

A Novel Technique for 3D Printer to Create Organ 3D Model from DICOM File

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Abstract

Three-Dimension (3D) model is used in many applications such as medical applications, industries etc. This work is used for assisting doctors' needs in seeing the organ in 3D model for diagnosing or for the patients to see what kind of abnormality they have. Doctor wants to see model with the actual size of the real organ to help the doctor carrying out the right diagnoses and treatments. We study 3D model created from 2D picture. We used Mimics software to create 3D model and to select the area or the organ of interest. We used manual to analyze picture in Mimics software. The original picture in this work was used as a Digital Imaging and Communications in Medicine (DICOM) file. This picture was obtained from an X-ray Computed tomography (CT scan). We propose how to make and improve the 3D model. The 3D model is very useful in the medical industries because doctors can do their jobs with 3D model before working on the real case. This can reduce the risk of what will happen to the patients.

Keywords: 3D printer, medical image, CT scan

บทคัดย่อ

แบบจำลองสามมิติถูกนำมาใช้ในการทำงานอย่างหลากหลายไม่ว่าจะเป็น การประยุกต์ใช้แบบจำลองสามมิติทางการแพทย์, ด้านอุตสาหกรรม และด้านอื่นๆอีกมากมาย โดยงานวิจัยนี้จะเน้นประยุกต์ใช้แบบจำลองสามมิติทางการแพทย์เพื่อใช้สำหรับแพทย์ที่ต้องการแสดงอวัยวะในรูปแบบจำลองสามมิติสำหรับการวิเคราะห์, การรักษาหรือให้ผู้ป่วยสามารถมองเห็นสิ่งที่ผิดปกติที่เกิดขึ้นกับตัวผู้ป่วยเองได้ และแพทย์ที่ต้องการจะเห็นแบบจำลองสามมิติในขนาดเดียวกันกับอวัยวะจริง ศึกษาการสร้างแบบจำลองสามมิติจากภาพสองมิติ โดยใช้ซอฟต์แวร์ Mimics ในการสร้างแบบจำลองสามมิติและเลือกพื้นที่หรืออวัยวะที่ต้องการเพื่อนำไปสร้างแบบจำลองสามมิติ ในส่วนของการวิเคราะห์ภาพจะใช้ตัวใช้ซอฟต์แวร์ Mimics เป็นผู้วิเคราะห์ โดยรูปภาพต้นฉบับในการทำงานจะใช้เป็นไฟล์ภาพดิจิทัลทางการแพทย์ (DICOM) ซึ่งภาพเหล่านี้ถูกสร้างมาจากเครื่องตรวจเอกซเรย์คอมพิวเตอร์ (CT scan) ในงานวิจัยนี้จะเป็นการนำเสนอวิธีการทำและการปรับปรุงภาพเพื่อทำแบบจำลองสามมิติ แบบจำลองสามมิติมีประโยชน์มากในด้านการแพทย์เพราะแพทย์สามารถทดลองกับโมเดลสามมิติก่อนใช้งานจริงได้ ซึ่งจะช่วยลดความเสี่ยงที่จะเกิดขึ้นในผู้ป่วย

คำสำคัญ: เครื่องพิมพ์สามมิติ ภาพทางการแพทย์ เครื่องตรวจเอกซเรย์คอมพิวเตอร์

1. Introduction

CT scan is used to analyze high solution by CT scan machine. X-ray used in CT scan machine is the as with X-ray Machine. CT scan have many readers used to receive shadow of picture in different angle. After that we used all the data to process and create 3D picture. The picture is computer data we can create picture to Tomography.

We use DICOM file from CT scan to make 3D model for doctors in the planning of the treatment. The picture from CT scan comes in a Grayscale picture. We use manual image processing to create 3D picture model using Mimics software. Mimics has an image processing and the tools to be used in selected area to be exported to STereoLithography (stl) type which we can print the 3D model from MakerBot program

In the selection step 3D designed model can be created in accordance with the selected areas or images. We will define the desired area by setting a manual thresholding of set gray level value. Gray level is used to collect all desired areas of thresholding. After that we use the erase tool to delete an unwanted area. When we finished, we export the file to stl type for printing in 3D model. Currently medical pictures from CT scan can create many pictures' files and erase the unwanted area manually.

In the past doctor could only see the DICOM file from the computer. They wanted to create 3D model in aiding them with the diagnose. An example of a cardio doctor who wanted to see the patients' hearts before operating or treating the patients with valvular heart disease. For the treatment of the valvular heart disease the doctor used 3D model to explain to the patients what they want to do with the patients, the 3D model is very useful for explaining to the patients. Moreover, doctors can foresee how the prosthesis works on the 3D Model before operating on the real case.

2. Materials

A. Mimics

Mimics is image processing software. By this software we can use for 3D modeling and design 3D surface models from stacks of 2D image data. And widely used in medical, manufacturing industries and engineering applications.

From stacked image data such as CT scan, Micro CT, X-ray Ultrasound, etc., User can selected the area of interest and converted to a 3D surface model using an adapted marching cubes algorithm that takes the partial volume effect into account, leading to very accurate 3D models.[1][2]

This software supports many image file formats such as TIFF, JPEG, BMP, Raw and DICOM is most common input format. Common 3D output formats include STL, VRML, PLY and DXF.

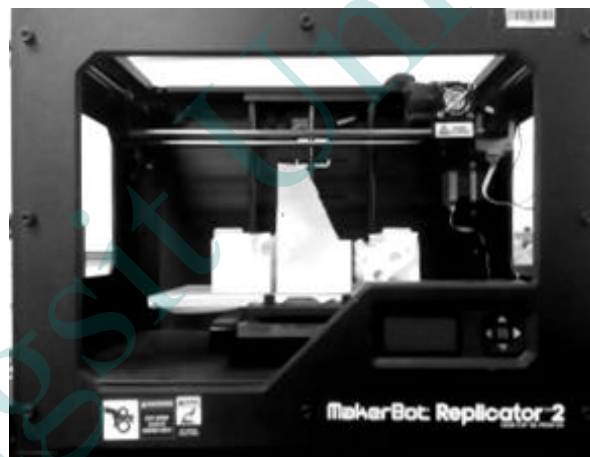


Figure 1 3D printer

B. 3D printer

In this work we used MakerBot Replicator 2 show in Figure. 1. This area model is 28.5 cm x 15.3 cm x 15.5 cm and can print at 100 μ m per layer. The dual extruder was changed back to a single extruder head, while the upgraded electronics, LCD, and gamepad remained similar to the original Replicator. Unlike previous models, the Replicator 2 can print only using polylactic acid (PLA) plastic.

To print a 3D model. The length of time it takes to print the model in the same size as the real organ takes about 10 hours at the normal resolution setting. In an area of 12³ centimeters.

C. DICOM file

DICOM is a standard medical image for handling, storing, printing, and transmitting information. In figure 2 show you about the detail DICOM file we are using. DICOM includes a file format definition and a network communications protocol [7]. The communication protocol is an application protocol that uses TCP/IP to communicate between systems. It was developed by the DICOM Standards Committee.

In this work we received the DICOM image file from the Ramathibodi hospital for study and modeling. The image file is an image from CT scan containing. There is information about the image of the chest of human body one set of files. One set consist of 560 picture.

```
>> info = dicominfo('d:\dicom file\Image_test.dcm') %qqqqqqqqqqdicom file
info =

    Filename: 'd:\dicom file\Image_test.dcm'
    FileModDate: '12-Nov.-2013 10:07:29'
    FileSize: 131954
    Format: 'DICOM'
    FormatVersion: 3
    Width: 256
    Height: 256
    BitDepth: 16
    ColorType: 'grayscale'
    FileMetaInformationGroupLength: 208
    FileMetaInformationVersion: [2x1 uint8]
    MediaStorageSOPClassUID: '1.2.840.10008.5.1.4.1.1.7'
    MediaStorageSOPInstanceUID: [1x64 char]
    TransferSyntaxUID: '1.2.840.10008.1.2'
    ImplementationClassUID: '1.3.6.1.4.1.9590.100.1.0.100.4.0'
    ImplementationVersionName: 'MATLAB IFT 4.0'
    SOPClassUID: '1.2.840.10008.5.1.4.1.1.7'
    SOPInstanceUID: [1x64 char]
    StudyDate: ''
    ContentDate: '20130512'
    StudyTime: ''
    ContentTime: '100729.248001'
    AccessionNumber: ''
    Modality: 'OT'
    ConversionType: 'WSD'
    ReferringPhysicianName: [1x1 struct]
    PatientName: [1x1 struct]
    PatientID: ''
    PatientBirthDate: ''
```

Figure 2 DICOM file detail

3. Methods

3D modeling from DICOM file we must set the area or organ of interest first because we will erase less unrelated area data in Mimics software and used this area to create 3D model. In the traditional method, we must erase unrelated area data in Mimics software. However, the way takes a long time to analyze and erase manually. The traditional way cannot directly destinate the area of interest.

. According to the method, we prepare DICOM file before opening with Mimics with image processing to adjust the quality of the image data and customize image resolution [5], [6]. It makes a clear division of the organ. When we prepared DICOM file, we decrease the time for analyzing in Mimics and easy to destinate the area of interest.

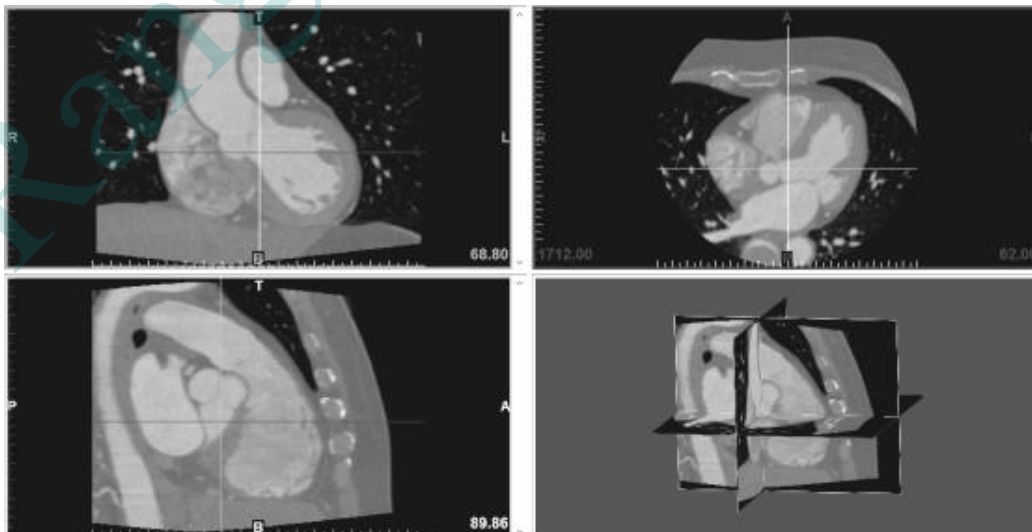


Figure 3 DICOM file open in Mimics

The steps to work in Mimics.

STEP 1 we import the DICOM file in Mimics software shown in figure 3

STEP 2 we selected the area of interest shown in figure 4.

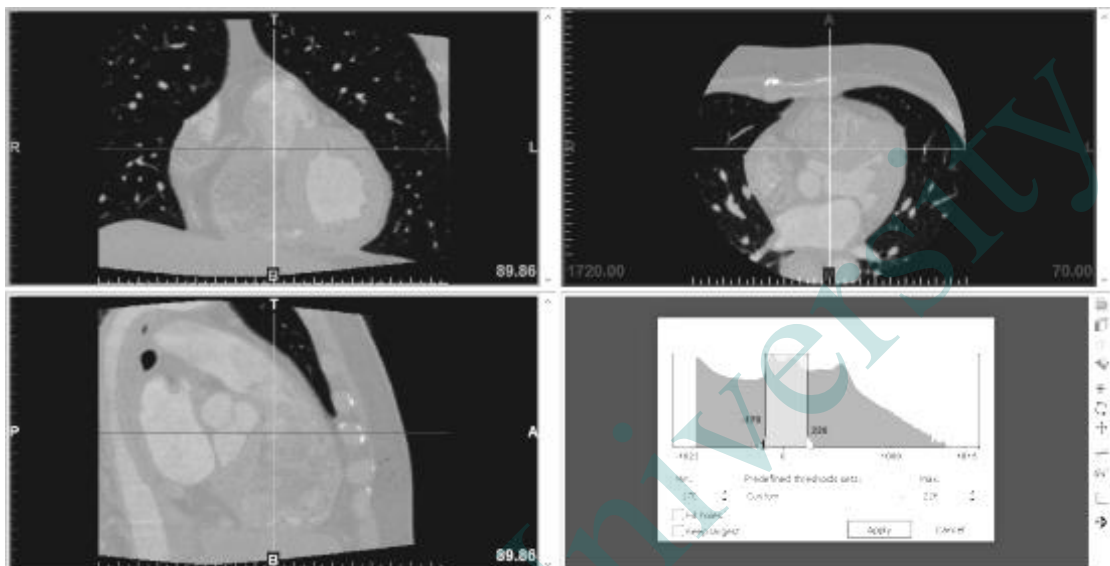


Figure 4 Selected area of interest

In the steps of selecting area of interest, we use the appropriately configured value of the Thresholding to defining the area. It must be observed at the edge of the image and to verify the accuracy of the image because it is manually selected, and difficult to determine. We must have medical specialists to determine before proceeding to the next step.

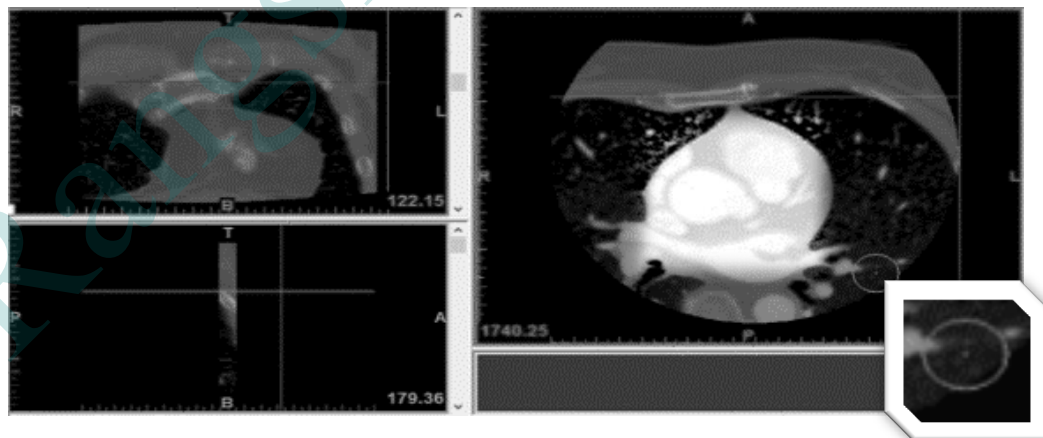


Figure 5 Deleted unrelated area used erase tools

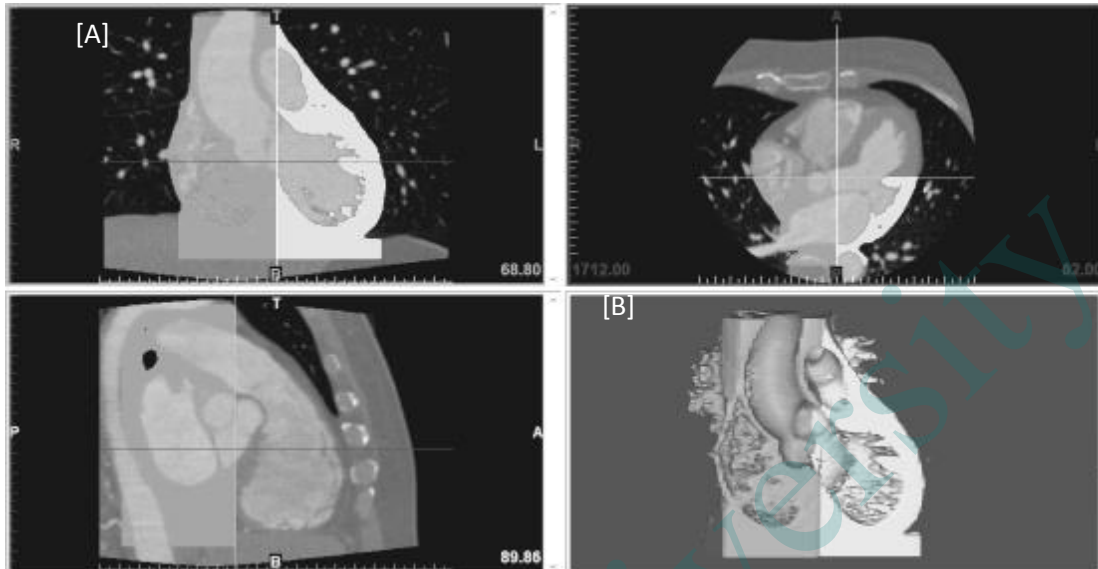


Figure 6 Use selected area of interest to create organ model

From the Figure 6, the image [A] is the image representing the selected area of interest by thresholding, and the image [B] is an image of a 3D model created from the selected area.

STEP 3 We cropped the desired area.

STEP 4 We used the erase tools to delete the unrelated area shown in figure 5.

STEP 5 When done with the desired area, we used the selected area to create the organ model shown in figure 6.

STEP 6 We exported the STL file to MakerBot program shown in figure 7.

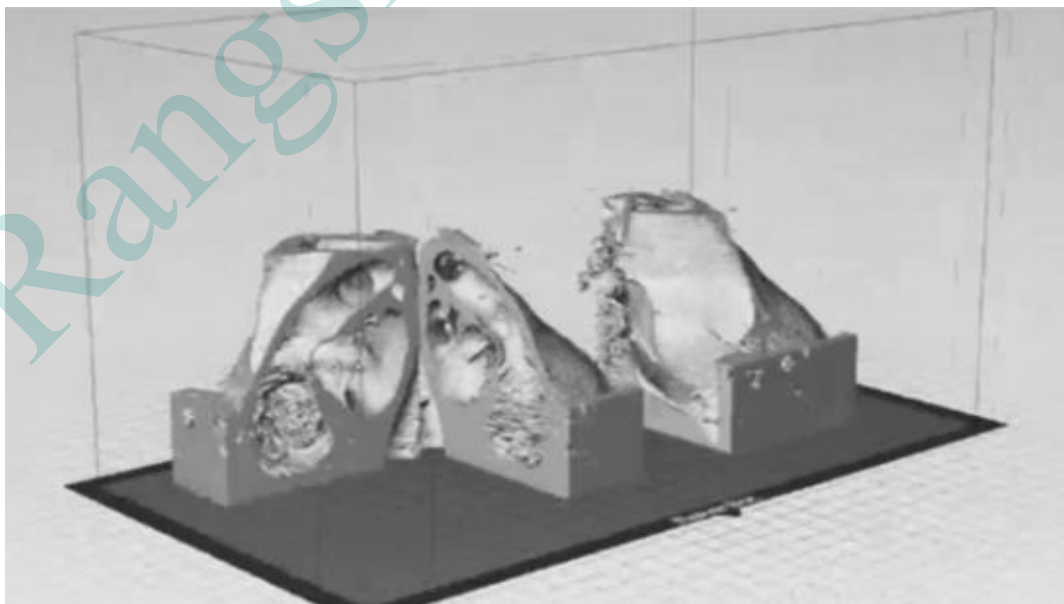


Figure 7 STL file to MakerBot program

STEP 7 Start printing in 3D printer show in figure 8

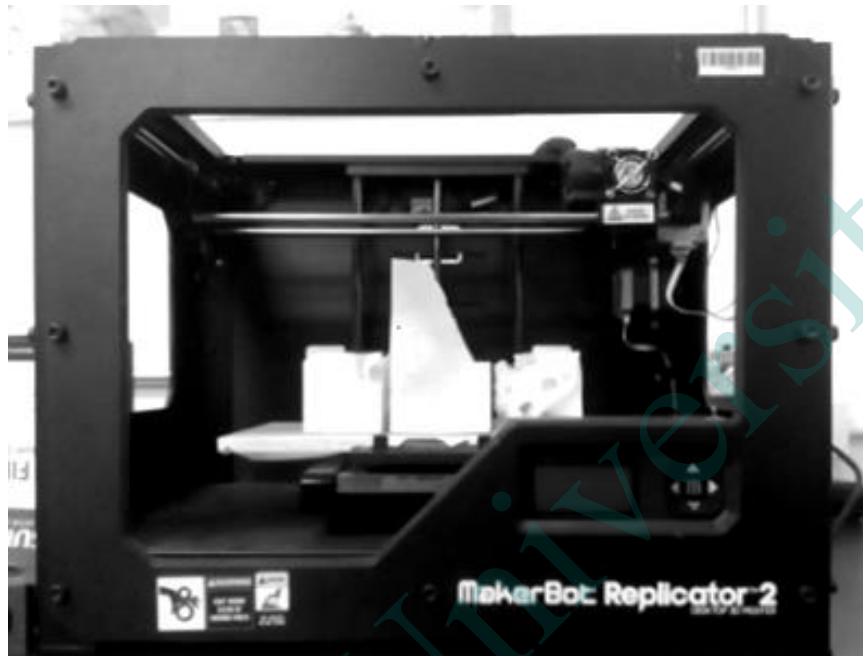


Figure 8 Printing in 3D printer

When the 3D printer finished printing, we have the 3D model shown in figure 9

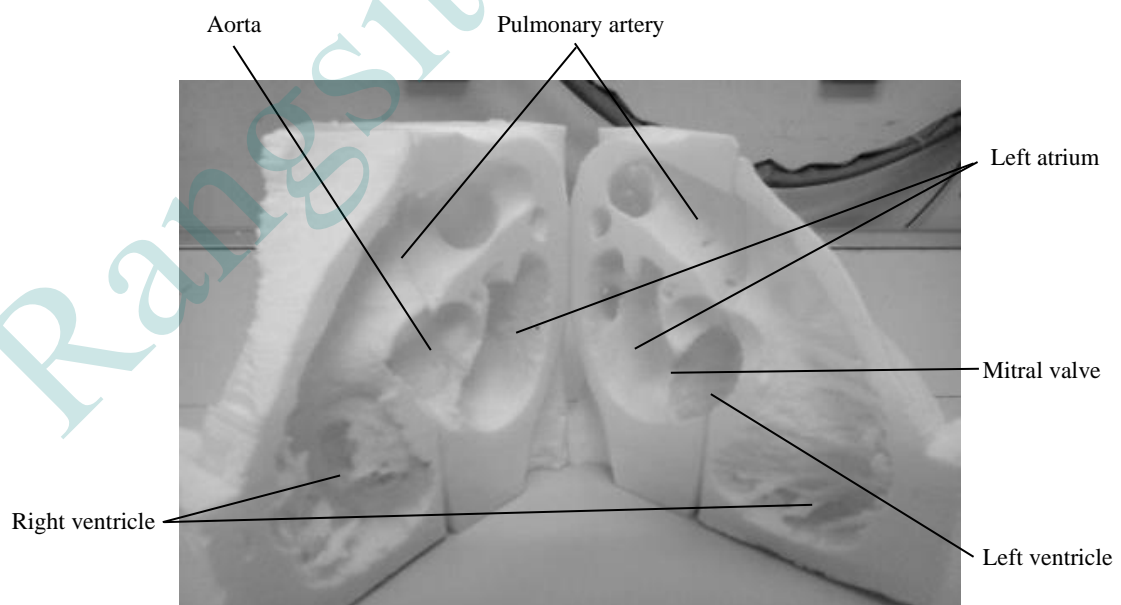


Figure 9 3D organ model

4. Discussion

This study is a joint project with Ramathibodi Hospital, which aims to develop media of medical device for the treatment of heart valve disease. The recent progress presented a method and a 3D model. As medical device media the 3D models are sufficiently detailed, but the time will have to be shortened to get the desired part. The 3D modeling with other materials will help patients understand the surgical procedures. It can be tested in conjunction with other devices used in the treatment, optimized the surgery and reduced the cost and length of treatment.

Choosing coronary artery and irrelevant structures in medical imaging is a fundamental work in 3D imaging, but this takes a lot of time and needs to be done manually in order to get the desired section. Choosing heart organs and irrelevant structures in medical imaging is a fundamental work in 3D imaging, but this takes a lot of time. Because of cardiac thresholding values are equal to other anatomical structures such as muscles, diaphragm, and blood vessels, the boundary between the heart and the adjoining organs is difficult to assign.

5. Conclusion

The 3D organs are imperfections in some parts of the heart valve because the underlying image is low detailed and low contrast. This affects the accuracy and completeness of the 3D model. And the complexity of the anatomy, other unrelated and complex tissues are difficult to distinguish from each other. We used image processing to adjust the quality of image data and customize image resolution [4], [5] to correct. And the quality of 3D model is depending on 3D printing and materials are used. In this work, we used PLA Filament material. PLA is a bioplastic which transitions quickly from liquid to solid. This makes it an ideal printing material, one of the most commonly used in consumer 3D printing. Moreover, the quality of 3D model depends on the quality of the picture, the unwanted area and the steps of creating 3D model from DICOM file. We must also have medical specialists. The 3D model is very useful in the medical field because a doctor can utilize the 3D model before using on the real case, which reduces the risk to the patients.

6. Acknowledgements

The authors would like to thank faculty of biomedical engineering, Rangsit university, Rangsit university, Ramathibodi hospital and King Mongkut's Institute of Technology Ladkrabang. This work was supported by the faculty of biomedical engineering, Rangsit university, Rangsit university, and King Mongkut's Institute of Technology Ladkrabang. We thank Ramathibodi hospital for the information provided regarding the DICOM file.

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