Ministry of Education and Science of the Russian Federation
National Research Tomsk Polytechnic University

Research School of Chemistry & Applied Biomedical Sciences
Biomedical Sciences and Engineering

Master Thesis

Title
3D Biomedical Image analysis & printing of Sphenoid bone **Реконструкция трехмерных моделей анатомических объектов на основе анализа биомедицинских изображений**

УДК 616-073.756.8:004.925.84--048.35

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Master Thesis

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3D Biomedical Image analysis and printing of Sphenoid bone	
Director approval order	
Date of Submission	

Major Information	
Content	
Assigned Date	

Task assigned by

Position	**Name**	**Education**	**Signature**

TASK FOR MASTER'S THESIS SECTION
"FINANCIAL MANAGEMENT, RESOURCE EFFICIENCY AND RESOURCE CONSERVATION"

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Education Level	Master	**Direction / specialty**	Biotechnical system and technologies

References for "Financial management, resource efficiency and resource conservation":	
1. The cost of research: Logistics, energy, financial, information and human	*According to manual provided*
2. Norms and standards resource consumption	*According to manual provided*
3. used the tax system, tax rates, deductions, discounting and credit	*According to manual provided*
The list of questions for study, design and development:	
1. Evaluation of commercial and innovative potential STI	**Implement** at least 1 option from the list (1-6) below: 1. Potential consumers of research results 2. Analysis of competitive technical solutions from the perspective of resource efficiency and resource savings 3. Technology QUAD 4. FAST-analysis 5. Diagram Ishikawa 6. SWOT-analysis **Perform** • Evaluation of the project readiness for commercialization • Methods for the commercialization of scientific and technological research

2. Development of the charter of scientific and technical project	• Objectives and outcomes of the project. • The organizational structure of the project. • Identification of possible alternatives
3. Project management planning: the structure and schedule of the budget, risk and procurement organization	• The structure of the work within the framework of scientific research • Determination of the complexity of work • Scheduling scientific research • The budget of the scientific and technical research (STR)
4. Defining resource, financial, economic efficiency	• Integral financial efficiency indicator • Integral resource-efficiency indicator • Integral total efficiency indicator • Comparative project efficiency indicator
List of graphic material	
1.Segmentation of the market *2.Estimation of competitiveness of technical solutions* *3.FAST-Chart* *4.SWOT Matrix* *5.Schedule and budget of the project* *6.Assessment resource, financial and economic efficiency of the project*	

Date of issue of assignment	

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Assignment received by student for implementation:

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REFERENCE TO THE SECTION
"SOCIAL RESPONSIBILITY"

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Education Level	Master	**Direction / specialty**	Biotechnical system and technologies

The initial data to the "social responsibility":	
1. Characteristics of the research object (a substance material, the device, the algorithm technique, the working zone) and its use	3D biomedical image analysis and printing of Sphenoid bone
List of subjects for the study, design and development:	
1. Operational safety	Analysis revealed harmful factors in the design and operation of the projected solutions Analysis of identified hazards in the design and operation of the designed solutions
2. Environmental Security:	– analysis of the impact object in the atmosphere (emission); – analysis of the impact object in the hydrosphere (discharges); – analysis of the impact of the object on the lithosphere (wastes); - develop solutions to ensure environmental safety, with reference to the reference document for environmental protection.
3. Safety in emergencies: –	– a list of possible emergencies in the development and operation of the designed solutions; – selection of the most typical emergencies; – the development of preventive measures for the prevention of emergency situations; - development of action arising as a result of emergency situations and elimination of consequences of its actions.
4. Legal and organizational issues of security: –	– special (typical of the operation of the object of research, designed work area) the legal norms of the labor legislation; - arrangements at the work area layout.

Date of issue job to the linear section of the schedule	

Specifying issued consultant:

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Contents

Abstract

Medical image analysis, 3D modeling & printing technology provide a solution for medical research and a specific path to diagnose & analyze human health issues. The 3D Biomedical images are based on image-based medical analysis of human body through magnetic resonance imaging (MRI), CT (Computed Tomography) scanning, X-ray imaging and Ultrasound imaging. These are the technologies that provide for all imaging data modification in the medical field. Practically image analysis provides a new technique of image processing through computer software tool including statistical analysis and algorithm. It has been divided into two main categories as image modeling and image processing. Anatomical models in medical research are most important for training purposes and in clinical research.

In this report, I am describing the procedure that how to use the DICOM data can transform into 3D printed models. In the first category of modeling, we are able to make a model and after that 3D printing through the specified software tools (I am using 3D Slicer software, Blender software package, and Mesh Mixer freeware application). Which is the finest route to find the actual disease in the human body and informative to understand a real environment or human organ system. In the second part of medical image processing, we can diagnose of interior parts of the body. MRI, CT scan, and Ultrasound imaging are the latest image analysis procedures. Through computer tomography (CT scan) with a specific software tool, the disease can be identified without any pain. In another hand in Magnetic resonance imaging (MRI), signals are received from the body’s magnetic particles they spun and to analyze the output of medical imaging systems also analyze symptoms of the patients in the clinic & hospitals.

Introduction

Medical imaging is a series of diagnostic and used to create images of human body parts. It can help to diagnose the cause of existing symptoms and monitor of the health condition of the patient and treatment of the disease. Sometimes this process called radiology, and the skilled or specialist are called radiologist. In more precisely we can say that medical imaging technology refers to a number of techniques that can be used as non-invasive methods of looking inside the body. This means the body does not have to be opened up surgically for medical doctors or specialists to look at various organs and areas. It can be used to assist diagnosis or treatment of different medical conditions. Medical imaging provides a platform for clinicians, doctors, and specialist to diagnose and a better solution to treatment also more information to understand that what is happening inside the patient's body. Some of the benefits and risks occur during the medical imaging process. Most diagnostic medical imaging advantages in terms of early detection of the problem of the patient and accurate diagnosis but instead of disadvantages cost effect and quite expensive for the patient.

The importance of these techniques able to diagnose, treat and cure patients without causing any harmful side effects. The use of medical imaging has enabled doctors to see inside a patient without having to cut them open.

The medical images have the bunch of natural information in all ways of human life and disease process also an ability to deliver the quality of healthcare. Medical imaging as a key role in clinical diagnosis, improvements in the quality along with the type of information available from such images has extended the diagnostic accuracy and range of new applications in healthcare. In biomedical imaging, the main concern of process to capture images through medical processes for a better quality of display of human body part’s images while in 3D printing technology allows the environment to analyze the real situation for better understanding. 3D printing technology is going to transform medical field in a meaningful way, whether it is patient-specific surgical models, custom-made prosthetics, personalized on-demand medicines, or even 3D printed human tissue. Implants can be made throughout the scan from MRI, CT scans and x-rays into digital and .stl or DICOM file format. The approach has been used to fabricate dental, spinal and hip implants. There are a large number of texts that deal in huge detail with the basic physics, instrumentation, and clinical applications of each imaging modality. Nowadays the modern imaging technology is digital and has a huge quality to describe the actual situation & diseases of a human organ.

Biomedical imaging only focusing on the caption of different image modalities. In the modern technology of biomedical imaging, imprints and snapshots can be taken by advanced high resolute CCD cameras and computers. In biomedical imaging technologies utilize either X-rays, CT scans, Ultrasound, MRI to assess the exact and actual condition of an organ and tissue can monitor a patient over time. Consideration of significant developments in new imaging contrast and the role of medical imaging looks like to continue to expand in modern-day health care.

Literature Review-1

Biomedical imaging has a long history, where the real images of human's internal organs can capture by optical devices for better intervention and able to analyze data for diagnosis purpose.

At the end of 18^{th} century, the X-ray imaging technique invented for improvement in recording data and enhancing the quality of imaging. Nowadays X-ray is also using for mammography, which is a dedicated system that takes high-resolution images of the breasts and finding for the breast cancer. X-ray imaging is also the basis of angiography or imaging of blood vessels.

X-ray tomography was introduced tomograms or slices to be obtained through tissues by rotating the X-ray tube. These techniques called computed axial tomography (CAT).In 1950s nuclear medicine involved in medical imaging and diagnostic test. In this test, the source of the X-ray is not a tube but was a radioactive compound which typically emits gamma rays as they decay. Later 1970s a new medical imaging technology invented named by computed tomography and magnetic resonance Imaging (MRI). In CT an X-ray tube rotates around the patient and various detectors pick up the X-rays that are not absorbed, reflected or refracted as they pass through the body. In MRI resistive magnets with weak magnetic fields, producing images with low spatial resolution. An MRI scanner consists of a large magnet which uniforms magnetic field. When imaging is performed resistive electro-magnets just inside this bore are temporarily activated, and generating magnetic field gradients along the x, y, and z-axes in the magnet. These gradient fields subtract from the main magnetic field creating a linear variation in net magnetic field along the three areas. While multi-detector CT scanning is frequently the first test ordered in the emergency room. A CT scan covering this entire body can be performed in twenty seconds. The same data set can be viewed.

Literature Review-2

Biomedical data processing and analysis has become a major component of biomedical research and clinical applications. To successfully detect and diagnose disease, it is vital for clinicians to properly apply the latest data processing and analysis technologies. Because of the volume of available biomedical data, early or obscured signs of disease can go undetected or can be misinterpreted. To combat these inaccuracies, biomedical researchers and clinicians have come to rely on advanced data processing and analysis techniques and software. The importance of biomedical imaging such as computed tomography (CT), magnetic resonance (MR), Endoscopy, mammography, ultrasound imaging etc. for the early detection, diagnosis, and treatment of diseases. In clinical research, the medical imaging interpretation has mostly been performed by human experts like physicians and doctors. However, due to large variations in pathology, the researchers and doctors have started to operate and benefited from computer-assisted interventions.

Biomedical data processing and analysis are the totally mixed information into the fabric of the signal processing and pattern analysis community. In this sphere, we have seen to applying pattern analysis and computer vision techniques to an interesting dataset. However, over the last two to three decades, the unique nature of the problems presented within this area of study has led to the development of a new discipline in its own right. It is an essential reference that details the primary methods, techniques, and approaches used to improve the quality of biomedical data visualization and interpretation as well as quantitative detection and diagnostic decision aids. This comprehensive volume illustrates analytical techniques such as medical image enhancement, medical image segmentation, medical image feature extraction, computer-aided diagnosis, and data-driven medical decisions by clinicians.

CHAPTER 1

1.1 Medical image visualization principals

In biomedical imaging technology, there is a similar concept of biomedical signal processing in 2D and 3D dimensions. It includes the enhancement, analysis, and display of images captured through X-ray, ultrasound or MRI. To make and modeling of a 3D image, used and analyze of 2D signals. The image processing software tool helps to identify and analyze the position of organ automatically, of the human body.

The different types of method of medical imaging and analysis techniques are using in this era.

(a)Endoscopy

(b) Computed Tomography (CT)

(c) Magnetic Resonance Imaging (MRI)

(d) Ultrasonic Imaging

(e) X-Ray Imaging

The short description of medical visualization principles is below:-

1.2 Endoscopy

An image can be taken with an illuminated optical wired frame tube inserted into the human body nerves and cavities to used imaging called endoscopy. The endoscope inspects and used to the more specific view of hollow and narrow cavities which are not possible to see the naked eye and difficult to take images.

In this medical device, there are two main fiber bundles. One of the illuminated for light perception and another one is used to collecting the data through reflecting light waves.

In endoscopes uses xenon arc lamps as a light source to reflecting light waves from human tissues. For color imaging more precisely RGB filters used between xenon lamp supply and the proximal end of the endoscope. The endoscopic picture is converted to digital images by using CCD cameras on display devices. A better 2D and 3D quality of image the two cameras are mounted on the endoscopic end. A display device is used to visualize the image captured.

In figure 1 has been shown the endoscopic process in the human stomach.

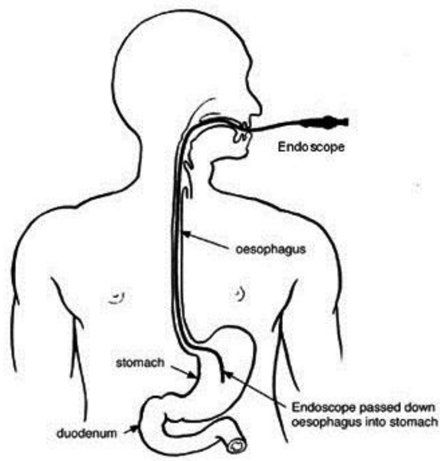


Figure-1. Endoscopy process in the Human body

1.3 Computer Tomography (CT)

Computer tomography is an imaging procedure that uses special X-ray machines to create an informative image or scanned pictures of inner part of human body. It is also known as computed axial tomography which is a volumetric imaging modality. This computed tomography is the process of reconstruction of 2D and 3D imaging. In CT scanning the pictures created during the procedure and shows the organs, bones and other tissues into a tiny layer or slice. The bunch of pictures or volume can be specified in a loaf or a sliced bread. During the procedure, we can analyze each of slice individually into the 2D and 3D volume of the loaf. The CT scan is vastly used the X-ray imaging in soft tissue contrast but CT can reveal small tumors, structural details in trabecular bone. In above figure 2, the CT scan has been shown of a human skull and spinal code.

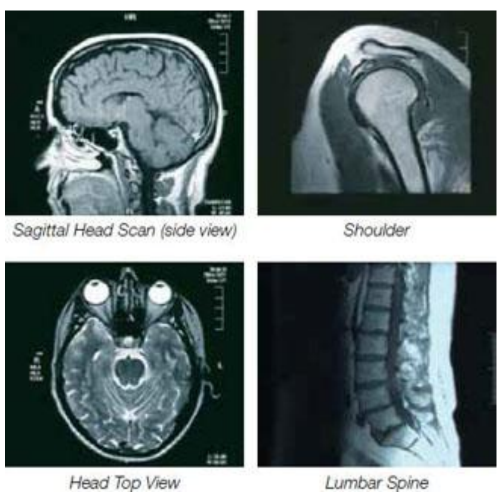


Figure-2. CT scan of human Head, Shoulder & Spine

1.4 Ultrasound Image

Ultrasound imaging makes use of the properties of sound waves in tissue. Pressure waves in the low-intensity range travel through tissue at the speed of sound being refracted and partially reflected at interfaces. Ultrasound contrast is therefore related to echogenic inhomogeneities in tissue. The depth of an echogenic object can be determined by the travel time of the echo. By emitting focused sound waves in different directions, 2D scans are possible. Ultrasound images are highly qualitative in nature due to the complex relationship between two inhomogeneous tissue and the echoes, due to the differences in speed of sound in different tissues, and due to the high noise component that is a result of the weak signal and high amplification. Ultrasound images show good soft tissue contrast and visualization but fail in the presence of bone and air. Although ultrasound images can be generated with purely analog circuitry, modern ultrasound devices use computerized image processing for image formation, enhancement, and visualization. Ultrasound imaging is very popular because of its low-cost instrumentation and easy application. In figure 3, the ultrasonic imaging process has been a show of a pregnant woman.

Figure-3 Ultrasound scan visualization of woman stomach during pregnancy

1.5 Magnetic Resonance Imaging (MRI)

Magnetic resonance imaging is the procedure or test that uses powerful magnets, radio waves and computer to make a detailed picture of the human body. Magnetic resonance imaging is a volumetric imaging modality that parallels, to a certain extent, computed tomography.MRI is based on the orientation of protons inside strong magnetic field intensity. This orientation can be manipulated with resonant radiofrequency waves and the return of the protons to their equilibrium state can be measured. MRI requires dramatically more time for image acquisition than CT(Computer Axial Tomography).MRI scanners provide images with a very high diagnostic value and MRI can be used to monitor some physiological process. It is a radiation-free modality, it is often used in clinical studies. The above figure 4, has been shown of a human skull.

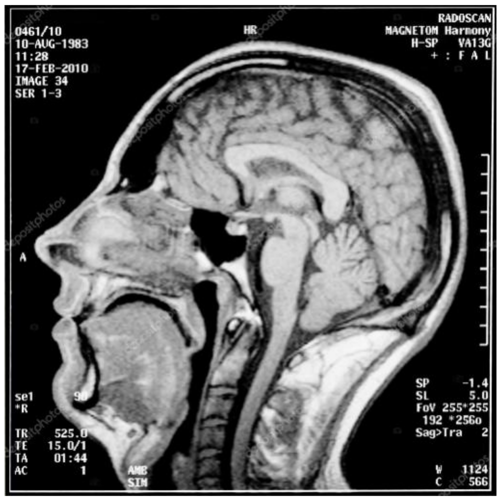


Figure-4 Magnetic Resonance of Human skull

1.6 X-Ray Imaging

X-ray imaging is the oldest medical imaging modality, X-ray imaging is a projection technique, and image formation takes place traditionally on photosensitive film, although direct digital X-ray imaging is becoming more and more common. X-rays are high-energy photons, and atomic interaction with inner shell electrons is fundamental to both X-ray production and generation of X-ray contrast. Soft-tissue contrast is comparatively low, but bone and air provide excellent contrast. The above figure 5 has been shown the X-ray image of the human foot.

Figure-5 X-Ray Image of the Human foot

Nowadays in medical imaging and processing, we have four key problems.
These are following:-

- Image Registration
- Image Segmentation
- Visualization
- Simulation

1.7 (a) Image Registration

The method of calibration of two or more images for obtaining information is called image registration. This is an important preprocess in image fusion, which can be used for aligning two or more images geometrically. It can be applied for fusion of medical images, and the images obtained from different sources at different times.
It involves the selection of the control points, which can be done manually or automatically.
The selected control points manually time-consuming and contained errors but automatic image registration process without human intervention.

1.7(b) Image Segmentation

This is the digital image partitioning process into multiple segments. The purpose of segmentation is to simplify the image and change its representation of an image into the meaningful way and easy to analyze. Image segmentation is also a process of assigning a label to every pixel in an image such that pixels with the same label share certain characteristic such as lines, curves etc.

1.7(c) Image Visualization

Through visualization process, we are able to characterize the quality of biological images. Working with cell images that were created under a variety of imaging conditions, we have defined metrics to describe image quality.

Chapter-2

2.1 Methods of image processing

The basic definition of image processing is called digital image processing, which is removing the noise and any kind of irregularities present in an image using the digital computer. The noise or irregularity may creep into the image either during its formation or during transformation etc. For mathematical analysis, an image may be defined as a two-dimensional coordinate functions f(x, y) where x and y are plane coordinates, and the amplitude of coordinates function (x, y) is called the intensity or gray level of the image at that point. When x, y, coordinates, the intensity values of the function are all finite. We call the image a digital image. It is important that a digital image is composed of a finite number of elements, each of which has a particular location and value. These elements are called picture elements, image elements, pels, and pixels. Pixel is the most widely used term to denote the elements of a digital image.

Various methodologies and techniques have been developed in digital image processing during the last five decades. Most of the other techniques are developed for enhancing and better image resolution obtained from spacecraft, space probes, and militaries flight etc. The image processing systems are becoming popular due to easy availability of powerful personal computers, large size memory devices, graphics software etc.

Image Processing is used in various applications such as:

- Remote Sensing
- Medical Imaging
- Document processing
- Non-destructive Evaluation
- Material Science.
- Military
- Textiles
- Printing Industry
- Graphic arts Forensic Studies
- Film industry

2.2 Digital Image Processing

The digital image processing method refers to the processing of 2D pictures by computer. In the processing of the digital image, it contained an array of real numbers they represented by a few finite numbers. In Digital image Processing methods, the advantage is its versatility, repeatability and the preservation of original data precision. The different types of image processing methodologies and techniques are:

- Image preprocessing
- Image enhancement
- Image segmentation
- Feature extraction of digital image
- Classification of image

2.2.1 Image Processing

In image preprocessing, image data recorded by sensors on a satellite restrain errors related to geometry and brightness values of the pixels. The errors are corrected using appropriate mathematical models which are either definite or statistical models. The image enhancement process is the method of modification of an image by changing the pixel brightness values to improve its visual impact. Image enhancement involves a collection of techniques that are used to improve the appearance of an image or to convert the image to a form which is better suited for human or machine interpretation.

2.2.2 Image Enhancement

Sometimes images captured by digital cameras due to lack of their limitation of contrast and brightness and illumination conditions. There are different types of noise in different types of images which would remove them. In image enhancement process the purpose of image features for analysis and image display or its visualization. Image enhancement process is more useful in feature extraction, image analysis, and an image display or its better quality of visualization. In enhancement process, it won’t be able to increase the inherent information. It simply emphasizes image characteristics. Enhancement algorithms are generally interactive and application dependent. Some of the enhancement techniques are:

a. Stretching & Contrasting

b. Noise Filtering

c. Histogram modification

2.2.2 (a) Contrast & Stretching

Some images are homogeneous and more complexity, which they do not have any modifications in their levels. In histogram representation, they characterized as the occurrence of very narrow peaks. The homogeneity can also be due to the incorrect illumination of the scenes. Ultimately the obtained images are not easily interpretable due to poor human perceptibility and nonvisibility. Why because they contain only a narrow range of gray-levels in the images. The contrast stretching methods are designed especially for frequently encountered situations. Different stretching techniques have been developed to stretch the narrow range to the whole of the available dynamic range.

2.2.2 (b) Noise Filtering

Noise Filtering is used to filter the unwanted and unnecessary information from an image. Noise filtering is also used to remove various types of noises from the image data. Different filters like low pass, high pass, mean, median etc., are available for filtering an image.

2.2.2(c) Histogram Modification

Histogram modification method is also a process of image enhancement and has contained a lot of importance. It reflects the characteristics of the image, due to modifying the histogram, image characteristics can be modified at the moment. One example is histogram equalization. Histogram equalization is nonlinear who redistributes pixel values so that there is approximately the same number of pixels with each value within a range. The result approximates a flat histogram.

There has been a variety of image enhancement algorithms. They are divided into two main categories **spatial domain** and **transform domain** based methods. The spatial domain methods include image operations on a whole image or a local region based on the image statistics. Histogram equalization, image averaging, sharpening of images using edge detection and morphology operators and nonlinear median all belong to this category. The other class is a transform domain based method because the image operations are performed in the transform domain, such as in the Fourier and wavelet domain. The frequency transform methods facilitate the extraction of certain image features that cannot be derived from the spatial domain. One can manipulate the transformation in the frequency domain and then recover the image in the spatial domain to highlight interested image contents. As one of powerful image transforms, wavelet approaches have been used in recent years for medical image analysis.

2.3 Image Segmentation

Segmentation is also a key problem of image processing. During image segmentation process the image has been subdivided into its constituent parts. The segmentation should stop when the objects of interest in an application have been isolated, and image thresholding techniques are used for image segmentation. After thresholding, a binary image is formed where all object pixels have one gray level and all background pixels have another, generally, the object pixels are 'black' and the background is 'white'. The best threshold is that selection of all the object pixels and maps them to 'black'. Various approaches for the automatic selection of the threshold have been proposed. Thresholding can be defined as a mapping of the grayscale into the binary set of [0, 1]. The segmented image can be used to make measurements such as brain volume, to detect abnormalities, or to visualize areas such as the brain surface. Image segmentation has been an active area of research in image processing and computer vision from the outset of digital imaging. As a result, there is a wide array of segmentation approaches for medical images.

Assume $S(x, y)$ is the value of the segmented image, $g(x, y)$ is the gray level of the pixel (x, y) and $T(x, y)$ is the threshold value at the coordinates (x, y). In the simplest case, $T(x, y)$ is coordinate independent and a constant for the whole image. It can be selected, for instance, on the basis of the gray level histogram. When the histogram has two pronounced maxima, which reflect gray levels of object and background, it is possible to select a single threshold for the entire image. A method which is based on this idea and uses a correlation criterion to select the best threshold is described below. Sometimes gray level histograms have only one maximum.

This can be caused, that is by inhomogeneous illumination of various regions of the image. In such case it is impossible to select a single thresholding value for the entire image and a local binarization technique must be applied. General methods to solve the problem of binarization of inhomogeneously illuminated images, however, are not available.

Segmentation of images involves sometimes not only the discrimination between objects and the background, but also a separation between different regions. One method for such separation is known as watershed segmentation.

We can find out the changes and exact position of disease through image registration. Due to the fusion of images, we can analyze the different modalities. Due to the fusion of medical images, we can conclude and improve the image qualities and accuracy of analyzation. In the procedure of diagnostic, the obtained image has a single modality through CT scan, which is not appropriate and all required information. It is needed to calibrate and combine information obtained from other modalities also improve the information acquired. For the efficient fusion, it is necessary to align properly with the corresponding coordinates system for obtaining different modalities. The process of aligning the input images before proceeding with the fusion is called image registration.

Some of Image registration methods and techniques are still used for preprocessing like feature detection, feature matching, and image resampling data. In feature detection, the features like regions, lines, edges, and corners are identified. In feature matching the features between the sensed image and the reference image can be sensed.

2.4 Image Registration

The method of calibration of two or more than two images for obtaining information and a good result is called image registration. This is an important pre-process in image fusion, which can be used for aligning two or more images geometrically. It can be applied for fusion of medical images, and the images obtained by different sources at different times.

It involves the selection of the control points, which can be done manually or automatically.

The selected control points manually time-consuming and contained errors but automatic image registration process without human intervention. We can find out the changes and exact position of disease through image registration. Due to the fusion of images, we can analyze the different modalities. Due to the fusion of medical images, we can conclude and improve the image qualities and accuracy of analyzation. In the procedure of diagnostic, the obtained image has a single modality through CT scan, which is not appropriate and all required information. It is needed to calibrate and combine information obtained from other modalities also improve the information acquired. For the efficient fusion, it is necessary to align properly with the corresponding coordinates system for obtaining different modalities. The process of aligning the input images before proceeding with the fusion is called image registration.

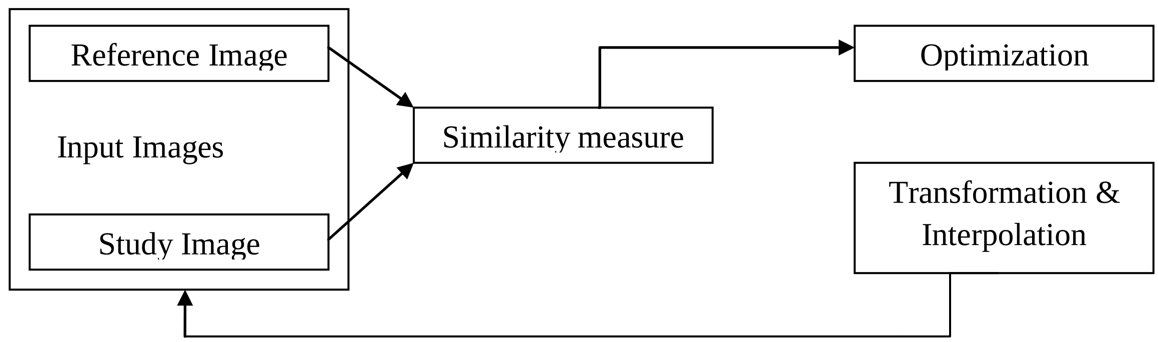


Figure-6 Image Registration process

Some of Image registration methods and techniques are still used for preprocessing like feature detection, feature matching, and image resampling data. In feature detection, the features like regions, lines, edges, and corners are identified. In feature matching the features between the sensed image and the reference image can be sensed. This includes area based methods like correlation-based methods, Fourier methods, mutual information methods and feature based methods using spatial relations, invariant descriptors, pyramids, and wavelets. This is followed by the computation of the mapping functions including global mapping methods, local mapping methods, mapping by radial basis functions. This is followed by image transformation and resampling of the sensed image.

There are the tree methods of image transformation

1. Linear or nonlinear translation
2. Scaling of the imaging data
3. Rotation of image

2.4.1 Linear or nonlinear translation:-

Transform an image to align its pixels with a new image deformation with initial Coordinates (x, y) of an image to change into a new coordinate (x´, y´). This transformation could be linear or non-linear transformation.

2.4.2 Scaling of the imaging data:-

Scaling of the 2D image transformation is in matrix form with the scaling factor as p = (x´, y´)

The new points will be with respect to the space variables

Where ***s*** is the space coordinate directly relating to the initial coordinates.

$$x' = s\,x$$
$$y' = s\,y$$

The scaling of 2D images in matrix form,

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} s & 0 \\ 0 & s \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

In general, the scaling factors for x and y can be different:

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} sx & 0 \\ 0 & sy \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

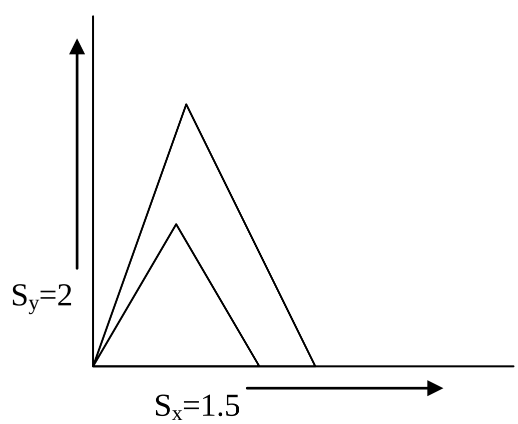


Figure-7(a) Scaling of the image with respect to initial coordinates

2.4.3 Rotation of image:-

Rotation is normally performed about the origin with a particular angle.

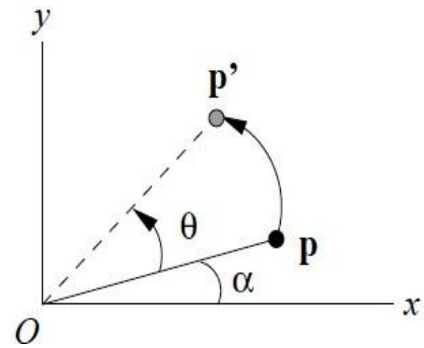


Figure-7(b) Rotation of image with respect to initial coordinates)

Let ρ denote the magnitude of the vector $\mathbf{p} = [x \quad y]'$.

Then $$\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} \rho\cos\alpha \\ \rho\sin\alpha \end{bmatrix}$$

After rotating about the origin by an angle θ, point **p** becomes (New rotating point)

$$\mathbf{p}' = [x' \quad y']'$$

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} \rho\cos(\alpha+\theta) \\ \rho\sin(\alpha+\theta) \end{bmatrix} = \begin{bmatrix} \rho(\cos\alpha\cos\theta - \sin\alpha\sin\theta) \\ \rho(\cos\alpha\cos\theta - \sin\alpha\sin\theta) \end{bmatrix}$$

$$= \begin{bmatrix} x\cos\theta - y\sin\theta \\ x\sin\theta + y\cos\theta \end{bmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} x \\ y \end{bmatrix}$$

Translation of point $\mathbf{p} = [x \quad y]'$ by the vector $\mathbf{T} = [tx \quad ty]'$ is given by

$$\begin{bmatrix} x' \\ y' \end{bmatrix} = \begin{bmatrix} x \\ y \end{bmatrix} + \begin{bmatrix} tx \\ ty \end{bmatrix} = \begin{bmatrix} x+tx \\ y+ty \end{bmatrix}$$

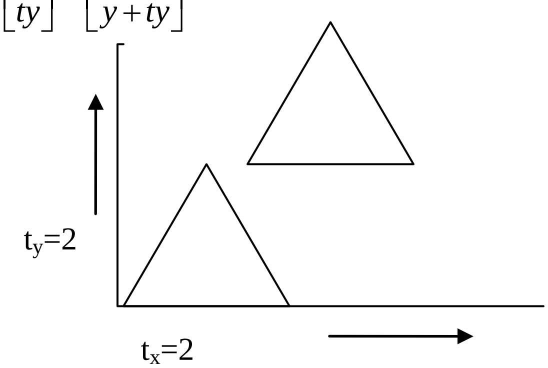


Figure-8 Translation of the image with respect to initial coordinates

Homogeneous coordinates of the 2D point

$$\mathbf{p}=\begin{bmatrix} x \\ y \end{bmatrix} \quad \text{are} \quad \begin{bmatrix} cx \\ cy \\ c \end{bmatrix}$$

For any non-zero c (third axis coordinate).

The 2D vector **p** becomes a 3D vector.

Given a point $\begin{bmatrix} x & y & z \end{bmatrix}'$ in homogeneous cords,

Its 2D Cartesian cords are $\begin{bmatrix} \frac{x}{z} & \frac{y}{z} \end{bmatrix}'$ provided $z \neq 0$

If z=0, then this is a point at infinity.

Homogeneous coordinates apply to 3D points as well, by adding a 4th component. Can combine rotation, scaling, and translation into a single matrix using homogeneous coordinates:

$$\begin{bmatrix} x' \\ y' \\ z' \end{bmatrix} = \begin{bmatrix} 1 & 0 & tx \\ 0 & 1 & ty \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} s & 0 & 0 \\ 0 & s & \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ z \end{bmatrix}$$

$$= \begin{bmatrix} s\cos\theta & -s\sin\theta & tx \\ s\sin\theta & s\cos\theta & ty \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

2D affine transformation

The affine transform is a generalization of a linear transformation

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} a11 & a12 & a13 \\ a21 & a22 & a23 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

For some parameters a_{ij}.

In short-hand notation: **p´=Ap**

Where A is the affine transformation matrix

REGISTRATION METHODS

There are two given images, how to register one with the other.

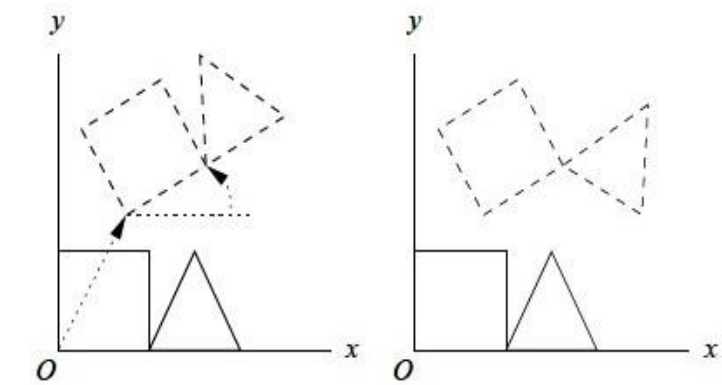
The basic idea to register images is following:-

Determine the corresponding points between the images.

- Manually mark corresponding points
- Detect and match feature detection and matching.

Determine the transformation between corresponding points.

- Assume that all pairs of corresponding points are related by the same transformation.
- Computer parameters of transformation given corresponding points.



(a) same rotation (b) Different rotation

Figure-9 Image rotation in different direction and angle

In general, need to apply non-linear method.

Let’s try affine transformation which is simpler to work with.

$$\begin{bmatrix} x' \\ y' \\ 1 \end{bmatrix} = \begin{bmatrix} a11 & a12 & a13 \\ a21 & a22 & a23 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} x \\ y \\ 1 \end{bmatrix}$$

Affine transformation has six parameters.

- Need 3 pairs of corresponding points.
- Usually, use more than 3 pairs to obtain best fitting affine parameters.

METHOD-1

Suppose we have n pairs of corresponding points pi and pi´.

$$x_i' = a_{11}x_i + a_{12}y_i + a_{13}$$

$$y_i' = a_{21}x_i + a_{12}y_i + a_{13}$$

For $\boldsymbol{i} = 1,2,3,\ldots,\boldsymbol{n}$.

Now, we have two sets of linear equations of the form

Ma=b

$$\text{First set: } = \begin{bmatrix} x1 & y1 & 1 \\ . & . & . \\ . & . & . \\ . & . & . \\ xn & yn & 1 \end{bmatrix} \begin{bmatrix} a11 \\ a12 \\ a13 \end{bmatrix} = \begin{bmatrix} x1' \\ . \\ . \\ . \\ xn' \end{bmatrix}$$

$$\text{Second set} = \begin{bmatrix} x1 & y1 & 1 \\ . & . & . \\ . & . & . \\ . & . & . \\ xn & yn & 1 \end{bmatrix} \begin{bmatrix} a21 \\ a22 \\ a23 \end{bmatrix} = \begin{bmatrix} y1' \\ . \\ . \\ . \\ yn' \end{bmatrix}$$

- A number of equations > number of unknowns. No exact solution.
- We can compute best fitting a_{ij} for each set independently
- Use linear least square fit to compute.
- There's a variation of this method

In ***Ma=b***

M is not square and so has no inverse.

But M´M is square and has an inverse (typically). So,

$$M'Ma = M'b$$

$$a = (M'M)^{-1} M'b$$

$(M'M)^{-1} M'$ is the pseudo-inverse of M.

Pseudo-inverse gives the least squared error solution.

In practice, pseudo-inverse can be a very large matrix. So, don't use it directly.

Numerical software such as NumPy, Matlab, Numerical Recipes provides functions for computing the linear least square solution.

METHOD-2

Put the x´ and y´ parts in the same matrix equation:

$$\begin{bmatrix} x1 & y1 & 1 & 0 & 0 & 0 \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ xn & yn & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & x1 & y1 & 1 \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ 0 & 0 & 0 & xn & yn & 1 \end{bmatrix} \begin{bmatrix} a21 \\ a22 \\ a23 \\ a21 \\ a22 \\ a23 \end{bmatrix} = \begin{bmatrix} x1' \\ . \\ . \\ xn' \\ y1' \\ . \\ . \\ yn' \end{bmatrix}$$

- This system of linear equations can be easily solved in NumPy.
- Actually, the x´ and y´ parts are still independent of each other.

Suppose we sum the x´ and y´ parts, you will get

$$x_i' + y_i' = a_{11}x_i + a_{12}y_i + a_{13} + a_{21}x_i + a_{22}y_i + a_{23}$$

That is correct. But, if we form the matrix equations like this

$$\begin{bmatrix} x1 & y1 & 1 & x1 & y1 & 1 \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ . & . & . & . & . & . \\ xn & yn & 1 & xn & yn & 1 \end{bmatrix} \begin{bmatrix} a11 \\ a12 \\ a13 \\ a21 \\ a22 \\ a23 \end{bmatrix} = \begin{bmatrix} x1' + y1' \\ x2' + y2' \\ . \\ . \\ . \\ xn' + yn' \end{bmatrix}$$

We can't get the correct results. Reasons

- There are only three independent columns in the matrix
- The matrix has a rank of three instead of the required six.

Interpolation

Interpolation is an essential part of image registration when the image needs to be transformed. When the coordinates of an image are mapped to non-grid positions after transformation, the interpolation is performed to approximate the values for these transformed coordinates. Interpolation also compensates for resolution differences among the images to be registered. For instance, interpolation is needed to compensate for the differences between the inter-slice resolution and the inter-slice resolution. Since images from differences imaging modalities have different resolutions, lower-resolution images in a multimodal image registration are often interpolated to the sample space of the higher-resolution images. The most frequently used interpolation methods include:

- Linear
- Bilinear
- Tri-linear
- Bi-cubic
- Tri-cubic
- Quadri-linear
- Cubic convolution

The more complex interpolation method, where more surrounding points are used, and the slower the registration speed. To speed up the registration procedure, computationally low-cost interpolation techniques are often preferred. Linear interpolation is one of the most popular techniques.

The value of a certain point will be determined by the weighted combination of its neighbors, and the weights will depend on the distances from the neighbors to the point. Because of its good trade-off between accuracy and computational complexity, the bilinear interpolation, which needs four points to get an interpolated value, is frequently employed. According to the research of in cardiac and thorax image registration, tri-linear interpolation, in which eight points are involved to calculate an interpolated value, can be used to achieve good registration performance.

BILINEAR INTERPOLATION

Suppose the matrix A maps **p** in the image I to P´ in the image I´. Then

$$p' = Ap$$

And $$I'(p') = I(p)$$

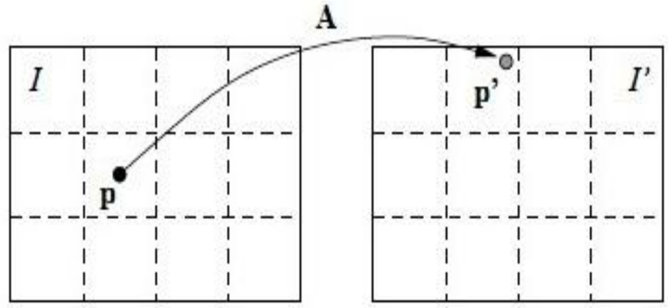


Figure-10 Linear interpolation of image coordinates

- Dashed squares called pixels
- Black dots called center of the pixel, integer-valued coordinates
- Gray dots call off-centered, real-valued coordinates

We cannot use ***I* (p)** for ***I*´ (p´)**

In general, **p´** has real-valued coordinates even when **p** has integer-valued coordinates.

- But Image pixel locations are integer-valued.
- Rounding **p´** to an integer causes an error in ***I*´(p´)**

However we

- Can use ***I*´(p´)** for ***I(p)***:

  Can estimate ***I´ (p´)*** from neighboring pixel values using bilinear interpolation.

LINEAR INTERPOLATION

First, consider the 1D case: - Linear interpolation.

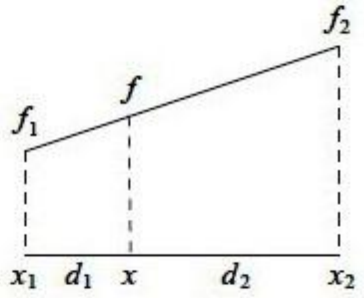


Figure-11 Linear interpolation of image coordinates

$$\frac{f - f1}{x - x1} = \frac{f2 - f}{x2 - x} \quad \text{so, i.e.,} \quad \frac{f - f1}{d1} = \frac{f2 - f}{d2}$$

Rearranging terms yields

$$f = \frac{d1 f2 + d2 f1}{d1 + d2}$$

If $[x1 \quad x2]$ is a unit interval, then

$f = \alpha f2 + (1 - \alpha) f1$

Where $\alpha = d1$

BILINEAR INTERPOLATION

Now, consider the 2D case: Bilinear interpolation.

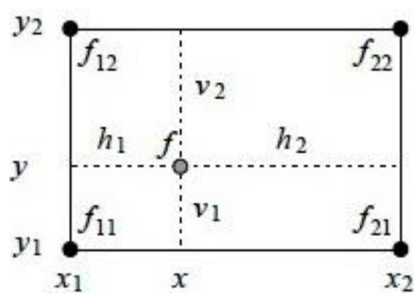


Figure-12 Bi-Linear interpolation of image coordinates

First, apply linear interpolation to obtain f(x_1 y) and f(x_2 y)

$$f(x1 \quad y) = \frac{v1 f(x1 \quad y2) + \quad v2 f(x2 \quad y1)}{v1 + v2}$$

$$f(x2\quad y)=\frac{v1\,f(x2\quad y2)+v2\,f(x2\quad y1)}{v1+v2}$$

Then, apply linear interpolation between $f(x1\quad y)$ and $f(x2\quad y)$

$$f(x\quad y)=\frac{h1\,f(x2\quad y)+h2\,f(x1\quad y)}{h1+h2}$$

$$=\frac{h1v1\,f22+h1v2\,f21+h2v1\,f12+h2v2\,f11}{(h1+h2)(v1+v2)}$$

Where f_{ij} = $f(xi\quad yi)$

For a unit square, with $\alpha = h1$, $\beta = v1$

$$f(x\quad y)=\alpha\beta f22+\alpha(1-\beta)f21+(1-\alpha)\beta f12+(1-\alpha)(1-\beta)f11$$

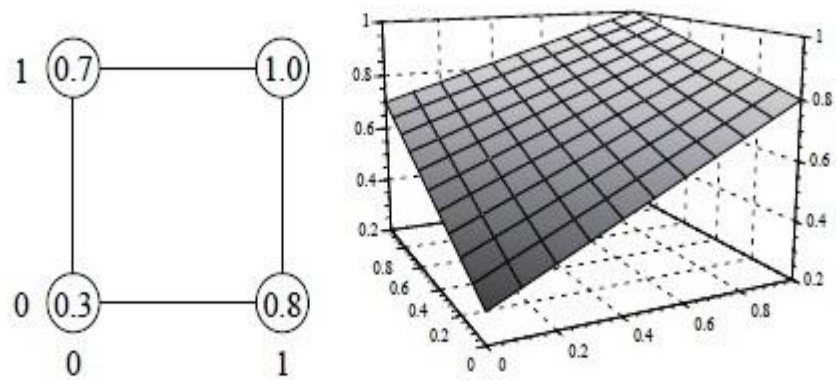


Figure-13 (a) Interpolation of image coordinates

In general, can have tri-linear interpolation in 3D multi-linear interpolation in multi-D

IMAGE MOSAICKING

Combine small overlapping images into the single large image.

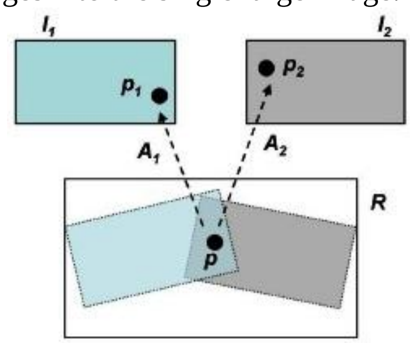


Figure-13(b) Image Mosaicking

Method:-

Suppose that A_1 and A_2 are known.

They specify the transformation between the output image R and the input images I_1 and I_2, respectively.

For each pixel p and R, do

Compute: $\mathbf{p_1=A_1p}$ and $\mathbf{p_2=A_2p}$.

If both p_1 and p_2 fall outside of I_1 and I_2, respectively, then R(p)=default color e.g. black.

If both p_1 and p_2 fall inside of I_1 and I_2 respectively, then R(p)=blending of $I_1(p_1)$ and $I_2(p_2)$.

Otherwise, only one of p_1 or p_2 falls inside I_1 or I_2.

So, R(p)=$I_1(p_1)$ or $I_2(p_2)$, as appropriate.

Notes:-

A_1 and A_2 are solved using the methods introduced earlier.

Usually, R is chosen to have the same viewpoint as one the input images i.e. that of I_1. Then A_1 are the identity matrix I.

Usually, p_1 and p_2 do not have integer coordinates, so, use bilinear interpolation to determine its color. Alpha blending is usually used to blend colors coming from different input images.

FEATURE EXTRACTION

The feature extraction techniques are developed to extract features in synthetic aperture radar images. This technique extracts high-level features needed in order to perform classification of targets. Features are those items which uniquely describe a target, such as size, shape, composition, location etc. Segmentation techniques used to isolate the desired object from the scene. Quantitative measurements of object features allow classification and description of the image.

When the pre-processing and the desired level of segmentation has been achieved, some feature extraction technique is applied to the segments to obtain features, which is followed by application of classification and post-processing techniques. It is essential to focus on the feature extraction phase as it has an observable impact on the efficiency of the recognition system. Feature selection of a feature extraction method is an important method for obtaining a high recognition performance. Feature extraction has been given as “extracting from the raw data information that is most suitable for classification purposes while minimizing the within class pattern variability and enhancing the between-class pattern variability". Thus, selection of a suitable feature extraction technique according to the input to be applied needs to be done with utmost care. Taking into consideration all these factors, it becomes essential to look at the various available techniques for feature extraction in a given domain, covering vast possibilities of cases.

IMAGE CLASSIFICATION

The simulation results show that the algorithm performs better with the total transmission energy metric than the maximum number of hops metric. The proposed algorithm provides energy efficient path for data transmission and maximizes the lifetime of the entire network. As the performance of the proposed algorithm is analyzed between two metrics in future with some modifications in design considerations the performance of the proposed algorithm can be compared with other energy efficient algorithm.

The Classification of the image is the labeling of a single pixel or a group of pixels based on its grey value. Classification is one of the most often used methods for information extraction. In Classification, usually, multiple features are used for a set of pixels which is, many images of a particular object are needed. In Remote Sensing area, this procedure assumes that the imagery of a specific geographic area is collected in multiple regions of the electromagnetic spectrum and is in good registration. Most of the information extraction techniques rely on analysis of the spectral reflectance properties of such imagery and employ special algorithms designed to perform various types of 'spectral analysis'. The process of multispectral classification can be performed using either of the two methods:

(a)**Supervised** (b) **Unsupervised.**

In Supervised classification, the identity and location of some of the land cover types such as urban, wetland, forest etc., are known as prior to a combination of field works and top sheets. The analyst attempts to locate specific sites in the remotely sensed data that represents homogeneous examples of these land cover types. These areas are commonly referred to as training sites because the spectral characteristics of these known areas are used to 'train' the classification algorithm for eventual land cover mapping of a reminder of the image. Multivariate statistical parameters are calculated for each training site. Every pixel both within and outside these training sites is then evaluated and assigned to a class of which it has the highest likelihood of being a member.

In an Unsupervised classification, the identities of land cover types have to be specified as classes within a scene are not generally known as prior because the ground truth is lacking or surface features within the scene are not well defined. The computer is required to group pixel data into different spectral classes according to some statistically determined criteria.

The comparison of image classification in the medical field is the labeling of cells based on their shape, size, color, and texture, which act as features. This image classification method is also useful for MRI images.

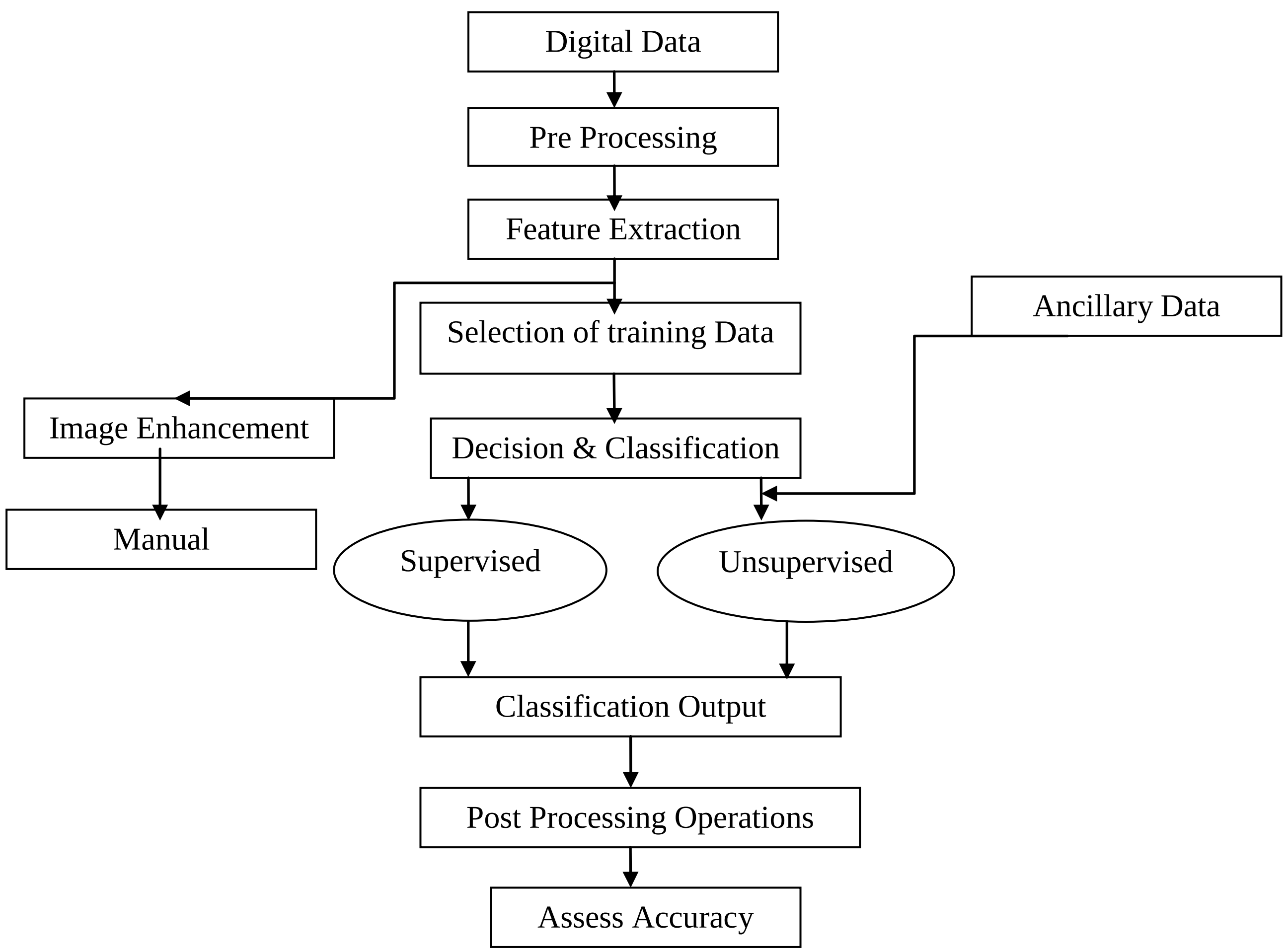


Figure-14 Flowchart of Image processing

Chapter 3

3.1 Materials and Methods

In this section, I am describing the methodology of the transformation of medical imaging data (CT scan) to a 3D printed model from a general point of view. The workflow is broken down into three steps.

3.2 Image segmentation

On acquiring a medical image data, the structures of interest need to be segmented. Image segmentation is the process of partitioning an image into multiple slices and labeled regions locating objects and specific boundaries in images. It uses to create patient's need and specific requirement, highly accurate finished computer models of human organs and tissues. There are various techniques of image segmentation, which each has contained some advantages and disadvantages, but there is no one and specified segmentation technique which is suitable for all image extension and applications. Basic segmentation approaches rely on the principle that each tissue type has a characteristic range of pixel intensities. Hence, it is possible to distinguish between tissues and identify boundaries.

There are various software packages that are capable of performing image segmentation, ranging from multi-purpose commercial platforms with integrated physics simulations. In this report, I have used the freeware software packages called 3D Slicer, as it is capable of processing a range of medical imaging data.

3.3 Mesh refinement

Following image segmentation, the 3D model can be further refined into a printable 3D mesh through Mesh mixer free software package. The software package provides a number of computer-aided design tools that can be used for this purpose and allow almost limitless mesh manipulation and refinement. However, the main purpose for such mesh post-processing of the segmentation is as follows:

3.3.1 Repairing

The Errors and discontinuities on the surface model that sometimes arise in the image segmentation and exporting process need to be repaired before 3D printing model.

3.3.2 Smoothing

Stair casing errors resulting from the resolution of the original medical image can be mitigated by smoothing the surface of the mesh model.

3.3.3 Appending

The segmentation will often only be one component of a final model. To convert the model into a useable form, it is often necessary to combine it with other structures or remove unneeded and unusable parts from the segmentation.

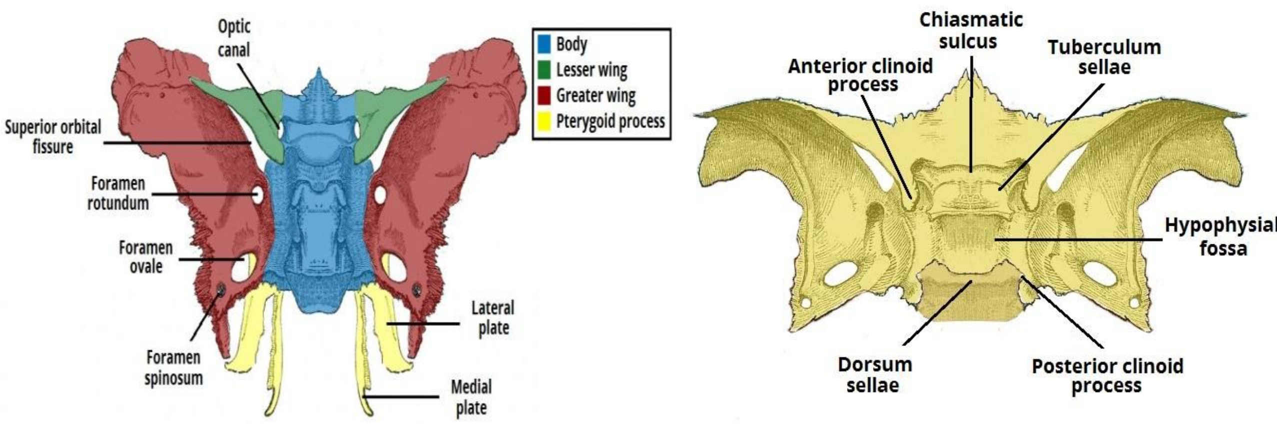
Anatomy of the sphenoid bone

3.4 Sphenoid bone

The human skull is made up of eight cranial bones that surround and protect the human brain and fourteen facial bones that form the underlying structure of the face and support for the teeth with the exception of the mandible. These all bones of the skull articulate with each other through joints known as sutures throughout. The skull holes known as foramina serve as passageways for blood vessels and nerves bones on the surface of the skull encase the brain protect sensory organs and service attachment sites for the muscles of the head and neck these bones include the occipital bone parietal bones temporal bones and the frontal bone as well as the nasal bones the zygomatic bones the maxilla and the mandible other bones become more visible only when looking inside the skull, the sphenoid bone makes up the anterior base of the cranium.it is a butterfly-shaped bone with a central body and two pair of laterally projecting wings these wings form portions of the orbit the body of the sphenoid features a depression known as the sella turcica which houses the pituitary gland located between the orbits the ethmoid bone makes up a portion of the cranial floor and also the roof of the nasal cavity an inferior projection the perpendicular plate of the ethmoid bone forms part of the nasal septum the crista galli project superiorly from the ethmoid bone and serves as the attachment point for the falx cerebri a dural fold extending laterally from the crista galli is the cribriform plate a perforated area through which the olfactory nerves pass the two I-shaped palatine bones from the posterior third of the hard palate part of the nasal cavity and a portion of the orbit the small thin lacrimal bones make up the anterior portion of the medial wall of each orbit groove is known as the lacrimal groove helps to form the nasolacrimal canal which contains a duct that allows tears to travel to the nasal cavity the vomer is an elongated plough shaped bone that forms the inferior and posterior part of the nasal septum the internal and external skull bones articulate precisely forming an intricate structure perfectly suited to its functions.

3.5 Sphenoid bone structure

The sphenoid bone has a complicated structure body. It has two large and small wings, the body of the bone and tow pterygoid processes.



(a) (b)

Figure-15 Sphenoid bone anatomy

3.4.1 Sphenoid body

The median body of the sphenoid bone is cuboid-shaped which is located at the center. There are almost six surfaces including the lower, upper and posterior surfaces on both sides. It has contained the sphenoid sinuses, the four air-filled cavities located and connected with the nasal cavity. On each side of the sphenoid body carotid sulcus for the internal carotid artery. On the upper surface of the body lies sella turcica, which is the main and large cavity of the pituitary gland? The sella turcica comprises the square-shaped dorsum sellae, the tuberculum sellar, posterior clinoid process and hypophyseal fossa. The posterior clinoid process extends on the left and right side of the dorsum sellae. The posterior and anterior clinoid processes enclose the posterior and anterior wall of sella turcica around the pituitary gland respectively. Sphenoid crest lies towards the front of the sphenoid bone, and sphenoidal conchae that lie on either side of the crest confine the orifice of the sphenoid sinus.

3.4.2 Sphenoid Lesser wings

In other words, the named of lesser wings, Ala minor, These are actually the smaller of two flattened, triangular-shaped, wing-like bone plates that extend on the lateral surface on both sides of the body of the sphenoid bone. Below them lie a paired of greater wings. Optic canals that lead into the orbits of the eyes are located at the base of the lesser wings. The lesser wings are a tiny section of the medial posterior wall of the orbit, and their free edges act as a border between the anterior and middle cranial fossae. The edges at the front of the lesser wings are connected with the orbital section of the frontal bone, as well as the cribriform plate of the ethmoid bone. The superior orbital fissure, which is a narrow opening, located between the greater and lesser wings runs diagonally along the back of orbit. Oculomotor, trochlear, trigeminal, and abducens nerves pass through the fissure. The optic nerve and the ophthalmic artery pass through the optical canal that lies on either side of the crest confine the orifice of the sphenoid sinus.

3.4.3 Sphenoid Greater wings

Greater wings also referred to as Ala major they are larger than the lesser wings. These bone plates curve upwards, to the side and back. These assist in the formation of the floor, as well as the lateral wall of the middle cranium. They have four surfaces. While the greater wings begin with a broad base at the lateral surface of the sphenoid bone body. These wings each have four surfaces (cerebral, orbital, temporal, and maxillary). On the cerebral surface that faces the cranial cavity, lies around opening called foramen rotundum, through which the maxillary nerve branch of the trigeminal nerve passes. It is anterior and medial to the foramen ovale, which is an oval opening that acts as a passageway for the mandibular nerve, accessory meningeal artery, lesser petrosal nerve, and emissary's veins. Posterior to the foramen ovale lies foramen spinosum. The middle meningeal artery and the meningeal branch of the mandibular nerve pass through the foramen spinosum. The orbital surface forms the lateral wall of the corresponding orbit, whereas the infratemporal crest lies on the temporal surface.

3.4.4 Sphenoid Pterygoid Processes

Pterygoid processes, also called Processes pterygoideus, it has two bony processes that descend downwards from the junction of the greater wings and the body of the sphenoid bone. A pterygoid canal passes from back to front at the base of each pterygoid process. Each of these processes comprises a lateral and medial plate. The pterygoid fossa is a concavity or depression that lies between the lateral and medial plates. The lateral pterygoid muscle that facilitates the movement of the mandible while chewing, attaches to the lateral plate. The muscles involved in swallowing attach to the medial plate.

The complex sphenoid bone structure is attributed to the fact that as it articulates with several cranial bones. It assists in the formation of the orbits, and also serves as an attachment of important muscles that facilitate chewing and swallowing. To add to that, it also acts as a passageway for important nerves and blood vessels.

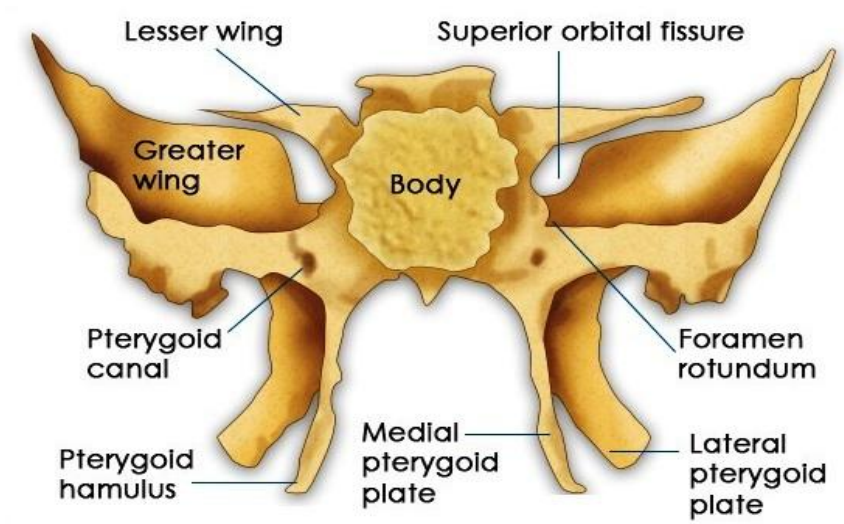


Figure-16 Sphenoid bone anatomical parts

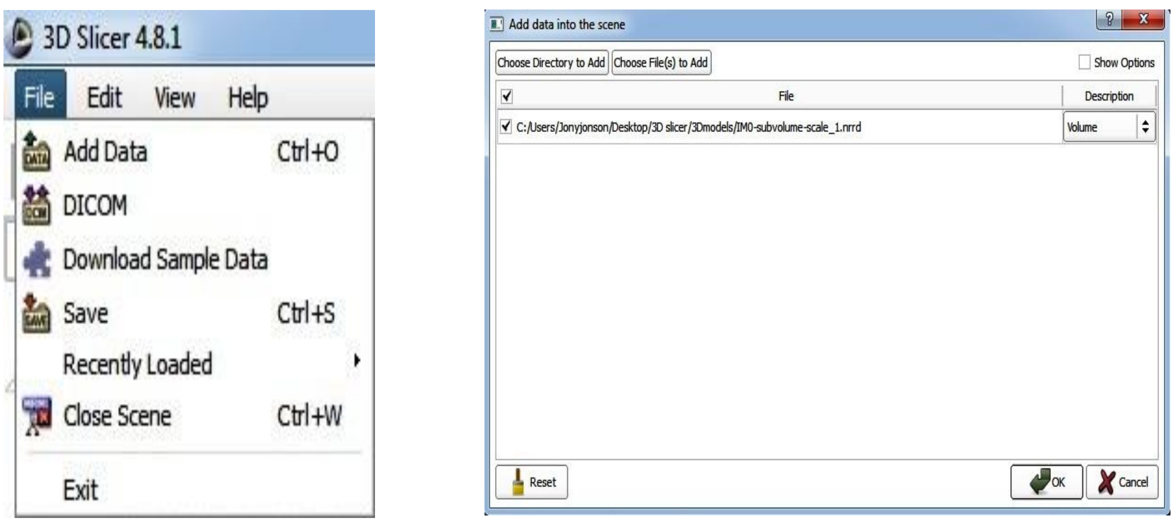
Process and Result

3D Slicer

3.5 Working on 3D Slicer

3D Slicer is a medical free open source software package that providing tools for image processing method, from downloading CT scan image data stored in the Digital Imaging and Communications in Medicine standard (DICOM), processing the data, to creating 3D reconstructions of selected parts of a human body. Extra features and result evaluation tools such as distance, area, and volume, rendering, measurement tools are available in this software platform Slicer 4.8.1.

To start adding CT image data on the 3D slicer, open a software platform and add data DATA through the command which specified file source contained DICOM format or drag the data from source folder directly to the software platform.



(a) (b)

Figure-17(a) & (b) Adding file or directory form the source folder

The source directories in the navigated folder choose it and drag to the software workbench.

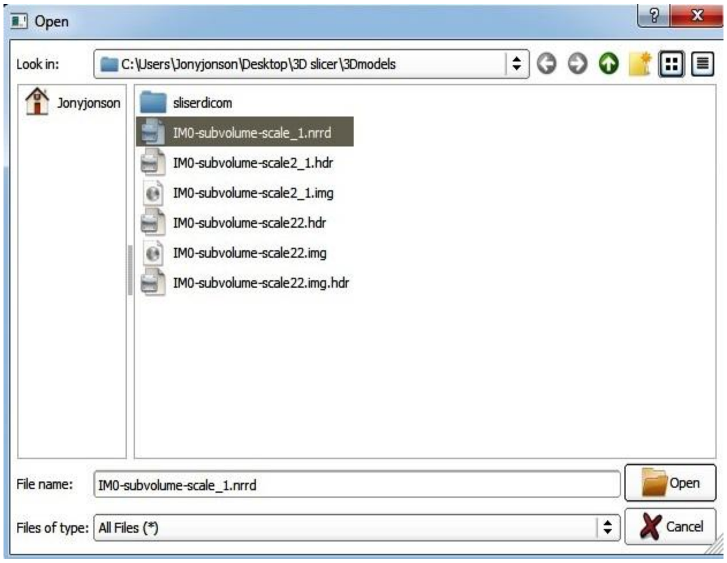
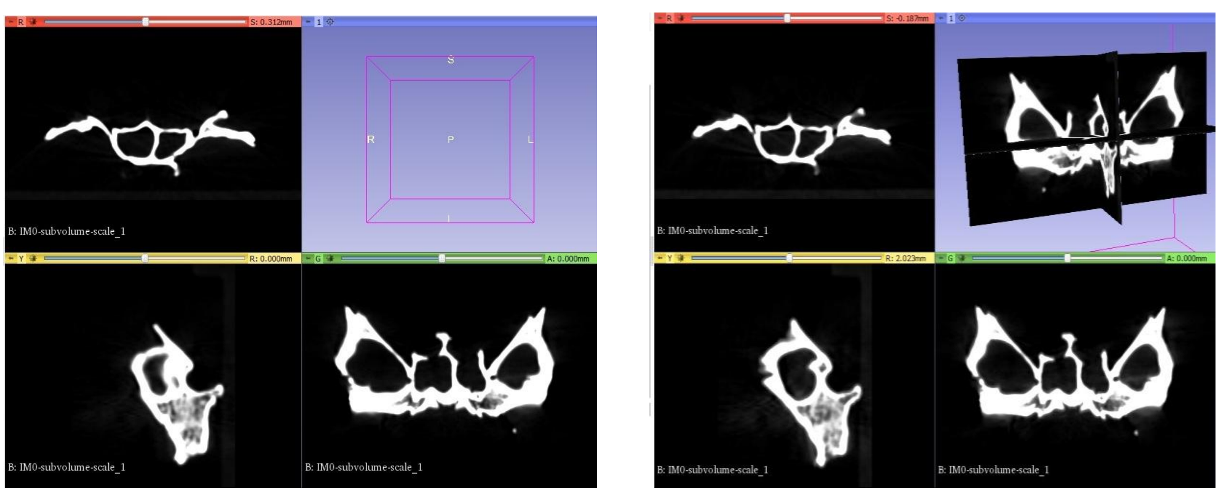


Figure-18 Loading the scene from the navigated folder

The startup window shows three different views of DICOM data file along with the 3D image panel windows where the DICOM data converted into 3D model view. The inserted file can be seeing into multiple windows as per requirement because the software package allows to analyzing the data and can be seen the views in different positions and rotation through the special tool as shown in figure-19. Then select four view layouts to view and adjusting the threshold limit on these windows pallet. The figure of window layout.



(a) (b)

Figure-19(a) & (b) CT scan views on 3DSlicer software tool

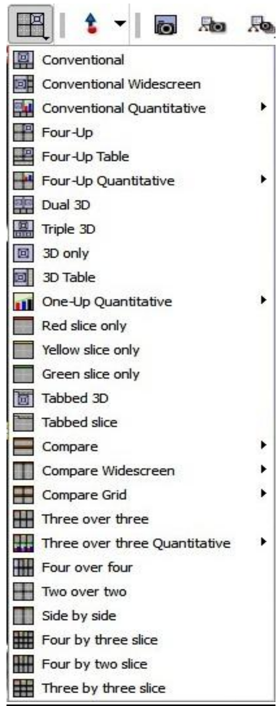
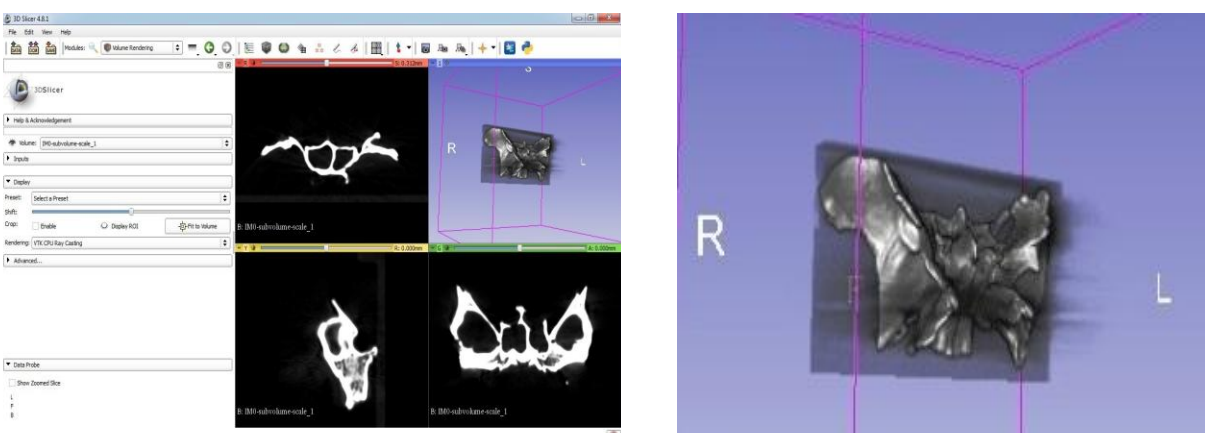


Figure-20 CT scan views selection on a 3DSlicer software tool

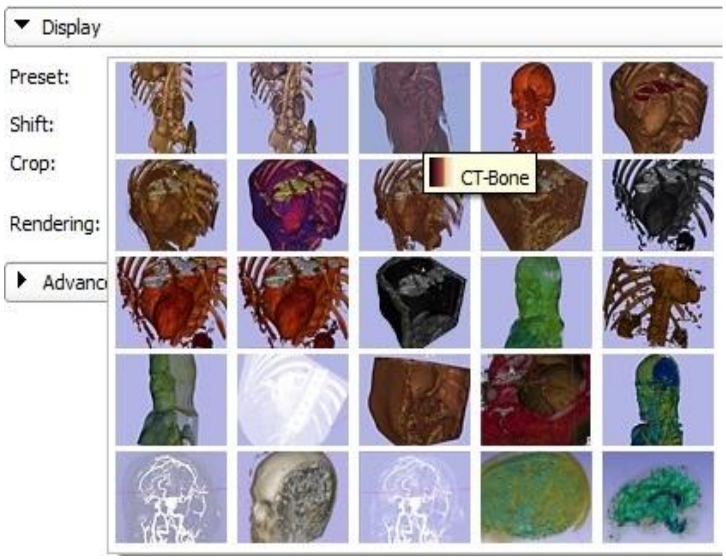
The basic conversion of CT scan data into the 3D model, we are going to use the command on the menu bar of the slicer that is  volume rendering. On selecting of this command there is the icon like an eyeball on the left side of the command window that has been turned on, the 3D volumetric model has been generated automatically. It has been viewing by rotation by the right click of computer mouse.



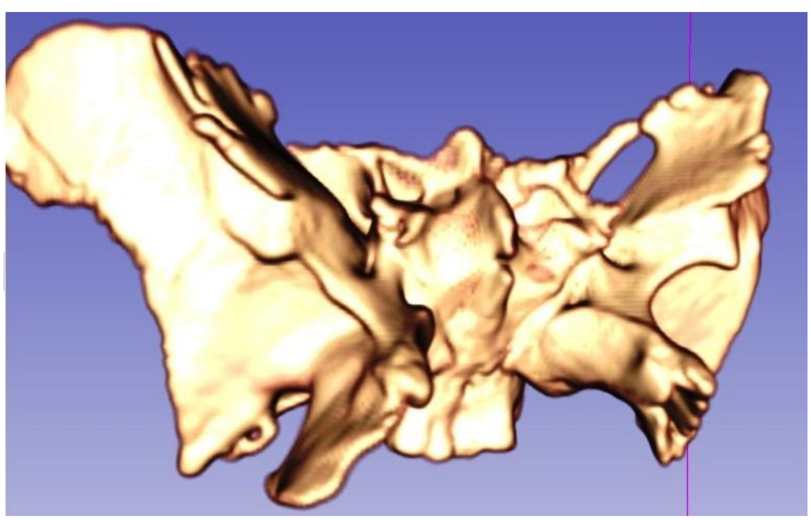
(a) (b)

Figure-21 (a) & (b) Volume conversion into the 3D model

The second step is the preset command for this particular model that will convert data into CT bone model. The slider is on the below side to raise it for the appropriate bone model until looks like a real model as per requirement. We can use the middle button of the mouse to zoom in and left button to rotate the data on windows for looks precisely.



(e)



(f)

Figure-22 (e) & (f) CT scan Rendered volume bone model on 3DSlicer software

The next step is to go on editor command for the modification like threshold and model effects also import this 3D volumetric data into.STL file format with exact and precisely bone structure surface model for printing and processing in the patient-specific health cost.

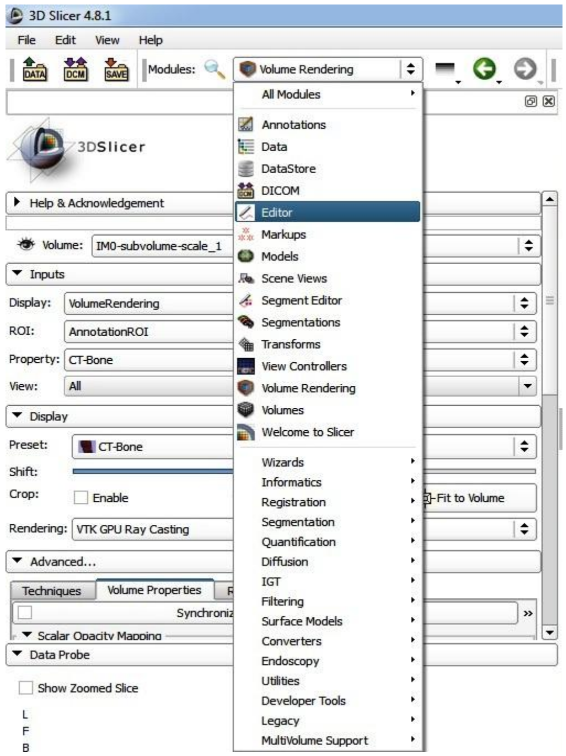


Figure-23 Modification of CT scan scene data from Editor mode command

So, select the editor command in command menu and the generic color is ok then applies and goes for further step. The Editor panel provides a toolbar for modification of targeted project.

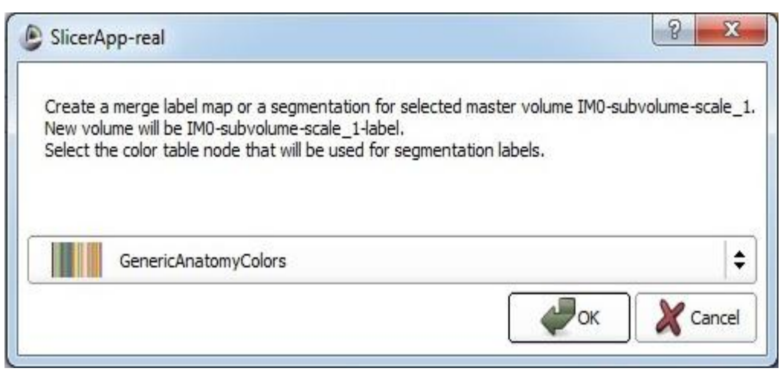


Figure-24 Rendered volume generic module conversation of the sphenoid bone model on 3DSlicer software

Now we are going to do the bone model label map for the perfect surface of the bone and structured model which we can import into STL file format.

Firstly we are going to select the threshold effect tool  button which allows us a facility of CT bone density for attenuation and also selected the bone colored form the color menu bar on the below side of the toolbar. The bone density for this model will be minimum 500 and maximum 2000. The above threshold limit is quiet enough for the bony structure and converted into STL file format.

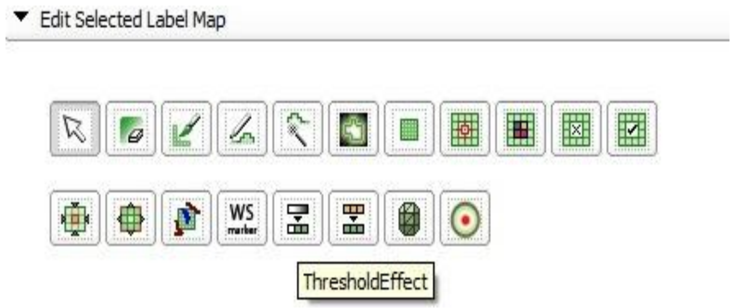


Figure-25 CT scan Rendered volume bone model thresholding on 3DSlicer software

On clicking on the apply button we created a label map which basically shows a bone model.

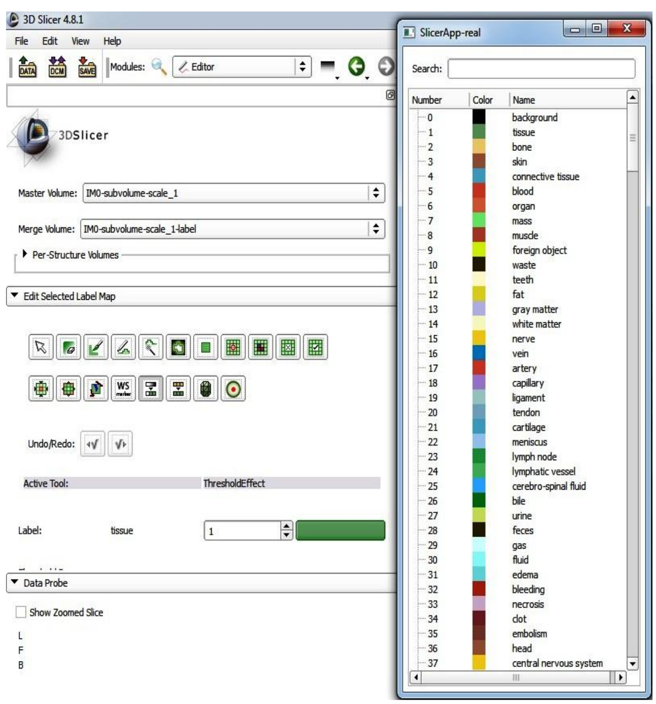


Figure-26 Selection the type of model according to its characteristic

For more precisely and create a surface model of this label map we need to click on Make Model Effect tool which allows the perfect surface structural model.

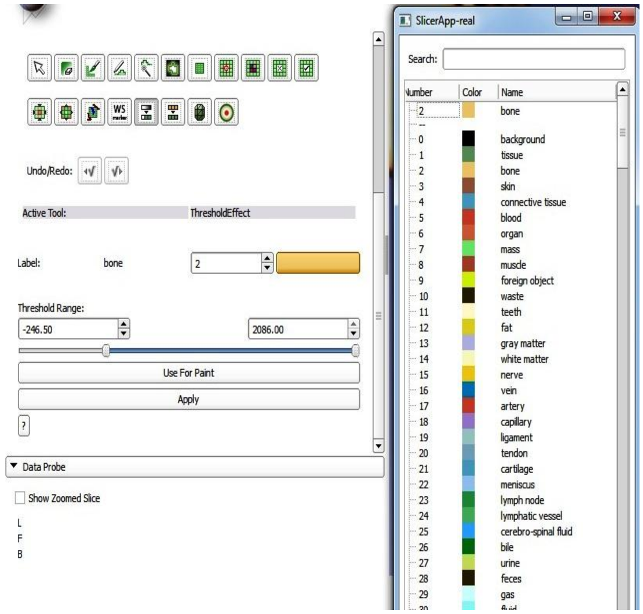


Figure-27 Selection bone type and set threshold limit

In make model effect command we may specify the color of the targeted model and choose the material type. Changing the properties of the sphenoid bone in terms of color and threshold set the limits according to the perfectness of that targeted model.

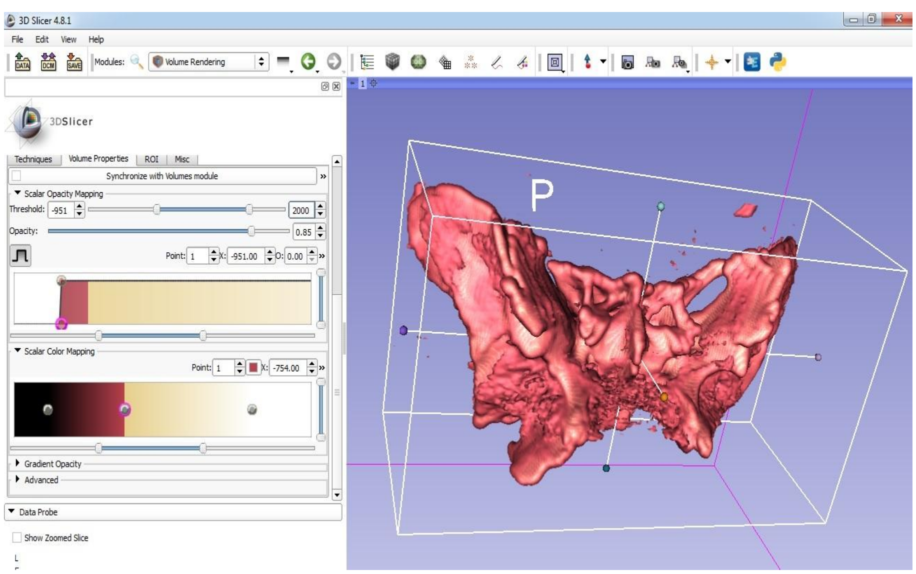
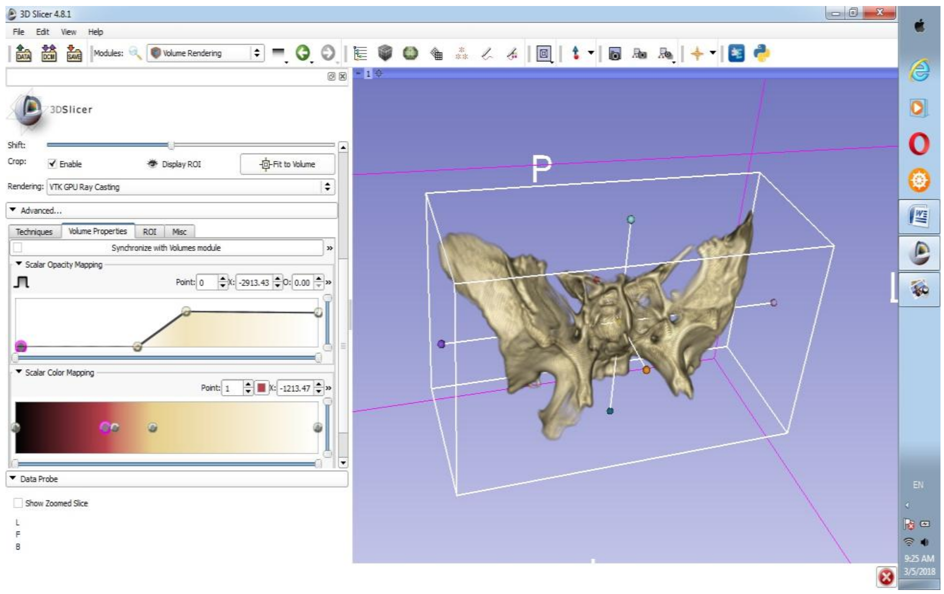
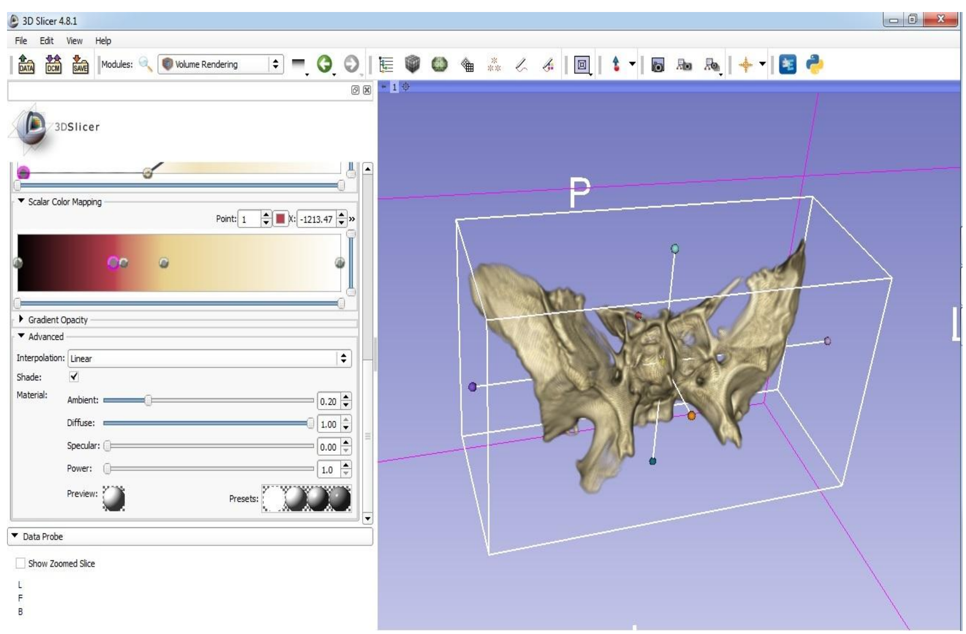


Figure-28 Selection and making threshold limit

In figure-29 (a) and (b) the colored and projected cube has been derived to specifying a model and material.



(a)



(b)

Figure-29 (a) & (b) Selection of the material of targeted project

Now we have the finished structural surface model to import into.STL file format.

We need to save this 3D model DICOM data in supportable file extension on Blender software and press the save button on software panel. It appears the popup mentioned in which file extension you want to save this projected directory.

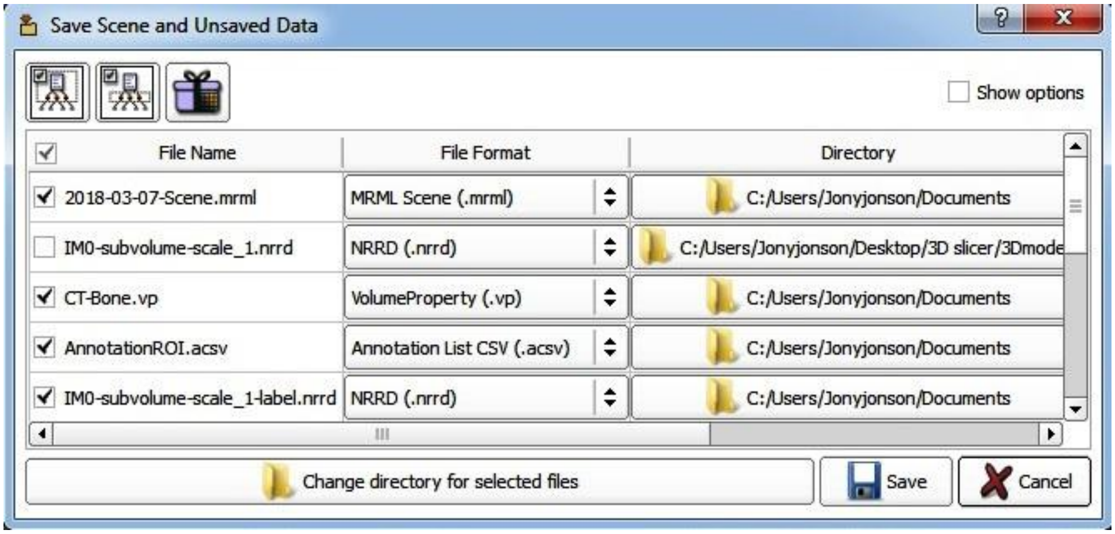


Figure-30 Saving Image mode

The existing file format is in .vtk file extension by default. So change the name of the targeted project file and it's format .vtk to a .stl extension. To save .stl file at the destination folder or path you provided on computer local hard drive.

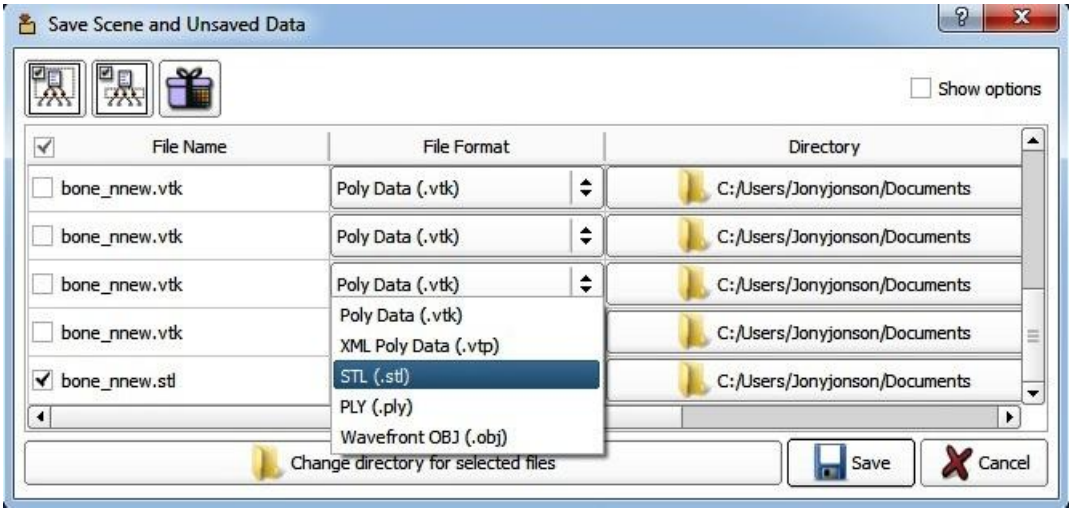


Figure-31 Saving Image mode into .stl file extension

For the further process to save this finished 3D bone model throughout the save command on left-hand corner side on the menu bar of the software. The save command appears a popup shows in which file extension you are going to save the targeted project.

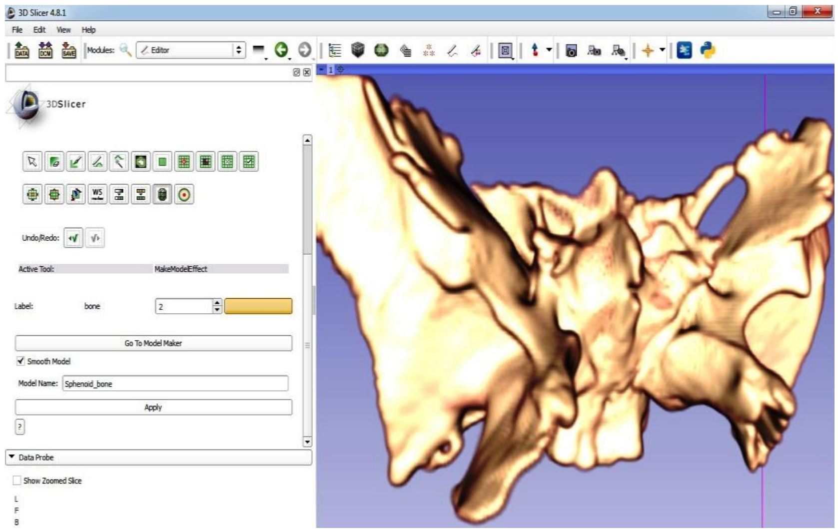


Figure-32 The final structured bone model on 3DSlicer software

We save this file format into.STL file and click to check on the .vtk option and select the directory into.STL file extension on specified storage destination.

Blender

3.6 Working on Blender

Blender is the free open source software package which is usually used for animation and some computer-aided design work. Blender provides an adhesive powerful of mesh editing tool facility to make a smooth a structural STL file format model in preparation for 3D printing. Blender also provides the facility of 3D creation model platform which supports the entirety of the 3D pipeline modeling, rigging, animation, simulation, rendering, compositing and motion tracking, even video editing, and game creation. Blender also using a medical application in such ways like MRI and CT scan making a perfect model and analysis.

The first step to import.STL file through the command menu of blender from import open tab and select the specified file on navigated source folder. The resulted file is too big and complicated structure with vertices also highly detailed mesh file.We need to center this 3D model data on the blender’s origin, to do this need to select object mode into transform and click on align to transform orientation. On blender software package is the bone model is very complex structure and get rid of the unwanted dimensions and irregularities.

The first step to open saved file from navigated folder saved by 3D slicer software. The saved file in STL format which could be imported on blender workbench through import command tab on blender software. So go to the file menu and select import button under the section of Stl.

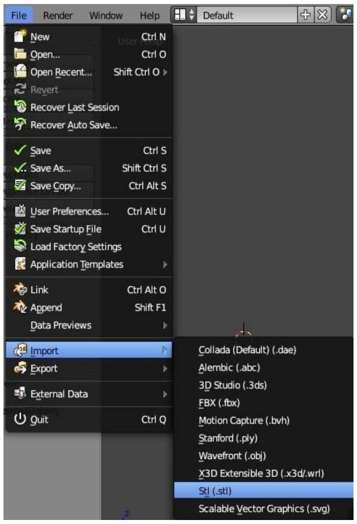


Figure-33(a) File menu bar to Import .stl file on the blender

Select the save file from 3D slicer and import into blender software workbench on pressing of import STL button.

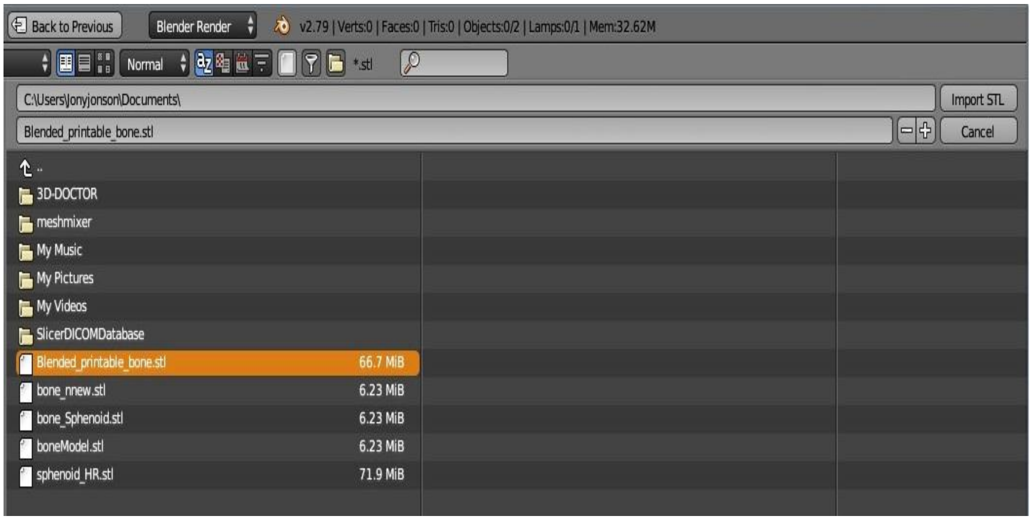
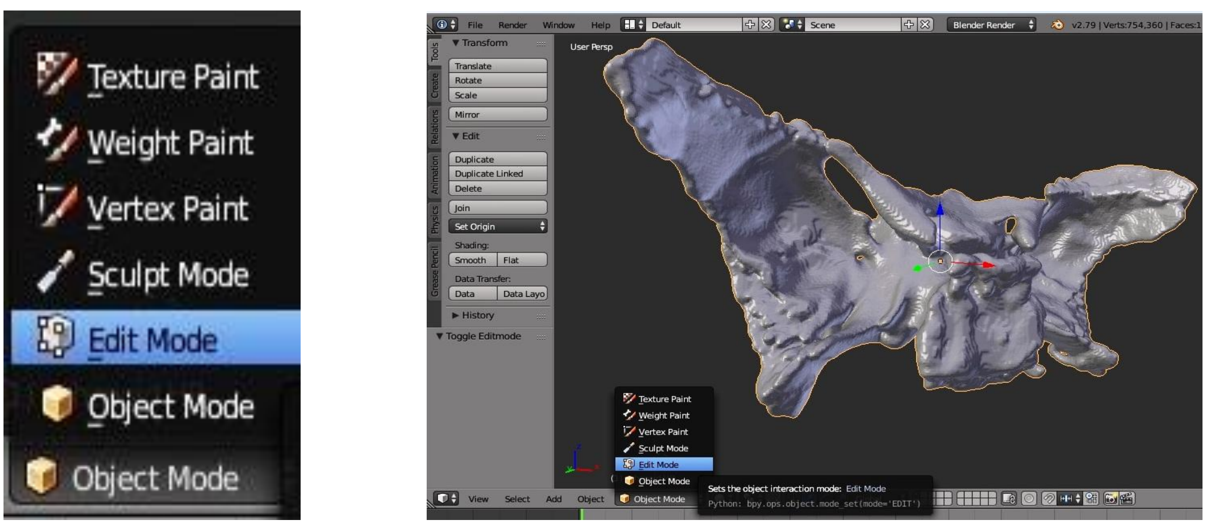


Figure-33(b) Import STL file on the blender

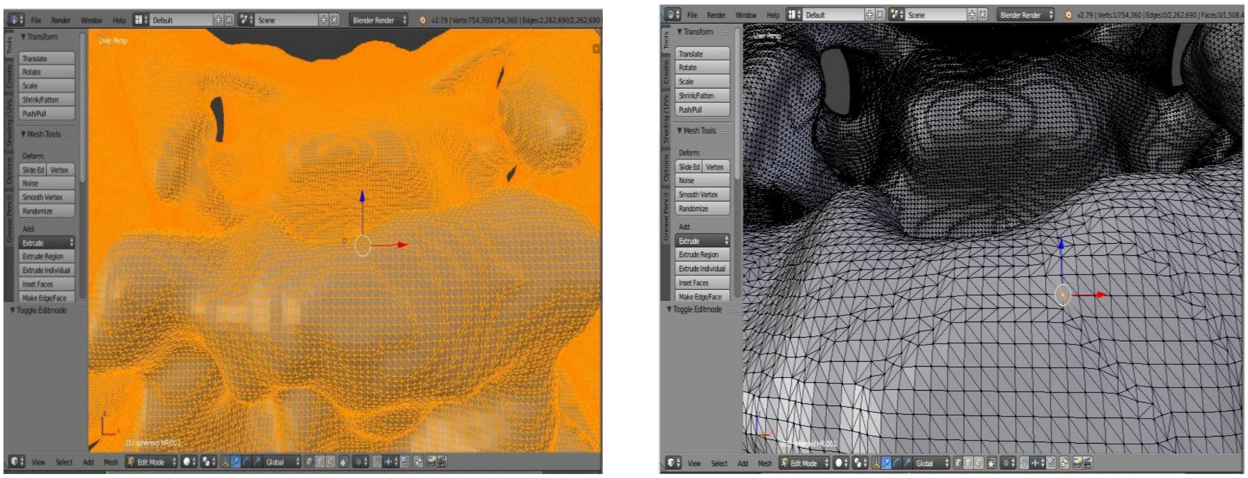
Now we need to go on edit mode for modification of meshing and fill cavities etc. and select this mode on below side of the left-hand corner. This is the mode who allows editing individual mesh element and vertices also remove extra material which is not connected directly to the targeted project. In this mode, all vertices are selected already.



(a) (b)

Figure-34 Sphenoid bone model on blender software through Edit mode command

For further modification select any vertex on this project, it doesn't matter where it is. This means we had selected vertices which is contiguous of the whole structure through ctrl+L command.



(a) (b)

Figure-35 Sphenoid bone model on blender through Edit mode command removing additional parts

To get rid of the unwanted part they would not take apart in 3D printing, hit X key on the keyboard for deleting. At the end of this process, the contiguous part has been viewed and can be considered for further process.

The second part of the blender for the targeted project is to smooth the rough surface. We are going to use smoothing command to apply on it. That function is containing on modifier toolbox like wrench icon. Under the modifier command, we are using smoothing algorithm command.

Figure-36 Sphenoid bone model on blender through smooth command & repeating algorithm

We are using the smooth command for the making a smooth surface and remove irregularities on that model. In this process, we give a limit of smoothness of the model surface and repeat this algorithm many times for required shape and size. For the permanent changes in this model apply all conditions as we've had.

On the result, we are going to save this model and import into.STL file in navigation folder.

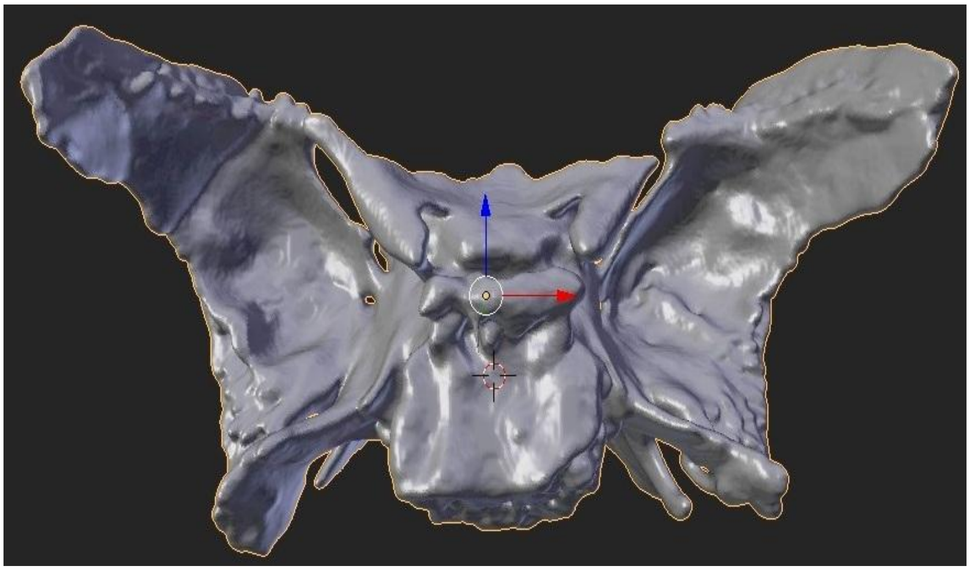


Figure-37 The resulting smooth Sphenoid bone model structure on blender

MeshMixer

3.7 Working on Mesh Mixer

Mesh mixer is the platform where the design of solid parts makes easily with appropriate of mechanical properties that can be appended. This is the free software package by Autodesk which is the largest company dealing software in almost every field. This software package is very useful in medical applications where the specialist can scan the damaged human organ and create an artificial arbitrary object into a 3D model for the patient-specific requirement. This software package able to clean up of 3D scans and fix them or transform into appropriate medical models also prepares it for 3D printing. Mesh mixer easy to operate and is being increasingly used by the medical community to create custom prosthetics, orthotics, and dental models, to visualize and to print patient-specific internal organs, blood vessels, bones or tumors based on medical imaging data. I am going to use this package to make my entire 3D model into perfect surface smoothing without the complex internal structure of triangles inside the model. The existing model that is finalized through 3D Slicer and Blender software might be imported into Mesh mixer and more previously to make a perfect 3D print throughout the specified printer and Slic3r application. The first step to import .stl data into Mesh mixer platform by import command that's displayed on the monitor screen with plus sign.

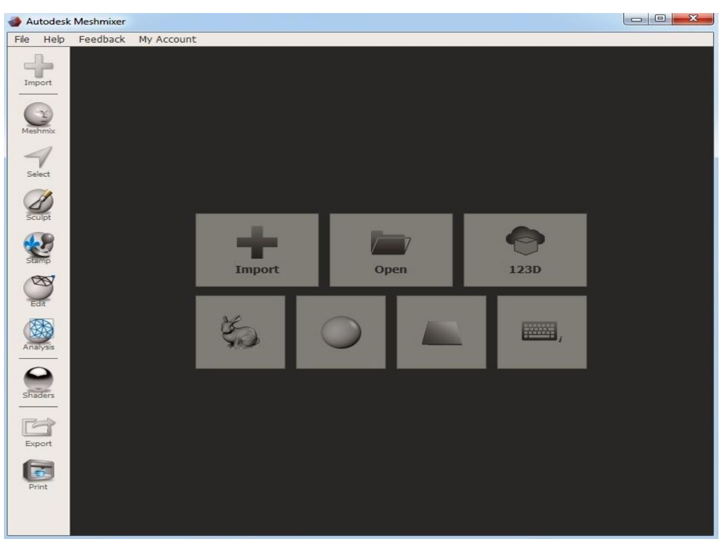


Figure-38 Importing file on MeshMixer

The recent data has imported on the Mesh Mixer could be modified and shown as in the figure.

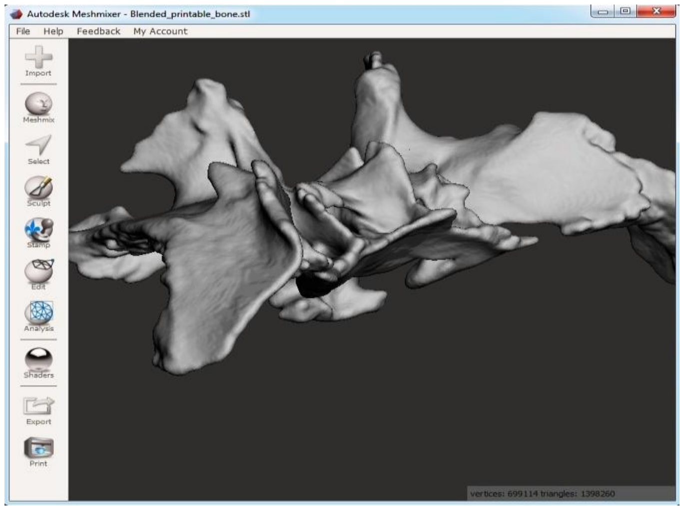
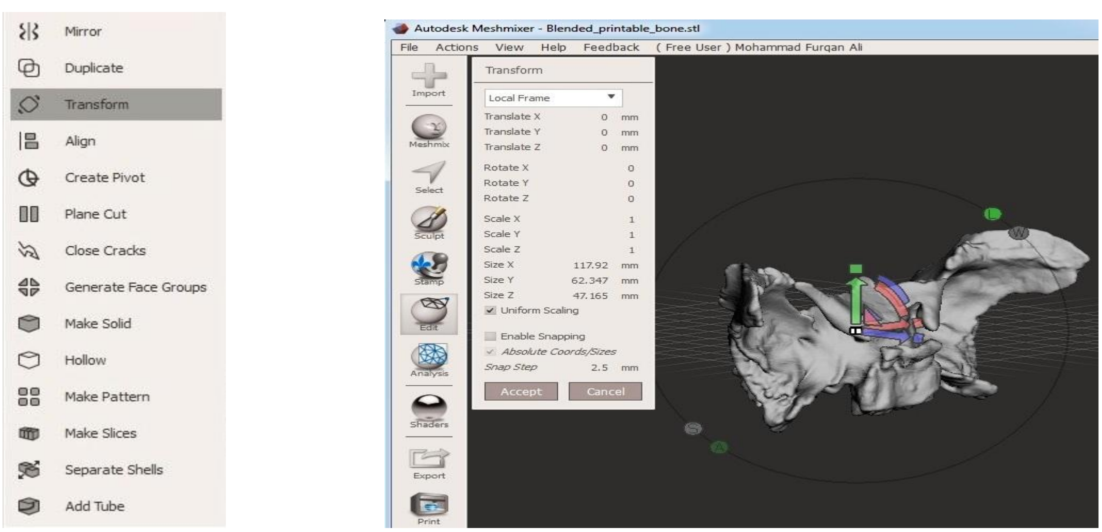


Figure-39 (a) Imported Sphenoid bone on MeshMixer

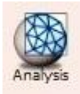
Now the project accessed and need to change by the command of position orientation. Through the Edit mode on the left-hand side on the software window.

In the menu bar of edit mode make changes could be done by transform command that's provided the rotation, scaling and translation of the targeted project in each corresponding axis with dimensions. On accepting of these parameters the changes have updated.



(b) (c)

Figure-39 (b) & (c) Imported Sphenoid bone on MeshMixer with different modalities



The next step is to specify the thickness of recently designed object through mesh Mixer in respecting of Analysis command window.

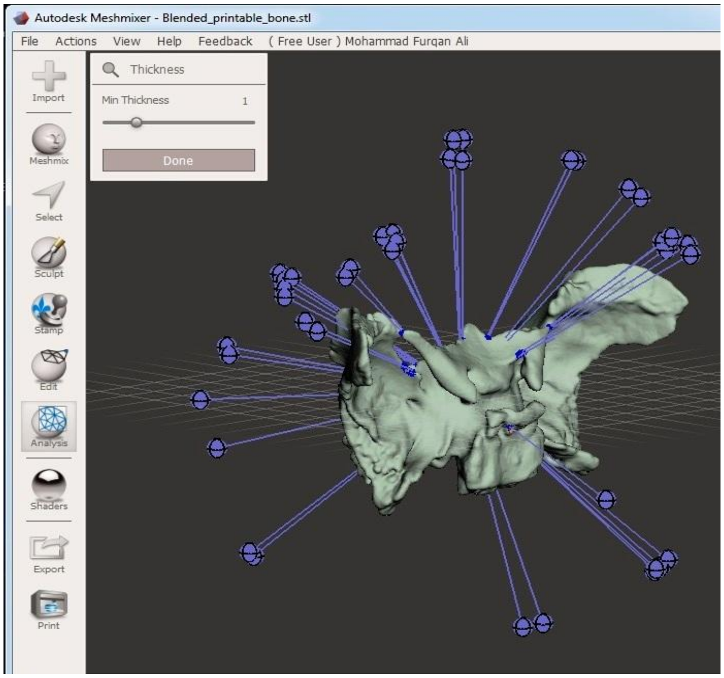
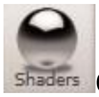


Figure-40 Different modalities parameters of Sphenoid bone

The blue colored ball is showing default thickness of the job. On clicking on each one, we can change the thickness of the body according to the requirement.



On finalizing our object that modified through Mesh Mixer can be edited by the specified material and its physical appearance by the Shades command on Mesh Mixer.

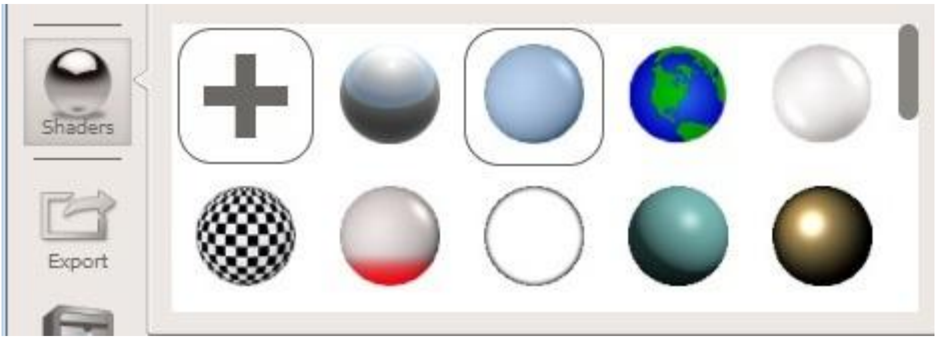


Figure-41 Different material modalities to choose mater for Sphenoid bone

Now on specifying the thickness of the job, next step is to remove all extra and complex triangular structure of the body. So, click again on analysis command under Inspector command to free all of errors and complexity by clicking on auto repair all button after that done.

The new and final object is ready to 3D printing.

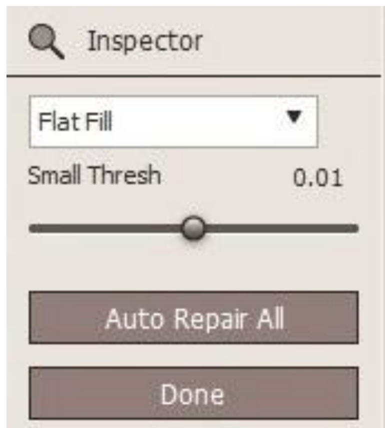


Figure-42 Final mesh mixer inspector

3D Printing

3.7 Printing model through the 3D printer

Anatomical models are important for training and the clinical purposes also useful for the clinical environment and used in medical imaging research and study. In the clinical environment, the physical interaction with models facilitates learning anatomy and how they work, also different structures interact spatially in the human body. Dynamic and Simulation-based training with anatomical models reduces the risks of surgical interventions and operations which are directly linked to patient's health.

The three-dimensional (3D) printers have made a required patient-specific model without expert's knowledge through segmentation algorithms. My main concern to provide a general idea to convert volumetric medical imaging data (CT & MRI scan) to 3D printed physical models. This process is categorized into three stages are below:-

1. Image segmentation
2. Mesh refinement
3. 3D printing.

Accessibility to 3D printers and segmentation algorithms process has led to an increase in the use of 3D printing in medicine, which has a potential medical application Models can be made as per patient-specific requirement, and rapidly modified, redesigned and prototyped, to generic commercially available anatomical models. 3D printing thus found applications in teaching the structure of bones, kidney, heart, Rib-cage, and liver. A deep study has also investigated 3D printing techniques to produce tissue-making for training research and teaching. The transformation method from medical imaging data to 3D printed models has been described for the human body structure, organs, brain, as well as from a general point of view, but challenges remain to make the process widely available to novice users.

In this report, I have mentioned that how to create an anatomical model of Sphenoid bone from medical imaging data. I have developed 3D printed models of the sphenoid bone. This particular bone was chosen as it has a complex structure, while the other human organs like liver illustrate the potential of segmenting and printing soft-tissue organs which has lower contrast with the surrounding tissue in CT images. Finally, I introduce and discuss the currently freely available segmentation tools, which can be applied to any organ or region of interest.

(a) (b)

(c) (d)

Figure-43 3D extrusion type printer used to print Sphenoid bone

There are lots of techniques to make a 3D printing jobs and each has its own characteristics. In this report, I am going to provide an overview of the 3D printing methods, which is averagely suitable for the creation of an anatomical model of the sphenoid bone.

The 3D printing technologies can be categorized into three groups:-

(a) Extrusion printing,

(b) Photo-polymerization

(c) Powder-based printing

Extrusion printing:-I am using an extrusion printing device which is called as Fused Deposition Modeling (FDM), This is based on melting and depositing a material layer by layer through a nozzle. In the photopolymerization process, the liquid polymers are selectively cured and using UV light. This technology used in Stereolithography (SLA) and Digital Light Processing (DLP), which selectively cure a plastic in a bath.

Photo-polymerization:- The photopolymer can be sprayed onto the print in thin layers, where it is subsequently cured. This technique is known as Material Jetting (MJ).

Powder-based printing:- In the last, powder-based techniques, a powdered material is bound together. This can either be done using a liquid binding agent (Binder Jetting, BJ) or by fusing the particles together using heat (Selective Laser Sintering, SLS). The characteristics of these techniques are summarized in the table.

The 3D printed models of the Sphenoid bone can be seen in Figure-44. The Sphenoid bone model was printed in white colored PLA, which will be used as a teaching and clinical training model. The print duration for this butterfly bone (Sphenoid bone) was 36 hours.

The final physical model of this bone could be used for clinical training. When going from medical imaging data to 3D printed anatomical models, the choice of an appropriate image segmentation algorithm is arguably the most important step. I have illustrated the use of three different open-source tools, which offer a multitude of ways to achieve accurate segmentation.

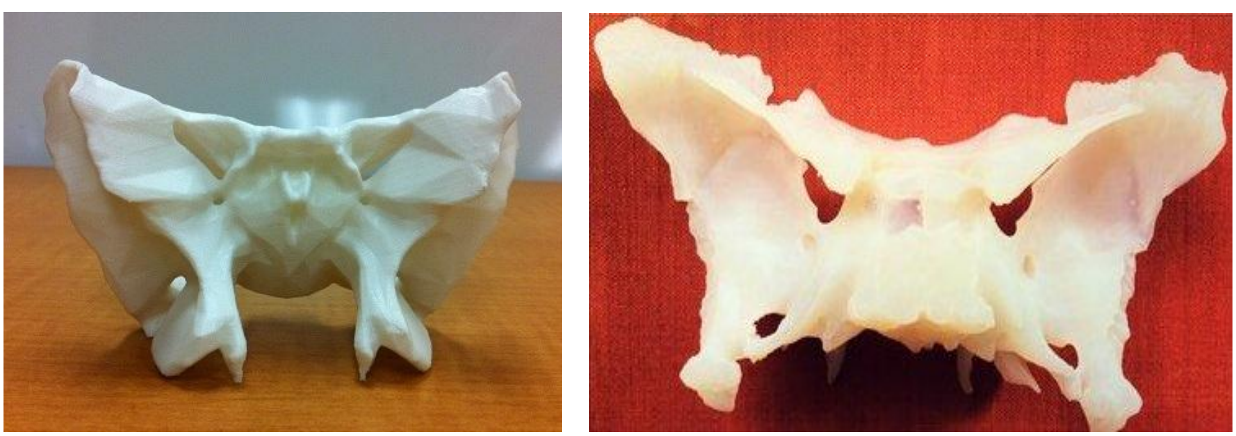


Figure-44 3D Printed Sphenoid bone

CHAPTER-4

4.1 The basic Idea of 3D Biomedical Image Analysis and printing

The basic idea of medical image processing and anatomical modeling is to provide a realistic environment for training, and teaching purposes also for the clinicians used in medical imaging research. Medical imaging is the technology that refers to a number of techniques that can be used as non-invasive methods of looking entire parts of the human body or inside the body. This means the body does not have to be opened up surgically for medical doctors or specialists to look at various organs and their functions. It can be used to assist diagnosis or treatment of different medical conditions in different ways or methods. The modern technologies played an important role in this sphere and provide a better and impressive solution for patient need basis in term of implants and a specific disease. The use of medical imaging has enabled doctors to see inside a patient without having to cut them open. Medical imaging also helps us to learn more about neurobiology and human behavior's. Medical imaging is the combining trade of biology, chemistry, and physics together and the technologies developed can often be used in many disciplines.

Some of the technical terms provide a solution for the patient need to bunch of information of disease within image file extensions like DICOM and .Stl formats file standards.

The first step is to convert DICOM images data format for storing and transmitting information in medical imaging into segmentation software tools like 3D slicer and Osiris, and Mimics.

Segmentation is providing threshold limit to human body organs and finishing bone and tissues quality and it's density. Advances in segmentation algorithms and increased availability of three-dimensional 3D printers have made it possible to create cost-efficient patient-specific models without expert knowledge. I have mentioned the workflow that can be used to convert volumetric CT scan medical imaging data to 3D printed physical models(I used the CT scan of Sphenoid bone). This process is categorized into three steps, image segmentation, mesh refinement and 3D printing. In these software tools, the automatic segmentation cannot be totally relied upon to impart the advanced medical knowledge of anatomy and pathology that is essential for high-quality medical segmentation. All segmentation involves some level of judgment on what to include, how to include it and what not to include. Experienced technologists and radiologists with knowledge of anatomy, pathology, and medical imaging techniques are critical for quality segmentation. Radiologists are the most skilled and trained personnel in this area and should oversee the segmentation process.

The second step on segmentation and separation of the critical structures form scans the data are converted into STL files through some specific software tools (As I used a blender to convert the file extension), the standard file format for 3D printing. The STL mesh files, made up of triangles of various shapes and sizes, are processed to varying degrees in order to be accepted by the 3D. Blender is providing to mesh refine and extra material to put on organs on the model part of being for 3D printing. It also provided a lot of tools for improving the quality and features of the printable objects.

4.2 3D Printing

Anatomical models are important for training and the clinical purposes also useful for the clinical environment and used in medical imaging research and study. In the clinical environment, the physical interaction with models facilitates learning anatomy and how they work also different structures interact spatially in the human body. Dynamic and Simulation-based training with anatomical models reduces the risks of surgical interventions and operations which are directly linked to patient's health.

The three-dimensional (3D) printers have made a required patient-specific model without expert's knowledge through segmentation algorithms. My main concern to provide a general idea to convert volumetric medical imaging data (CT & MRI scan) to 3D printed physical models. This process is categorized into three stages are below:-

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- Mesh refinement
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4.3 SWOT Analysis

SWOT analysis is a sphere for better understanding strengths and weaknesses of work in a specific direction or scientific work.

Medical imaging technology has revolutionized health care over the last three decades years, allowing doctors to find disease earlier and improve patient outcomes. From physicians and patients to professional organizations and peer-reviewed journals, those who have evaluated and experienced medical imaging know its immense benefits, both personally and empirically.

3D printing is an ideal partner for 3D medical imaging because of the uniqueness of every patient and the challenges this creates in sustainable business models that require selling large volumes of similar products.

4.4 Strengths

The medical images bear the bunch of natural information in all ways of human life and disease process also an ability to deliver the quality of healthcare. In biomedical imaging, the main concern of process to capture images through medical processes for a better quality of display of human body part's images while in 3D printing technology allows the environment to analyze the real situation to better understanding. Nowadays the modern imaging technology is digital and has a huge quality to describe the actual situation & diseases of a human organ. In the modern technology of biomedical imaging, imprints and snapshots can be taken by advanced high resolute CCD cameras and computers. In biomedical imaging technologies utilize either Xrays, CT scans, Ultrasound, MRI to assess the exact condition of an organ and tissue can monitor a patient over time.

Biomedical engineers take a patient's MRI or CT scan and , using specialized computer software they identify the patient's individual brain arteries in a process called "segmentation". Next, another computer program (Meshmixer) is used to hollow-out the vessels and add support and connectors , which attach the printed model to a cardiac pump to simulate blood flow . Afterward, the fully-refined and translated computer model is loaded into a program called Object Studio, which is what the Stratasys Objet Connex 3 multi-material printer reads to create the 3D model. Once printed, the biomedical engineers then clean and physically hollow out the model using a clean station , which removes support material and transforms it into a usable model. The model then accurately replicates the structure , texture, and fragility of human vasculature. The physicians have a model of human vasculature on which they can train other surgeons, test endovascular device prototypes, or even plan and practice for a complex surgery.

Medicine is one of the most rapidly changing industries in the world as innovation and technological advancements come to light every day, and 3D medical imaging is no different. The technology is poised to change how we diagnose and treat a plethora of medical scenarios where a picture is worth a thousand words, a 3D image could save a life.

I have mentioned a general workflow that can be used to generate 3D printed anatomical models from medical imaging data. This CT scan volumetric medical imaging data and works for a wide variety of organs and other anatomical regions of interest.

Recent developments in image segmentation algorithms have enabled the use of a multitude of tools and strategies in delineating anatomical structures of interest. I have provided an overview of the most relevant open-source tools that can be used for anatomical structure segmentation by end-users who are not medical or image processing specialists.

4.5 Weaknesses

Problem Statement & Solution 3D anatomical models allow bettering understanding and deep study in clinical training and surgical planning along with the sphere of in medical imaging research. On the floor of clinical organizations, the physical interaction with 3D models facilitates learning the anatomy of human body and how different structures function & interact spatially in the body. On another hand, the simulation-based training with 3D modalities reduces the risks and consuming of time of surgical interventions which are directly linked to patient's healthcare costs. Additionally, the phantoms may be used for pre-operative surgical planning, which has been shown to be beneficial in craniofacial surgery and is being explored in a number of other surgical fields. Finally, anatomical models can be designed to mimic tissues, where an image with the modality required, In general ultrasound, Computed Tomography (CT), or Magnetic Resonance Imaging (MRI). Imaging phantoms are also important for the development of novel imaging modalities such as pore size estimation using nuclear magnetic resonance.

4.6 Opportunities & Future Work

I described the procedure that how to generate the 3D printed anatomical models from medical imaging data (DICOM file). The conversion of CT scan of sphenoid bone into volumetric medical imaging data and works for a wide range of variety of organs and other anatomical regions of interest. I demonstrated the methodologies and creation of models of sphenoid skull bone from CT datasets. Recent developments and research in image segmentation algorithms innovated the use of a multitude of tools and strategies in delineating of anatomical structures of interest as per patient-specific need. I provided an overview of the most relevant open-source tools that can be used for anatomical structure segmentation and 3D modeling by end-users they are not medical or image processing specialists also novice in this 3D printing technology. Future work will focus on creating flexible phantoms, provide the best solution to diagnose, surgical and implantation of the 3D created model that is predefined for the human body and fulfill its desired functions as real part also exploring different materials with regard to their tissue mimicking characteristics in US and MRI systems.

Economic Conclusion

The 3D biomedical image analysis of sphenoid bone and construction through the software tool is likely more informative to find the cavity, decay, and the actual disease. Due to age-related decay and infections are also respectively considered. A CT scan of the patient's skull can be analyzed with modern technologies in clinics. The registration and segmentation process of the particular section of this butterfly-shaped bone has been discussed. The main concern to implant this bone structure into the human skull if they had an abnormality. Some of the diseases occur due to age and some of the miss happened such as fibrous dysplasia causes misshapen bones. It can occur in the bones in the front of the head or sphenoid bones that are situated at the base of the skull. If this happens, it can eventually lead to deformation of facial features and affect the shape of the skull. Sphenoid sinus disease also occurs due to the disorder of optical and other cranial nerves. In this report, we analyzed the biomedical image of sphenoid bone through 3D slicer and blender software tools. The 3D printing of sphenoid bone of particular section with its parameters, requirement and material for implantation in the human skull for the better function has been articulated.

Chapter 5

Social Responsibilities

Imaging is a series of diagnostic of tests used to create images of human body parts. It can help to diagnose the cause of existing symptoms and monitor of the health condition of the patient and treatment of the disease. Sometimes this process called radiology and skilled or specialist are called radiologist. In more precisely we can say that medical imaging technology refers to a number of techniques that can be used as non-invasive methods of looking inside the body. This means the body does not have to be opened up surgically for medical doctors or specialists to look at various organs and areas. It can be used to assist diagnosis or treatment of different medical conditions.

There are some of the modern technological process existing in our medical system like CT scan(Computed Tomography), Ultrasound, MRI(Magnetic Resonance Imaging), Endoscopy. The different technological method has the unique technique to create an image. Medical imaging provides a platform for clinicians, doctors, and specialist to diagnose and a better solution to treatment also more information to understand that what is happening inside the patient body.

Some of the benefits and risks occur during the medical imaging process. Most diagnostic medical imaging advantages in terms of early detection of the problem of the patient and accurate diagnosis but instead of disadvantages cost effect and quite expensive for the patient.

The importance of these techniques able to diagnose, treat and cure patients without causing any harmful side effects. The use of medical imaging has enabled doctors to see inside a patient without having to cut them open. Medical imaging also helps us to learn more about neurobiology and human behavior's. Medical imaging is the combining trade of biology, chemistry, and physics together and the technologies developed can often be used in many disciplines. 3D printing technology is going to transform medical field in a meaningful way, whether it is patient-specific surgical models, custom-made prosthetics, personalized on-demand medicines, or even 3D printed human tissue. Implants can be made throughout the scan from MRI, CT scans and x-rays into digital and .stl or DICOM file format. The approach has been used to fabricate dental, spinal and hip implants.

5.1 Occupational safety

Occupational safety is a discipline the of safety and health issues of human being at work place with many specialized fields. Occupational safety includes different types of things for the social, mental and physical well-being of workers. A successful occupational health and safety practice requires the collaboration and participation of both company and employees in health and safety training, and involves the consideration of issues relating to occupational medicine, toxicology, education, engineering safety, psychology, etc.

The following points have been included in this direction.

- It provides the highest degree of physical, mental and social well being of workers in all occupations
- It prevents effects of working condition on workers at working place.
- It has provided a protection of workers in their employment from risks.

Occupational health issues are often given less attention than occupational safety issues because the former are generally more difficult to confront. However, when health is addressed, so is safety, because a healthy workplace is by definition also a safe workplace. The important point is that issues of both health and safety must be addressed in every workplace. By and large, the definition of occupational health and safety gaveabove encompasses both health and safety in their broadest contexts.

5.2 Identification and analysis of workplace hazards, which the research object can create for people.

There are a thousand of hazards that could be found in almost any workplace in any organization. There are obvious unsafe working conditions, such as unguarded machinery, slippery floors or inadequate fire precautions, but there are also a number of categories of insidious hazards which are, those hazards that are dangerous:

Some of the hazards are above

- Chemical hazards, arising from liquids, solids, dust, fumes, vapors and different gases
- Physical hazards, such as noise, vibration, unsatisfactory lighting, radiation and extreme temperatures are included.

- Biological hazards, such as bacteria, viruses, infectious waste, and infestations.
- Psychological hazards resulting from stress and strain;
- Hazards associated with the non-application of ergonomic principles, for example badly designed machinery, mechanical devices, and tools used by workers, improper seating and workstation design, or poorly designed work practices.

Most workers are faced with a combination of these hazards at work. For example, it is not difficult to imagine a workplace where you are exposed to chemicals, unguarded and noisy machines, hot temperatures, slippery floors, etc. all at the same time.

5.3 Identification and analysis of workplace hazards, which may influence a researcher during the research process

In many cases, the hazards are built into the workplace. Occupational safety is to ensure that work is made safer by modifying the workplace and any unsafe work processes. This means that the solution is to remove the hazards, not to try to get workers to adapt to unsafe conditions. Requiring workers to wear protective clothing which may not be suited or designed for the climate of your region is an example of forcing workers to try to adapt themselves to unsafe conditions, which is also shifting the responsibility from management to the worker.

It is important for an organization because many employers blame workers when there is an accident, claiming that the workers were careless. This attitude implies that work can be made safer if workers change their behavior or if employers only hire workers who never make mistakes. It is human nature, but workers should not pay for mistakes with their lives. Accidents do not stop simply by making workers more safety conscious. Safety awareness may help but it does not remove unsafe work processes or conditions. The most effective accident and disease prevention begin when work processes are still in the design stage when safe conditions can be built into the work process.

Here are some of the ways you can identify health and safety problems:

- Observe your workplace;
- Investigate complaints from workers;
- Examine accident and near-miss records;
- Examine sickness figures;

- Use simple surveys to ask your co-workers about their health and safety concerns;
- Use checklists to help you inspect your workplace;
- Learn the results of inspections that are done by the employer, the union or anyone else;
- Read reports or other information about your workplace.

As a researcher and worker being followed safety and health protection my role is to work proactively to prevent other workers from being exposed to occupational hazards. I can do this by making sure management eliminates hazards or keeps them under control when they cannot be eliminated.

Steps to help you reach your goals are:

- Be well informed about the various hazards in your workplace and the possible solutions for controlling those hazards.
- Work together with your union and the employer to identify and control hazards.

5.4 Protection methods to mitigate the potential damage.

All workplace hazards (chemical, physical, etc.) can be controlled by a variety of methods. The goal of controlling hazards is to prevent workers from being exposed to occupational hazards. Some methods of hazard control are more efficient than others, but a combination of methods usually provides a safer workplace than relying on only one method. Some methods of control are cheaper than others but may not provide the most effective way to reduce exposures.

The most effective method of controlling hazards is to control at the source byeliminating the hazard or by substituting a hazardous agent or work process with a less dangerous one. Before thinking about what control measures are needed, first you need to know whether there are health and safety problems in your workplace, and if so, what they are.

It is important to consider worker health and safety when work processes are still in the planning stages. For example, when purchasing machines, safety should be the first concern, not cost. Machines should conform to national safety standards — they should be designed with the correct guard on them to eliminate the danger of a worker getting caught in the machine while using it. Machines that are not produced with the proper guards on them may cost less to purchase, but cost more in terms of accidents, loss of production, compensation, etc. Unfortunately, many used machines that do not meet safety standards are exported to developing countries, causing workers to pay the price for accidents, hearing loss from noise, etc.

5.2.1 Environmental safety

Environmental Safety work for organizations to promote good working practices for employees. Mostly, they observe their organizations ensure that they comply with environmental legislation regarding safety in the workplace. When they work in environmental roles, it is about ensuring that steps are taken to protect the environment from the actions of the organization, and ensuring that people are protected from the environment.

Business owners and senior managers should always be aware of their health & safety obligations, environmental or the workplace. Businesses may also see the benefits of employing professionals in this area to help them reduce carbon footprint or minimize environmental impact.

5.2.2 Impact analysis of research object on the environment

We are aware of the environmental degradation occurs due to major development projects, construction etc. When a construction project is proposed and designed, that project may affect the environment, including impacts on water or air quality, economic disruption for a community, or even impacts on social interactions. These possibilities need to be evaluated so that negative effects can be minimized or made up for somehow through other avenues.

This is the reason environmental Impact Assessment is important. An environment impact assessment is based on an interdisciplinary process to inform the public and decision makers of likely consequences of a proposed action in order to avoid or mitigate environmental degradation. It is essential that predicted impacts are evaluated in order to protect the environment and the quality of life for humans and organisms.

The environment impact assessment explores both positive and negative impacts. It even explores possibilities for enhancing the environment, such as improving wetland areas as part of the project and enhancing economic opportunities in the area. Perhaps most importantly, it identifies possible negative impacts and suggests ways to minimize them.

All reasonable alternatives are taken into account, including the effect of taking no action. Alternatives also include project redesign, alternative sites, and alternative technologies and construction techniques. The environment impact assessment examines all of these with an eye towards minimizing impacts to the environment and allowing decision makers to choose the best alternatives to protect and enhance environmental quality.

5.2.3 Impact analysis of research process on the environment

The objective of environmental impact assessment is to offer information to decision makers concerning matters that may be brought about as a result of decisions relating to a

new project, program, plan or policy. Environmental impact assessment must realize decision-making based on the inputted information including potentially important factors and it must be beneficial for both the proponent and the citizens. Furthermore, environmental impact assessment is a technique that presents in a systematic manner a technical assessment of impacts on the environment that the project is likely to cause and explains the significance of predicted impacts and as a result, it indicates the scope for modification or mitigation. Finally, it makes the concerned ministries/agencies assess the potential results of the project before a decision is given. Project developers and administrative agencies who have a responsibility for environmental consideration can use environmental impact assessment technique to improve the quality of both the project plan and decision-making by identifying possible effects in the early stages. The specific objections of the environmental impact assessment system are as follows:

- To disclose significant environmental effects of proposed projects to decision-makers and the public.
- To identify ways to avoid or reduce environmental damage.
- To prevent adverse environmental impacts by requiring implementation of feasible alternatives or mitigation measures.
- To disclose reason of approvals for the projects with significant environmental impacts to the public.
- To enhance public participation.

Potential environmental impacts could arise during construction and operation phases of the project. The positive impacts of the flower farm project include generating high-income tax, creating job opportunities, introducing modern technology, supporting the nearby schools and health centers. The negative impacts could arise mainly during the operation phase of the project. Therefore, based on the nature and size of projects and features of the project's environment the following issues have been identified and analyzed so as to identify the critical issues and to make the project sustainable.

Impacts on human health Agricultural fertilizers and pesticides are hazardous, in certain circumstances, to human health especially on those who are engaged in the application. The effect of fertilizers includes dust exposure and ingesting nitrate which causes gastric and bladder esophageal cancer. The effects of pesticides on human beings are a headache, irritability, dizziness, loss of appetite, nausea, muscle twitching, convulsion and loss of consciousness, carcinogenic effects, neurobehavioral effect, reproductive effects, and diabetes. The nearby farmers depend on ground water from wells for their daily life. Therefore, frequent application of chemical pesticides will result in increased risk of pesticide leaching to the sources of water or may result in odour and thus affect the quality of life of the community.

5.2.4 Protection methods to mitigate the potential damage.

Environmental impact assessment is a procedure for preventing actions with significant environmental impacts from being implemented. Rather the intention is that project actions are authorized in the full knowledge of their environmental impacts. There are some cases that environmental impacts assessment takes place in a political context. It is inevitable that economic, social or political factors will outweigh environmental factors in many instances. This is why the mitigation measures are so central to environmental impact assessment.

Decisions on proposals in which the adverse environmental effects have been mitigated are much easier to make and justify than those in which mitigation has not been achieved. The significance of environmental impacts assessment is

- Environmental impact assessment is more than technical reports, it is a means to a larger intention – the protection and improvement of the environmental quality of life.
- Environmental impact assessment is a procedure to identify and evaluate the effects of activities (mainly human) on the environment

- Environmental impact assessment is not a science but uses many sciences in an integrated inter-disciplinary manner, evaluating phenomenon and relationships as they occur in the real world.
- Environmental impact assessment should not be treated as an appendage, or add-on, to a project, but be regarded as an integral part of project planning. Its costs should be calculated as an adequate part of planning and not regarded as something extra.
- Environmental impact assessment does not give decisions but its findings should be considered in policy and decision making and should be reflected in final choices. Thus it should be part of the decision making process. The findings of environmental impact assessment should be focused on the significant and essential issues. It is also required to provide a sufficient explanation on why they are important, and study its validity in order to facilitate a basis for policy decisions.

5.3.1 Safety in emergency
(Identification and analysis of emergency situations, which the research object can create).

The Safety and Health for employers, including self-employed persons, prepare adequate plans to be followed and measures to be taken in the case of an emergency or serious and imminent danger. Emergencies can occur any time without warning, It can be happens due to unsafe working environment and tools used at the working place by ignoring the safety conditions and lack of skills of workers.

In an emergency situation, people can react differently to normal yet rapid decisions will have to be made in a short period of time. The stress of the situation can lead to poor judgment, panic and confusion and the inability to think clearly and logically. Normal channels of authority and communication may also break down. So pre-planning is essential in order to enable people to act to prevent disaster. It will also highlight any deficiencies or lack of resources, which can then be addressed before an actual emergency occurs. The plan should be familiar to all, outline clear roles and responsibilities and be regularly reviewed and rehearsed.

- A Safety Statement is a written action program for safeguarding the health and safety of those at work. It details how health and safety is managed in the workplace, which for fishing means the boat.

- The Safety Statement is based on the principle that safety can be managed because most accidents and ill-health are foreseeable and can usually be prevented. The Safety Statement should be used to plan and control everything that is done in the workplace so that accidents don't occur.
- By law, the Safety Statement must be based on the risk assessment of hazards in the workplace . The control measures and the resources necessary to reduce the risks to an acceptable level must be indicated. In addition, employee's duties and the responsibilities of key personnel in relation to safety, health and welfare must be documented. As part of the written health and safety program, emergency plans and consultation arrangements should be documented.

5.3.2. Identification and analysis of emergency situations, which may occur during the research process.

The safety and health care strongly emphasizes the need to provide employees with instruction, information and training necessary to ensure the worker's health and safety. Providing employees with health and safety information and training reduces the chance of them suffering injuries and ill health. It helps them acquire the skills, knowledge and attitude to make them competent in the safety and health aspects of their work and instills a positive health and safety culture.

Training means showing a person the correct method of doing a task and making sure that he or she can carry out the task correctly and safely. It can be formal, mandatory training such as the basic safety training course or informal on the job training such as showing a person the correct method of doing a job, pointing out dangers and ensuring that the person understands and can do the job safely.

Work practices and the effectiveness of any training provided should be monitored. Where unsafe work practices are detected and safety, health and welfare measures are not being followed by any member of the crew, the work or activity should be stopped until corrective action has been taken and safety controls are fully complied with.

5.3.3 Protection methods to mitigate the potential damage.

A large percentage of accidents occur due to lack of or failure in systems of work. Implementing safe systems of work is an important part of safety.

The law, requires employers to provide systems of work that are planned, organized, performed, maintained and revised as appropriate so as to be, so far as is reasonably practicable, safe and without risk to health.

A system of work is a set of procedures according to which work must be carried out. Safe systems of work are required where hazards cannot be eliminated and some risk still exists. When developing safe systems of work, consider how the work is carried out and the difficulties that might arise and expose workers to risk. Then develop a set of procedures detailing how the work must be carried out to minimize or reduce the risk of accident or injury.

Systems of work must be communicated and understood by the relevant employees. The detail of the system of work, for example, whether it is oral or written will depend on the level of risk and the complexity of the work involved. For example, high risk activities where there is a risk of serious injury or death, will need to have documented systems of work which are strictly supervised and enforced.

Regularly review your systems of work to ensure that they still reduce or minimize risk and revise as necessary. Safe systems of Work can reduce or eliminate exposure to hazards but they must be strictly followed.

Safe Systems of Work

1. Know about space & equipment

- Know your building:-
- Exit routes
- Areas of rescue assistance
- Shelter in place locations
- Assembly location

2.Know your gear:-

- First aid supplies
- Emergency Procedures poster
- Keep a Go Bag (flashlight, emergency contacts, etc.)

3. Hearing about an emergency

- Siren
- Fire alarm
- Social media
- Alerted by a colleague
- Call from a friend
- Witness the event

4. Getting help:-

- For any type of emergency call police or administrator
- Give your name, address, and the nature of the emergency
- Stay on the line until you are told you may hang up
- Remain calm and answer questions as clearly as possible

5. Deciding what to do - evaluation

- Gather information Watch and listen for instructions
- Follow instructions
- Shelter in Place = Stay
- Evacuate = Go Sometimes you just have to use your best judgment

5.4 Workplace design (workplace ergonomics)

Workplace design is used to assess how tasks or the entire job is organized within the work environment, and then ensure these are well-matched to the attributes of the employee. While both terms, job design and workplace design are used interchangeably, workplace design has a focus on those administrative changes that are required to improve working conditions, with work design having a more pragmatic approach and addressing those adjustments that may be required to workstations, tools, and body positions to allow the worker to function more effectively. A properly designed job guarantees that the worker is able to accomplish what is required in a safe and healthy fashion, and thereby reduce physical and psychological strain. Further, it helps with the organization of work, in identifying issues such as work overload, repetitiveness, and limited control over work; and thereby improve on occupational safety and health within organizations. A well-designed job could result in more engaged, healthy and productive employees, and these outcomes would benefit both employees and organizations.

Conclusion

Biomedical imaging has been a long technological history. The important needs in biomedical imaging include increasing multidimensional resolution through space and time of images, procedures and devices and automatic accurate anatomic and functional segmentation from image data produced by medical volume scanners of the human body, fast and robust multidimensional image registration and fusion, faithful tissue feature and property classification and realistic real-time volume rendering and visualization. Progress in these areas will have an ever-increasing positive impact on medicine and healthcare. 3D biomedical image analysis of sphenoid bone and construction through the software tool is likely more informative to find the cavity, decay, and the actual disease. Due to age-related decay and infections are also respectively considered. A CT scan of the patient's skull can be analyzed with modern technologies in clinics. The registration and segmentation process of the particular section of this butterfly-shaped bone has been discussed. The main concern to implant this bone structure into the human skull if they had an abnormality. Some of the diseases occur due to age and some of the miss happened such as fibrous dysplasia causes misshapen bones. It can occur in the bones in the front of the head or sphenoid bones that are situated at the base of the skull. If this happens, it can eventually lead to deformation of facial features and affect the shape of the skull. Sphenoid sinus disease also occurs due to the disorder of optical and other cranial nerves. In this report, we analyzed the biomedical image of sphenoid bone through 3D slicer and blender software tools. The 3D printing of sphenoid bone of particular section with its parameters, requirement and material for implantation in the human skull for the better function has been articulated.

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