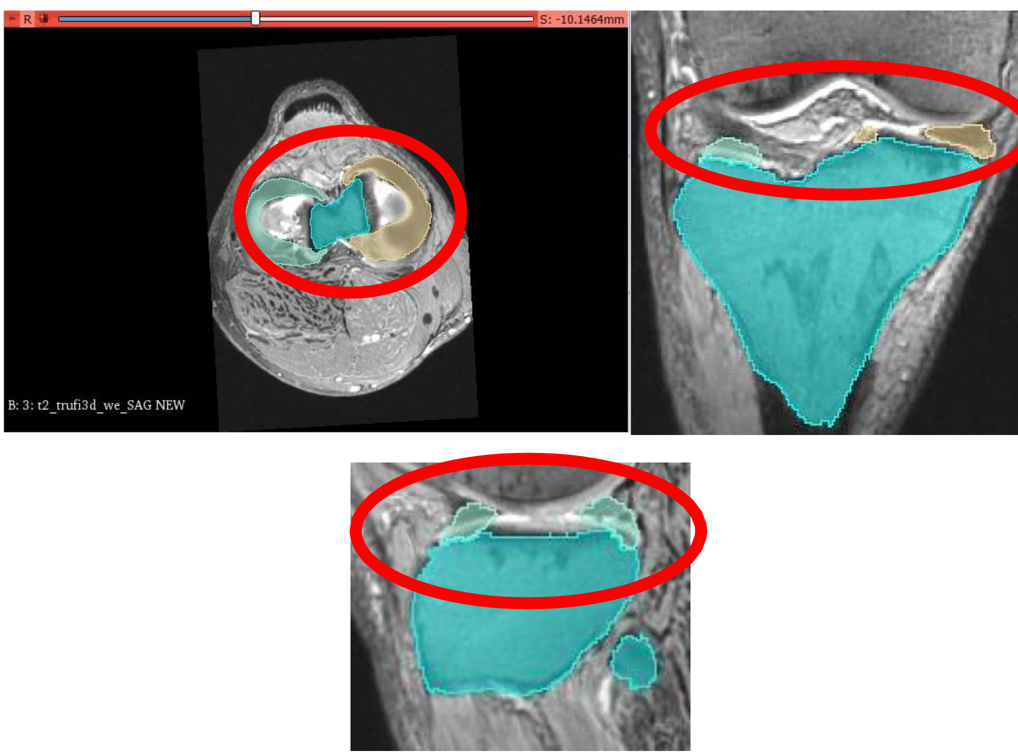



**Figure 33: Segmentation of the Menisca**

## 5.2 3D visualization

Since the edge of the segmentation gives an uneven surface of the 3D parts, the surface of the segmented parts is then smoothed by using the Gaussian smoothing module, and the 3D visualization of the smooth knee anatomy was produced. Some ligaments are not segmented like the medial collateral ligament (MCL) and the Lateral collateral ligament (LCL) due to the intensity of the ligaments are not as bright as it is. The following 3D visualization for the model are shown as below:

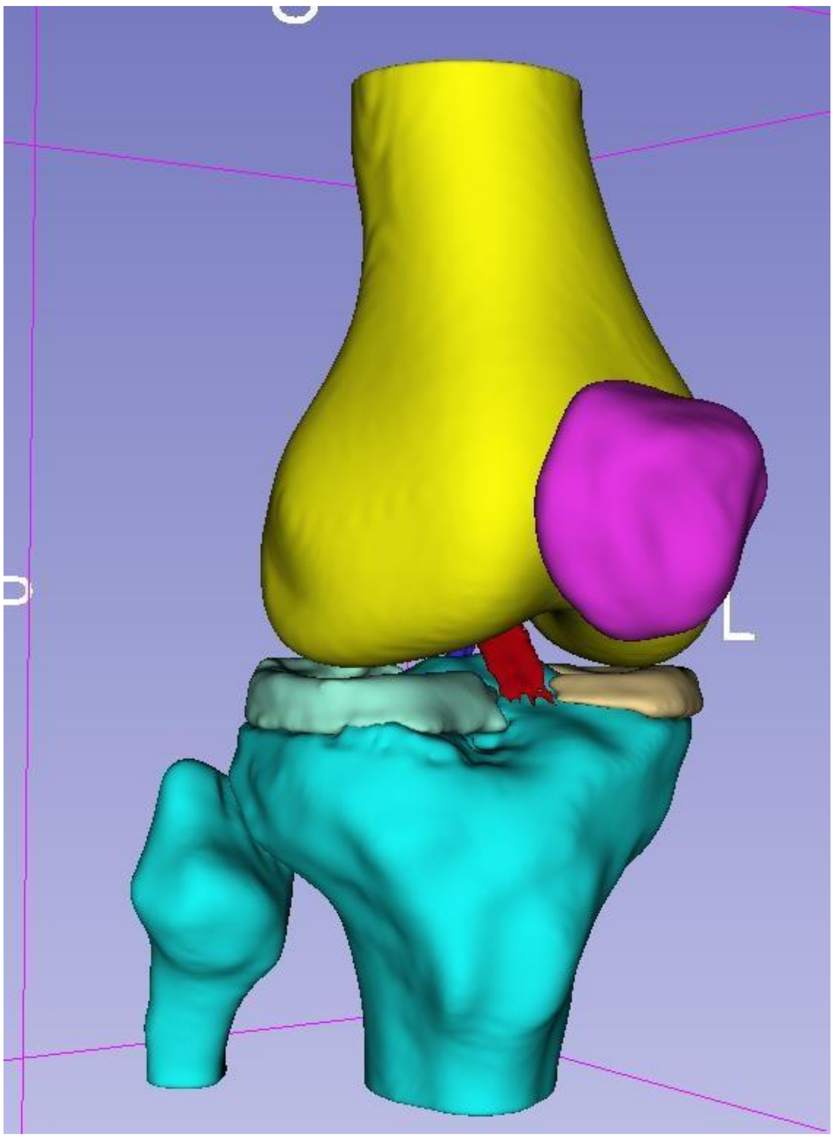


**Figure 34: 3D visualization of the bones**

### 5.3 3D printing parts

Once the segmentations are confirmed to be satisfied, the segmentation is then converted to STL and was printed with Snapmaker Luban. The material that was used for the printing was a PLA black material. The results of the printing turn out great, however there are some parts of the printing that requires some cleanups to make it smooth due to the speed of the printing. The following figures below shows the printed 3D model of the knee:

1)

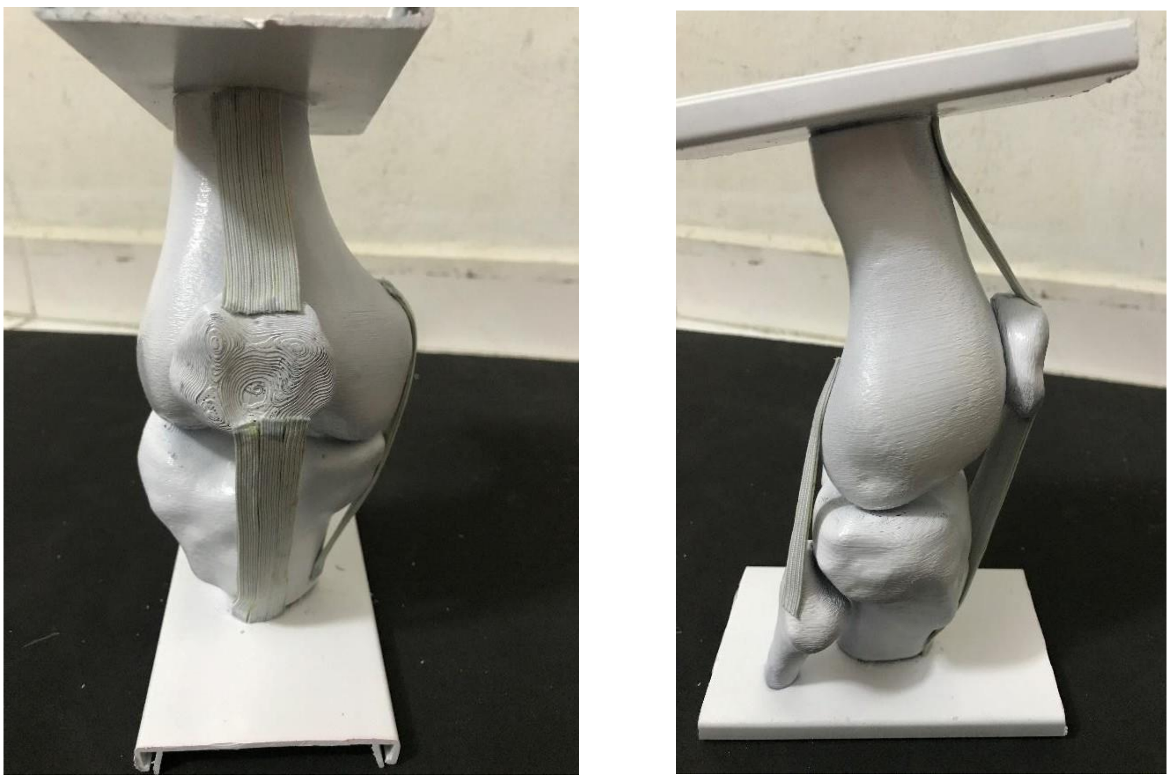
2)

3)

**Figure 35: 3D printed models of the parts – (1) Femur, (2) Patella, and (3) Fibula and tibia**

### 5.4 3D printing assemble.

The 3D print of the model is assembled by using 2 platforms for both bones to have upright position. Once the bones' part is glued down and secured the position, the back of the model was then placed with another PVC board to place the position of the whole leg. The ligaments of the model are represented with the use of elastic straps. The reason of not using silicon to make the ligaments or the tendon was because the surface area of both muscles is small, and the hardening of the silicon will not allow it to stretch like muscles. The following figure below shows the product of the model:



a) b)

**Figure 36: a) front view and b) side view of the knee anatomy model**

### 5.5 Based survey

A survey with 11 questions had been conducted to study the feedback on the 3D model of the knee joint based on the medical image. The targeted audiences are mostly experienced doctors, surgeons, and veterinarian. The first 5 questions were designed to survey whether if the doctors were to know about 3D model reconstructions, experience of their studies, and opinions. The following 6 remaining questions were to survey the accuracy of the 3D models of knee joint based on their opinions.

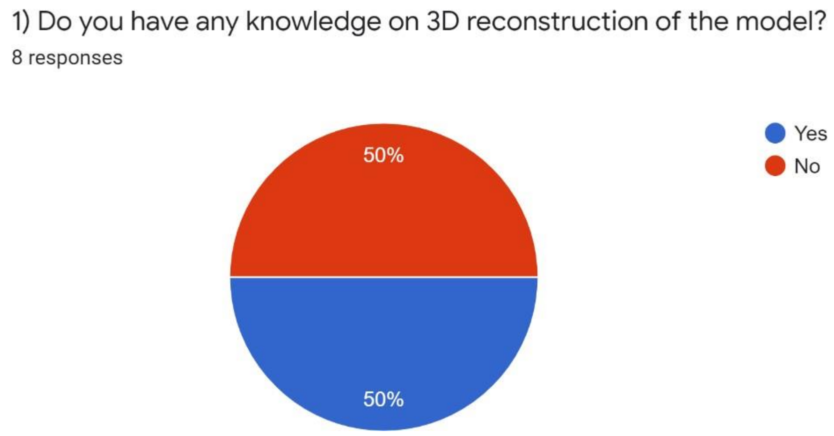



**Figure 37 Question 1**

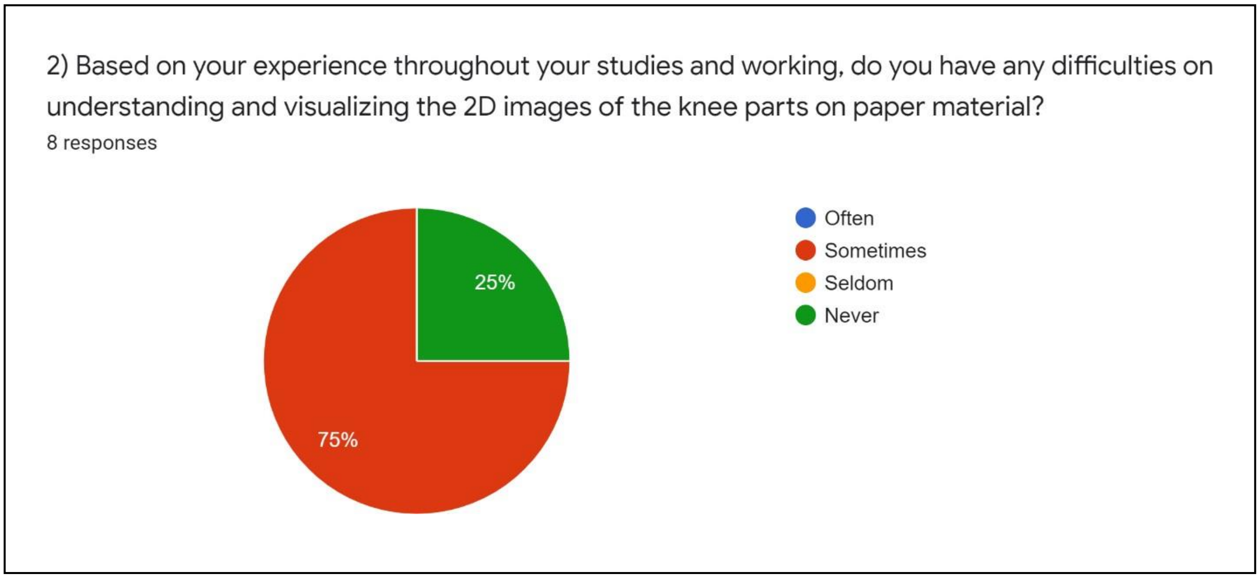



**Figure 38 Question 2**

Based on Figure 37 and Figure 38, half of the respondents had heard of about 3D reconstructions of the model and most of the respondents had sometimes face difficulty on understanding and visualizing the 2D image of the knee parts on paper material. These questions are to determine on their knowledge on 3D model and difficulties they had faced.

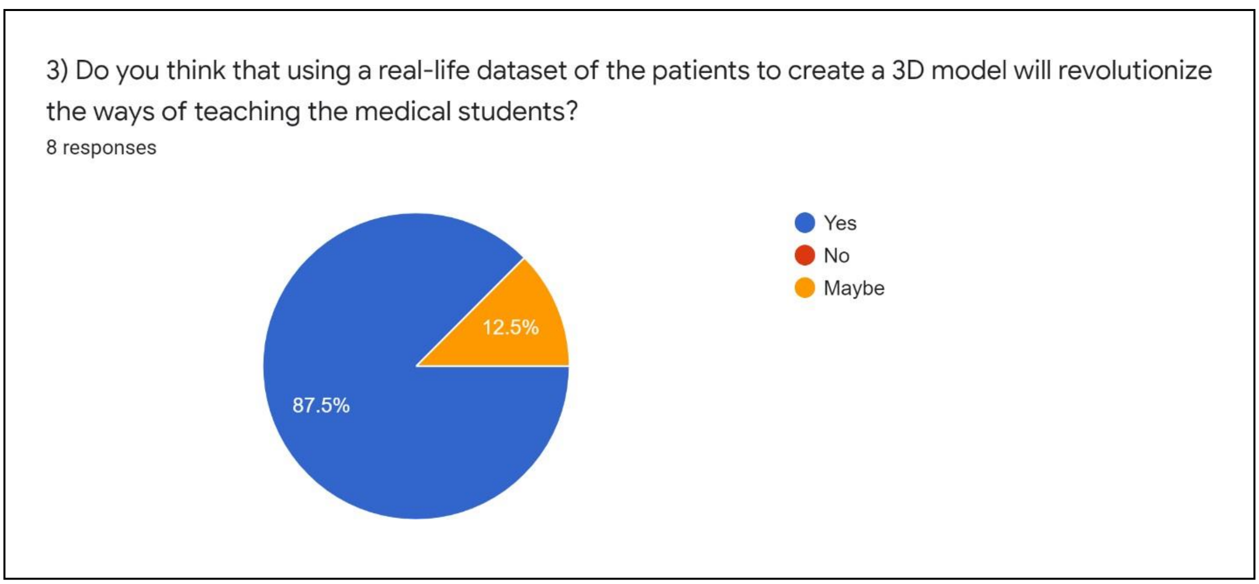



**Figure 39 Question 3**

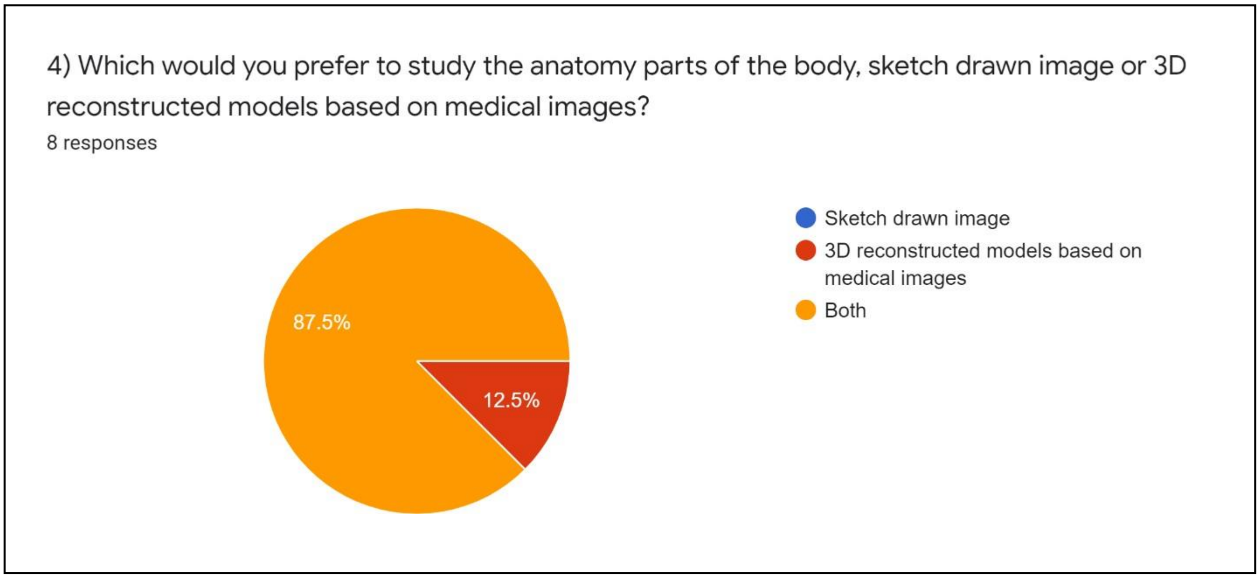



**Figure 40 Question 4**

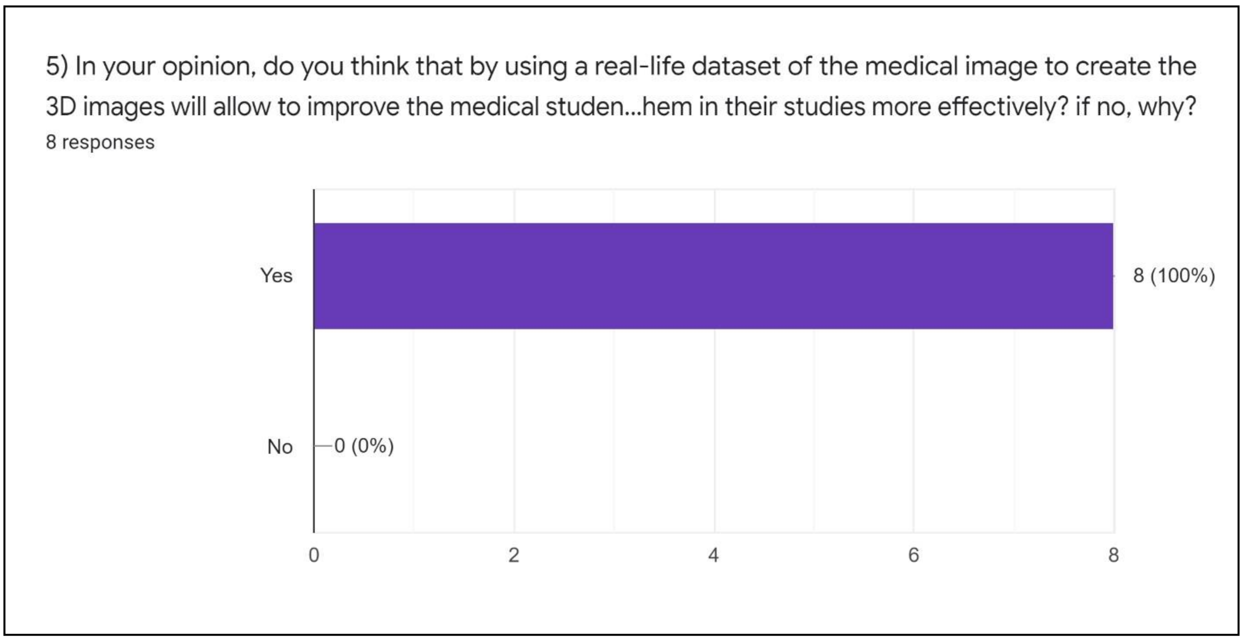



**Figure 41 Question 5**

Figure 39, Figure 40, and Figure 41 focused mostly on opinions on using medical image to create 3D models of the anatomy parts. According to the response, majority of the respondents think that using 3D model along with the help of 2D sketch will help to revolutionize the way of teaching and improves the understandings for the students' learning.

## 5.6 Model Survey

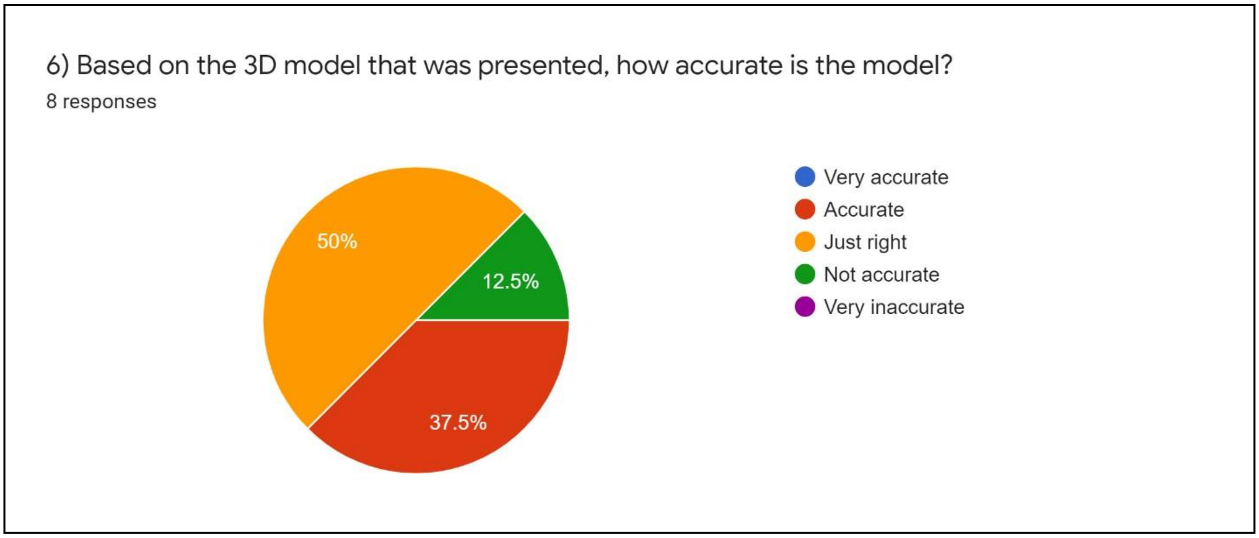



**Figure 42: Question 6**

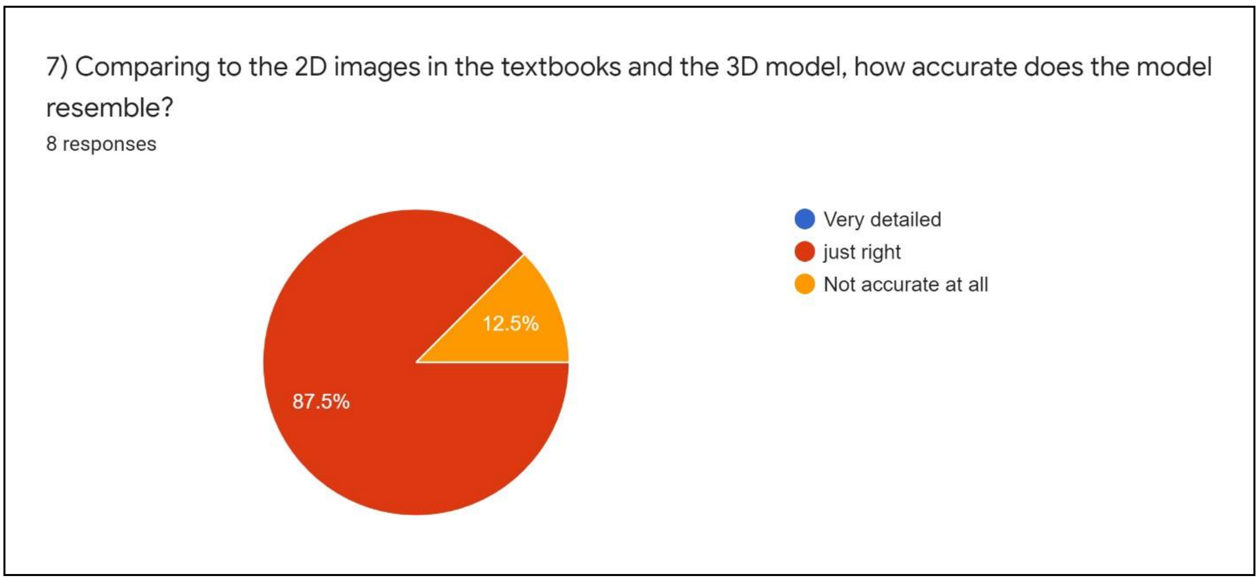



**Figure 43: Question 7**

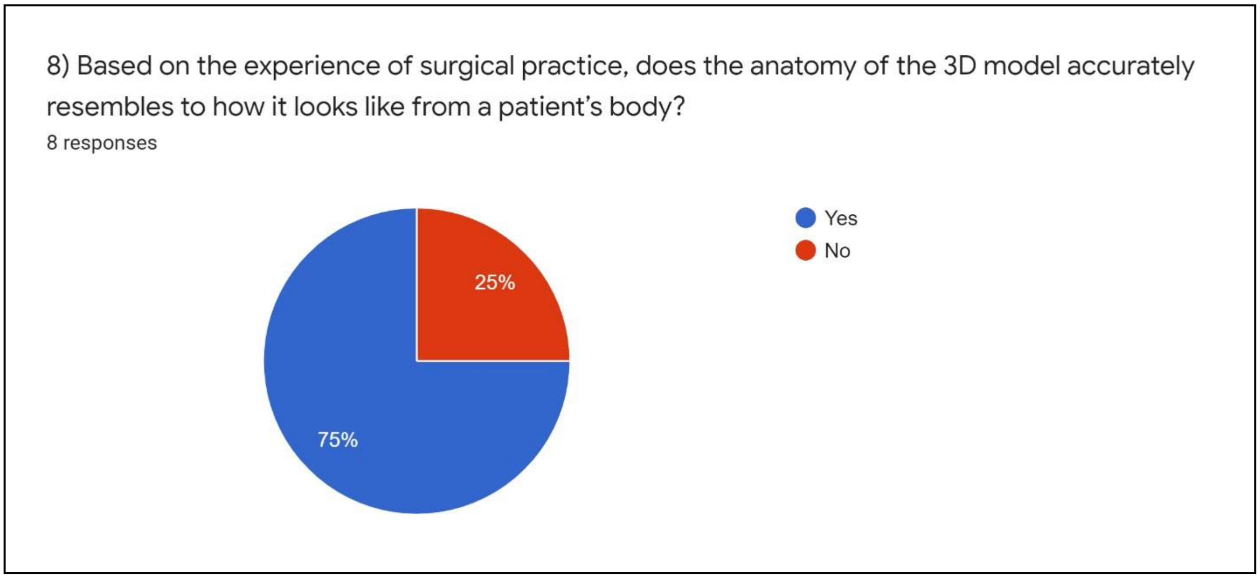



**Figure 44: Question 8**

According to Figure 42, Figure 43, and Figure 44, majority of the respondents reviewed that the accuracy of 3D model of the knee joints is just right based on the 2D images and resembles the anatomy of the patient's knee. This shows that the 3D model can somehow improve on teaching the students.

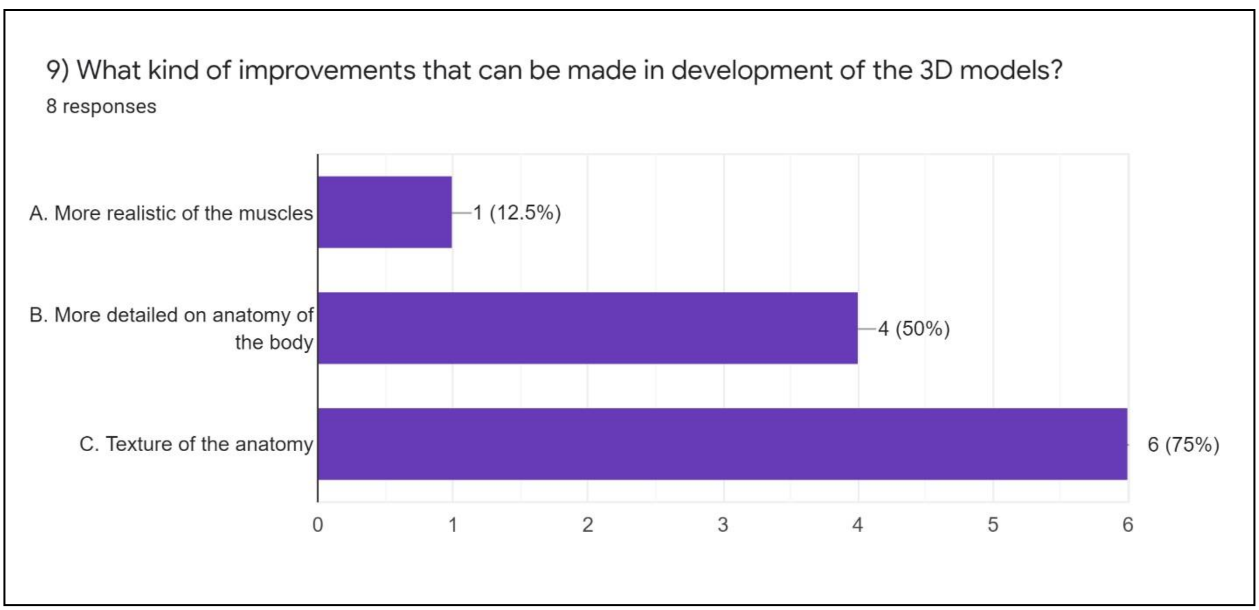



**Figure 45: Question 9**

Figure 45 shows the feedback of the improvement that need to be made on the 3D model. according to the respondents, texture wise of the anatomy was the most important while second to come is to be more detailed on anatomy of the body. This shows that the texture of the anatomy plays the role on allowing students to experience the realism of the model.

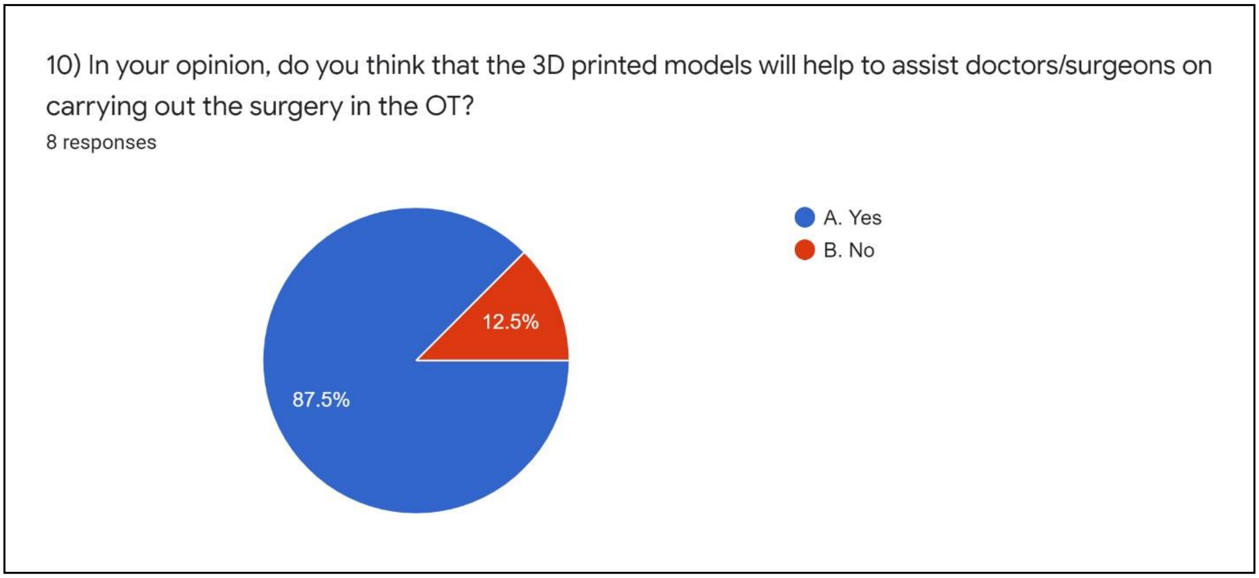



**Figure 46: Question 10**

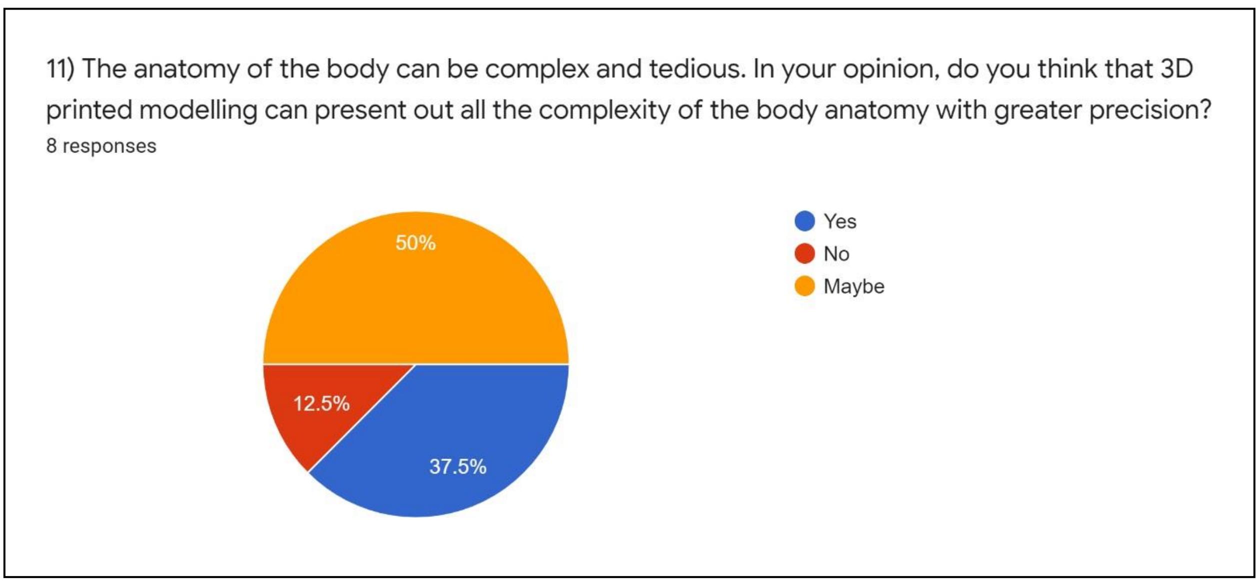



**Figure 47: Question 11**

According to survey result on Figure 46 and Figure 47, most of the respondents agrees that the 3D models will able to help on assisting the surgeons to carry out the surgery and half of the respondents too agree on 3D printed modelling can present out all the complexity of the body anatomy with greater precision.

## 5.7 Discussion

During the printing process of the 3D model, the material used for the bone parts does not resembles the texture of the bone very accurately and therefore the results of having to improve on the texture. Furthermore, the silicon material to use on printing the ligament is impossible for the material will tend to harden and cause the ligament not able to stretch out even though the silicon material may be flexible. In addition, some parts of the surface did not turn out smooth after the printing process due to the speed setting of the printing was fast printing. Hence, the speed of better quality of the model must be set according to the recommended time to print out.

Improvements must be made mostly on finding a right filament material to resemble every texture of the anatomy. The improvement of the details for anatomy of the knee joints must also be made to have more precise part; this will allow the knee joint to have a better mechanism of moving parts.

# Chapter 6: Discussion and Conclusion

## 6.1 Future work

This project was able to reconstruct a 3D model of the knee anatomy based on the medical imaging of MRI and CT scans. The details of the model can display out physically exactly how the MRI image shows. Therefore, one of the fundamental objectives is to develop 3D reconstructed anatomy structure based on real medical images of the patient. To enhance the details of the 3D models and make more effective on medical learning, a better quality of the medical image datasets must be obtained with more numbers of slices of the image and better intensity of the image. In fact, a survey on types of materials to create a real muscle-like tissues must be done so that medical students will be able to understand better. Furthermore, due to time constraints of the final year project, some parts of the knee anatomy like the nerves are not completely done and is a challenging to complete it as well. The future work for this project is to segment more parts of the anatomy along with good materials to create the model parts. Adding a software that helps on the mechanism will help as well.

## 6.2 Conclusion

In conclusion, Biology subject is a compulsory for all students who wish to advance themselves into medical field. In fact, the problem here is that the medical students in Malaysia are now having trouble understanding the medical images and having difficulties in visualization towards the medical image. The knee joint ligaments visualization is one example of difficulty to view using medical images. It is challenging to find ligament parts in our dataset project.

To solve the problems for the new batch of a medical students coming into the university, using 3D model reconstruction of the medical imaging for learning purpose is one of the solutions to help them. Making use of the modern technologies implements and replace any traditional method of learning or study for the students. Learning on the model based on real datasets of the patients will allow them to understand better of the anatomies. Therefore, 3D Slicer provides a suitable segmentation technique that can be used for the project to create a new part of the anatomy model and with greater detail of the parts. This technique will allow to segment all the parts in the medical imaging and making it to see clearer. The segmentation of the anatomy parts from the 3D slicer will then be implemented into the 3D printing software so that to create out the model. This method will allow students to physically see the parts before undergoing into any surgical practical. Even without the 3D model, the students will still be able to obtain the 3D models in the STL format so that they may get a copy and bring back home for their studies. Even so, in the future, the 3D model may provide some of live mechanisms and functionality of the printed organs to further improve their learnings.

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# APPENDIX A: WEEKLY REPORT

## FINAL YEAR PROJECT WEEKLY REPORT

*(Project I / Project II)*

| | |
|---|---|
| **Trimester, Year: Semester 2, 4th year** | **Study week no.: 1&2** |
| **Student Name & ID: CHOY CHEE MUN 16ACB04938** | |
| **Supervisor: DR. SAYED AHMAD ZIKRI BIN SAYED ALUWEE** | |
| **Project Title: 3D model reconstruction of human knee joint based on medical images for education purposes** | |

**1. WORK DONE**

[Please write the details of the work done in the last fortnight.]

- Cmake 3D slicer
- Understand the 3D slicer toolkits and modules

**2. WORK TO BE DONE**

- 3D design of the model.
- Segmentation process.
- 3D prints the model parts.
- Segmentation checking.
- Smoothing process.
- Interview with Dr.Dylan

**3. PROBLEMS ENCOUNTERED**

- No problem has occurred during the segmentation.

**4. SELF EVALUATION OF THE PROGRESS**

- Learnt to understand medical images and their intensity values.

Sayed Ahmad Zikri

Supervisor's signature

Student's signature

# FINAL YEAR PROJECT WEEKLY REPORT

*(Project I / Project II)*

| Trimester, Year: Semester 2, 4th year | Study week no.: 4 |
|---|---|
| **Student Name & ID: CHOY CHEE MUN 16ACB04938** | |
| **Supervisor: DR. SAYED AHMAD ZIKRI BIN SAYED ALUWEE** | |
| **Project Title: 3D model reconstruction of human knee joint based on medical images for education purposes** | |

**1. WORK DONE**

[Please write the details of the work done in the last fortnight.]

- 3D design of the model.
- Segmentation process.

**2. WORK TO BE DONE**

- Segmentation checking.
- Smoothing process.
- Interview with Dr.Dylan

**3. PROBLEMS ENCOUNTERED**

- Thresholding method not suitable for the DICOM file due to noises, need to use region growing method.

**4. SELF EVALUATION OF THE PROGRESS**

- No comment

Sayed Ahmad Zikri

Supervisor's signature

Student's signature

# FINAL YEAR PROJECT WEEKLY REPORT

*(Project I / Project II)*

| | |
|---|---|
| **Trimester, Year: Semester 2, 4th year** | **Study week no.: 6** |
| **Student Name & ID: CHOY CHEE MUN 16ACB04938** | |
| **Supervisor: DR. SAYED AHMAD ZIKRI BIN SAYED ALUWEE** | |
| **Project Title: 3D model reconstruction of human knee joint based on medical images for education purposes** | |

**1. WORK DONE**

[Please write the details of the work done in the last fortnight.]

- Double checking and confirm the segmentation with supervisor.
- Smoothing process done for segmentation.

**2. WORK TO BE DONE**

- 3D prints the model parts.
- Interview with Dr.Dylan

**3. PROBLEMS ENCOUNTERED**

- No problem has occurred during the segmentation.

**4. SELF EVALUATION OF THE PROGRESS**

- Successfully finish the segmentation.

Sayed Ahmad Zikri

Supervisor's signature

Student's signature

# FINAL YEAR PROJECT WEEKLY REPORT

*(Project I / Project II)*

| Trimester, Year: Semester 2, 4th year | Study week no.: 8 |
|---|---|
| **Student Name & ID: CHOY CHEE MUN 16ACB04938** | |
| **Supervisor: DR. SAYED AHMAD ZIKRI BIN SAYED ALUWEE** | |
| **Project Title: 3D model reconstruction of human knee joint based on medical images for education purposes** | |

| **1. WORK DONE** |
|---|
| - Segmentation of the MRI successfully segmented.<br>- 3D visualization of the segmentation was done.<br>- STL conversion of the model was also done.<br>- 3D printed the work.<br>- Done interviewed Dr.Dylan |
| **2. WORK TO BE DONE** |
| - Report and surveys. |
| **3. PROBLEMS ENCOUNTERED** |
| – Smoothing process may vary from the original<br>– Speed of the printing did not give smooth job of the models.<br>– Both collateral ligaments cannot be found in the MRI or CT scan. |
| **4. SELF EVALUATION OF THE PROGRESS** |
| - Still in the progress of learning the functionality of the project templates.<br>- Learnt the anatomy of the knee.<br>- Learnt the process of 3D printing. |

Sayed Ahmad Zikri

Supervisor's signature

Student's signature

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## APPENDIX C: QUESTIONNAIRE SURVEY

Questionaire sample

Survey form for Final Year Project 2

1) Do you have any knowledge on 3D reconstruction of the model?
A. Yes
B. No

2) Based on your experience throughout your studies and working, do you have any difficulties on understanding and visualizing the 2D images of the knee parts on paper material?
A. Often
B. Sometimes
C. Seldom
D. Never

3) Do you think that using a real-life dataset of the patients to create a 3D model will revolutionise the ways of teaching the medical students?
A. Yes
B. No
C. Maybe

4) Which would you prefer to study the anatomy parts of the body, sketch drawn image or 3D reconstructed models based on medical images?
A. Sketch drawn image.
B. 3D reconstructed models based on medical images.
C. Both

5) In your opinion, do you think that by using a real-life dataset of the medical image to create the 3D images will allow to improve the medical student's understandings on the anatomy of the body parts and able to aid them in their studies more effectively? If no, why?
A. Yes
B. No

Reason: ____________________________________________________

6) Based on the 3D model that was presented, how accurate is the model?
A. Very accurate
B. Accurate
C. Just right
D. Not accurate
E. Very inaccurate

7) Comparing to the 2D images in the textbooks and the 3D model, how accurate does the model resemble?

A. Very detailed
B. Just right
C. Not accurate at all

8) Based on the experience of surgical practice, does the anatomy of the 3D model accurately resembles to how it looks like from a patient's body?

A. Yes
B. No

9) What kind of improvements that can be made in development of the 3D models?

A. More realistic of the muscles
B. More detailed on anatomy of the body
C. Texture of the anatomy
D. All the above
E. Others: ______________________________________________

10) In your opinion, do you think that the 3D printed models will help to assist doctors/surgeons on carrying out the surgery in the OT?

A. Yes
B. No

11) The anatomy of the body can be complex and tedious. In your opinion, do you think that 3D printed modelling can present out all the complexity of the body anatomy with greater precision?

A. Yes
B. Maybe
C. No

POSTER

# 3D MODEL RECONSTRUCTION OF HUMAN KNEE JOINT BASED ON MEDICAL IMAGES FOR EDUCATION PURPOSE

**3D MODEL RECONSTRUCTION OF HUMAN KNEE JOINT BASED ON MEDICAL IMAGES FOR EDUCATION PURPOSE**

## INTRODUCTION

The 3D reconstruction of human organ based on medical images segmentation is a technique that allows the doctors to study the anatomy and the functions of the organs in living things. Furthermore, the medical-based segmentation allows specialists to detect the location of the disease and enable the doctor to diagnose quickly on the patients' situation. In addition, segmentations also had helped to ease the studies on anatomy of living things, allowing all medical students to understand better on living things' complexity. However, some parts of the anatomy of the bodies can be hard to be seen through the image itself and often the specialist will need to detect it manually using the manual segmentation.

## OBJECTIVE

1. To develop 3D reconstructed anatomy structure based on real medical images of the patient. .
2. To allow students to study the 3D anatomy structure from actual medical images

## METHODOLOGY

IMAGE PRE-PROCESSING

↓

IMAGE SEGMENTATION

↓

REGION GROWING METHOD

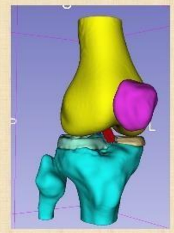
↓

SMOOTHING PROCESS

↓

RENDERING

## RESULT



3D VISUALIZATION OF THE KNEE JOINT

3D PRINT OF THE KNEE JOINT

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Sayed Ahmad Zikri

Signature of Supervisor

Name: Dr Sayed Ahmad Zikri Bin Sayed Aluwee

Date: 14th APRIL 2021

Signature of Co-Supervisor

Name:

Date: 14th APRIL 2021

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