3D Reconstruction OF Facial Structures From 2D Images For Cosmetic Surgery

T.Senthil Kumar
Assistant Professor , Computer Science Department
Amrita School of Engineering
Amrita Vishwa Vidyapeetham
Coimbatore ,India
t_senthilkumar@cb.amrita.edu

Rakesh.P.B
M.Tech(Computer Vision and Image Processing)
Amrita School of Engineering
Amrita Vishwa Vidyapeetham
Coimbatore, India
rakesh_official@yahoo.com

Abstract- **3D-operation planning which makes the preoperative visualization of patient's postoperative appearance is one of the main applications in reconstructive and cranio-facial surgeries. The current preoperative surgical planning with respect to tissue changes is based mostly on frontal analysis of 2D information sources such as photographs and X-rays. It is necessary to develop an automatic guided software for performing cosmetic surgery by the process of simulating three dimensional visualization techniques suitable for the display of complex structures of the facial skeleton and of skull base. Three dimensional surface reconstruction of cranial anatomy is obtained from CT (Computer Tomographic) or MRI(Magnetic Resonance Images) images. 3D CT/MRI reconstruction of images is an attractive field generally in digital image processing techniques especially in bi0-medical applications. This paper discusses the process of developing a 3D model from the given CT/MRI images based on iso-surface extraction and reconstruction.**

Keywords:- 3D Modeling, iso-surface reconstruction , Cranio facial surgery

I. INTRODUCTION

Computer-based surgical planning has been investigated by many researchers over the past decade. The promise of the technology is to provide better surgical results with fewer procedures, decreased time in the operating room, lower risk to the patient (increased precision of technique, decreased infection risk), and a lower resulting cost. Because of their wide-ranging surgical impact, craniofacial operations require careful preoperative planning[1]. The goal is to improve the functionalities to a considerable extent and there by reconstructing an aesthetically pleasing face for the patient

The desire to obtain these goals has led to a large number of research papers and clinical applications in this area. Routine use of surgical planning is still in its infancy, although the application of computer-based cranio-facial measurement and surgical planning is clearly of great interest to surgeons. Here using a suitable algorithm a proper and near to perfect 3D model of a cranio facial anatomy is proposed.

Three dimensional visualisation techniques suitable for the display of complex structures of the facial skeleton and of the skull base from a given set of CT images can be developed for interactive surgical simulations before performing the actual surgeries.The produced 3D model can be used for educational purposes for the studying the cranio-facial anatomy of the head and face.

II. EXISTING METHODS OVERVIEW AND PROPOSED SYSTEM

There are lots of prior works has been done on 3D Reconstruction of face for bio-medical applications and purposes. All recent medical 3D image reconstruction techniques create 3D images from sets of 2D slices, which can be recorded by various equipments such as CT, MRI, ultrasound etc.

Generally, the general principle of 3D reconstruction is composed of following two steps:

Step 1: 2D data slices need to be read and arranged exactly with the real spatial positions, the result is a data volume, which is saved in memory of computer.

Step 2: use rendering techniques to visualize data volume as 3D image. Usual rendering techniques for medical image are multi planar rendering (MPR), surface rendering (SR) and volume rendering (VR)

A. INTERACTIVE SURGICAL SIMULATION SYSTEM

The paper proposed with its wide and advanced perspective is an interactive surgical simulation system.The interactive surgical system can be used for the simulation of surgical alignments and re-alignments of bone and soft tissues to get the post operative appearance of a patient's face before the cosmetic surgery[2].The focus of work should be in the first step, of developing a 3D volume/model of face from the 2D CT/MRI images of human head.

III. PROBLEM DEFINITION AND METHODOLOGY

The process of generating a 3D surface from a CT-dataset is not trivial. A CT dataset consists of a series of monochrome 2D slices. When generating the 3D volume, information from each 2D slice is processed and interpolation between the slices is performed in order to create a volume as depicted in Figure 1.

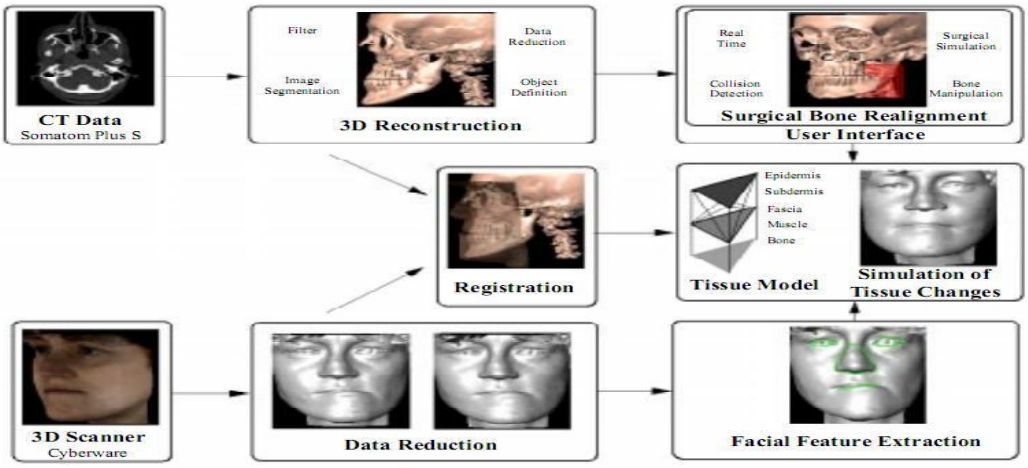

Figure 1. Overall Model of the Interactive Surgical System

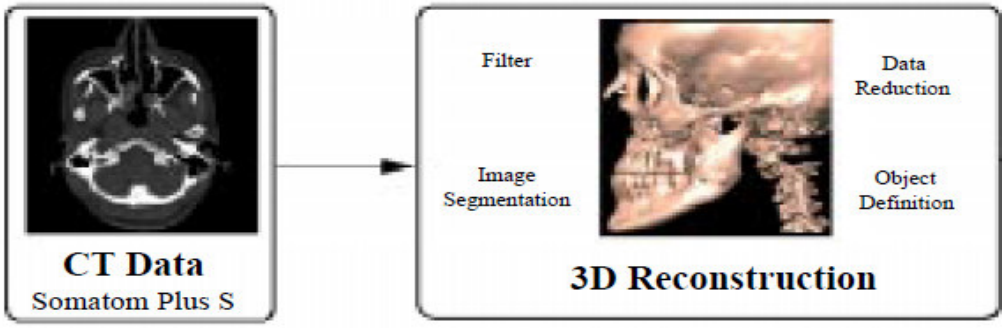

Figure 2. 3D Reconstruction mechansim from CT Data

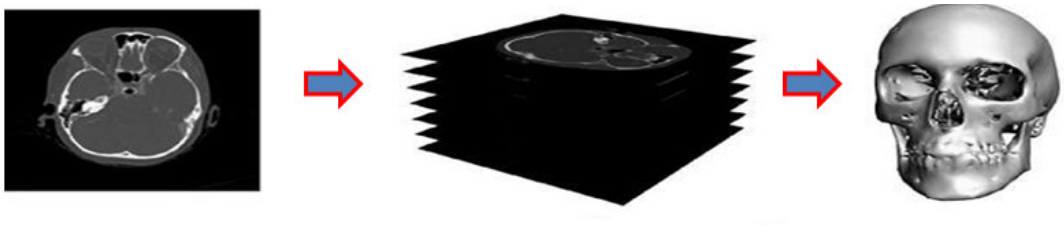

Figure 3. Cranio Facial Anatomy

A. *METHODOLOGY*

Here each of two neighboring slices will form a voxel. The information from each slice is taken and it is processed to form the whole data of the volume created. The overall model reconstructs a 3D Model from 2D slices as shown in Figure 2 and Figure 3. The orientation is preserved in the overall approach.

B. *PRE-PROCESSING BY FILTERING*

Medical image has its own uniqueness such as human tissues' wiggle and disturbance of power level in imaging equipment. And these unavoidable factors add some noise into image data. Adding a filter module before reconstruction module to reduce the noise can improve the precision of the 3D images. Filtering technique should be selected and executed after modeling the noise in the image. The approach is shown in Figure 4.

C. *ISO-SURFACE RECONSTRUCTION ALGORITHM FOR 3D RECONSTRUCTION*

A voxel is created from two adjacent cross-sectional 2D images opposite each other by selecting 8 pixels.

The CT/MRI scan of a patient's head will consist of axial, sagittal and coronal slices as 2D images. In this the axial slices will be taken as the DICOM input,as it contains the vertical scan of human head from top to bottom[5].

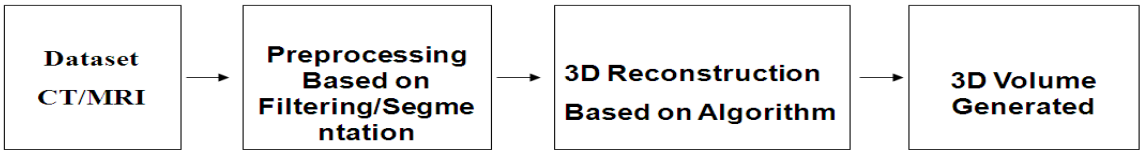

Figure 4. Isosurface reconstruction mechanim

They are at the vertices of a cube, and their coordinates are (i, j, k), (i, j+1, k), (i+1, j, k), (i+1, j+1, k), (i, j, k+1),(i, j +1, k +1), (i+1, j, k +1) and (i+1, j +1, k +1).

An isosurface of the datafield given is calculated using surface modeling.The predefined 8 vertices are used to determine the whether the voxel is inside/outside the iso-surface.The rule to classify the vertices is by,

(i) If (value of a vertice is not less than the value of the isosurface)

{

the vertice is outside the isosurface

}.

else if (t value of the vertice is less than the value of the isosurface)

{

the vertice is inside the isosurface.

}

(ii)Find border pixels which has vertices both inside and outside the voxels.

(iii)Calculate the coordinates of the intersection points by use of linear interpolation. Connect and patch the intersection points based on relative position of voxels and isosurface,which forms the approximate iso-surface created.

IV. SYSTEM OVERVIEW

The proposed method proposes a 3D Reconstruction method of developing a 3D model from complete 2D CT/MRI scan of axial slides of a patient. Iso-surface reconstruction is the process by which extraction of surfaces is done from a 3D array having same density in 3D volume. A basic 3D model of outer face is created using algorithm of iso-surface reconstruction by defining proper iso-value or intensity value[3].

The given set of slices are then processed to extract the internal layers and structures of head based on interested density of 3D volume depends on two dimensional pixel intensity. Three dimensional modeling is then extended to ROI (region of interest) approach by

Three dimensional modeling is then extended to ROI (region of interest) approach by which selection of a specific region or particular number of y the surgeon for 3D modeling[4][8]. The ROI based reconstruction can develop a cross-section of face , part of skin,/soft tissues and internal structures in 3D view. The images given are square images of size 512*512,which should be resized to a size of 50*50 to reduce the execution time and RAM usage of the program. The images taken will then batch processed to form a three dimensional array with selected number of images.

The surgeon has the provision of viewing and analyzing all the slices given using a slider control. The screen layout is shown in Figure 5.

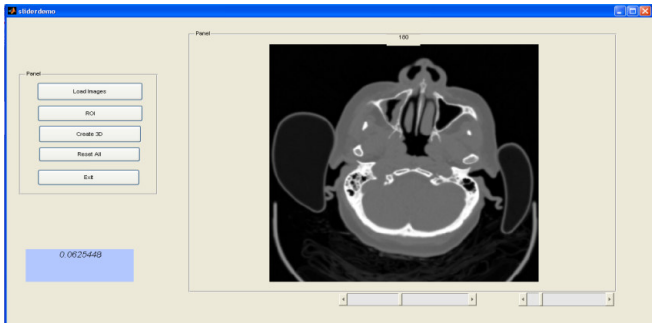

Figure 5. Image Viewer developed for the surgeon

The 3D modeling of facial structures can be divided into three important parts as follows:

(i) Basic 3D model of human face and head

(ii)Extract different inner surfaces of head in three dimensional view.

(iii)Developing 3D parts based on focus of ROI(Region of Interest).

A. *BASIC 3D MODELING OF HUMAN FACE*

3D Reconstruction by iso-surface reconstruction is the process by which extraction of surfaces from a 3D array having same density[9]. In collection of images the density value or iso-value used for extraction will be the intensity specified for images. The intensity or iso-value for extraction will vary from (1-255) range with '0' representing a void or empty space in 3D. The developed 3D Model for the input slices is shown in Figure 6.

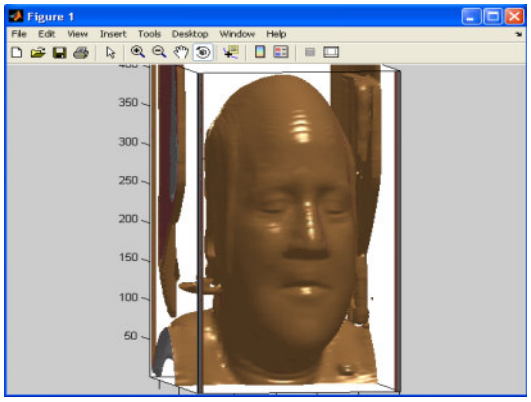

Figure 6. Outer 3DModel of Created Face

B. 3D VISUALISATION OF SKULL AND INTERNAL STRUCTURES

The algorithm is restructured with change of iso-value as per user requirement is done for extracting different surfaces and reconstruction of inner layers inside the head. The head and face can be considered as a composite with three or more regions inside it based on its density[6]. The proposed method can be used to construct different regions based on user defined value. Each region is reconstructed in 3D using different colors for identification. This include skin ,soft tissues, hard tissues and extra hard bones like jaws and teeth[10]. The developed 3D Model for different layer of human face is shown in Figure 7.

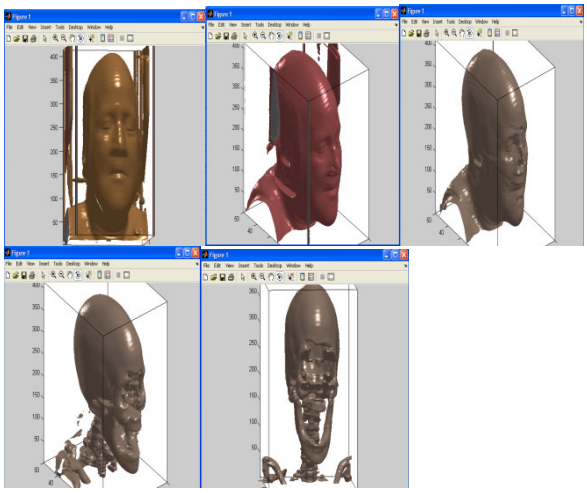

Figure 7. 3D Models developed for different layers of human face(Form outer region to internal hard tissues)

The iso-value of extraction is defined as :

(i) 25-40 for dry skin and outer region
(ii)40-65 for soft tissues after skin
(iii)65-above will the hard tissues.
(iv)100 and above will give extra hard tissues like skull, jaws and teeth.

C.3D VISUALISATION BASED ON ROI(REGION OF INTEREST)

Region OF Interest(ROI) is the process of developing a particular region based on surgeon's interest. If surgeon wants to focus and concentrate anywhere after noticing anything extra ordinary like an infection or defect, he can select that particular portion using mouse from the image

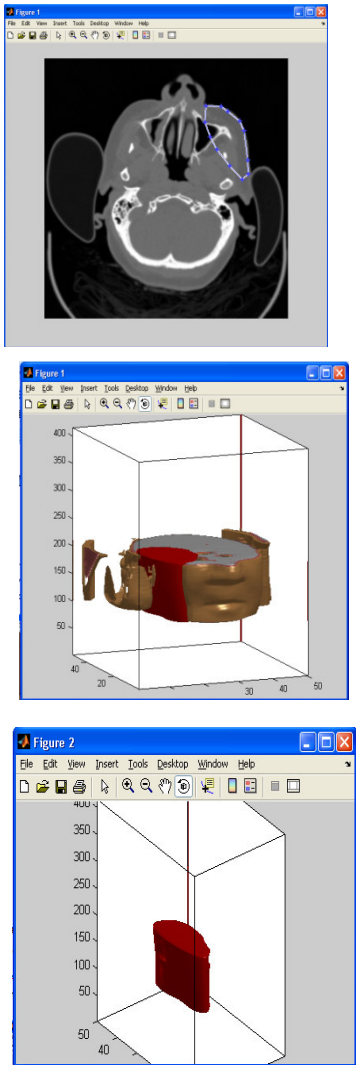

Figure 8. Selection of ROI from Slice and Extraction of ROI

The region selected will be considered as ROI(Region Of Interest),which will be reconstructed with the views of 3D

models of face with highlighting the affected region,the affected part only and the model of complete face after chopping the selected portion. The selection of ROI can make 3D modeling limited to specific number of slides where the surgeon wants to focus and view the region in 3D[7]. The selection of ROI is shown is Figure 8. The region of interest is shown in red colorThe region of interest approach can be used in developing skin and cross sections of human head with the real model and 3D model of portion which can be cut off.

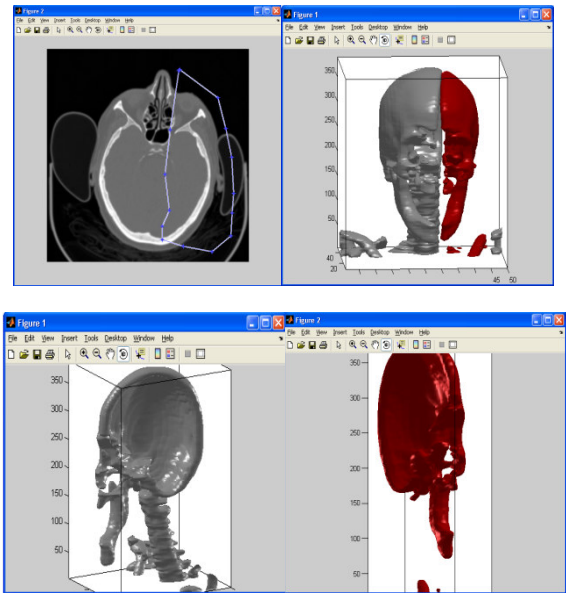

Figure 9. View of cross sections in three dimensional view based on region of interest

The 3D model created by region of interest can then be extended in developing various levels of internal structures with highlighting the portion selected specifically. The extracted cross sections are shown in Figure 9. At any time the 3D model can be cut apart for viewing the internal structure and cross sections.

V. IMPLEMENTATION

A.DATASET

The dataset will be a collection of 250 -400 CT/MRI images which have been taken after scanning a person's head from top to bottom. These images will be in a form of raw medical data which will have noises in it and also the relevant details wouldn't be segmented out from the unimportant background. The sample data set images used for the research work are shown in Figure 10.

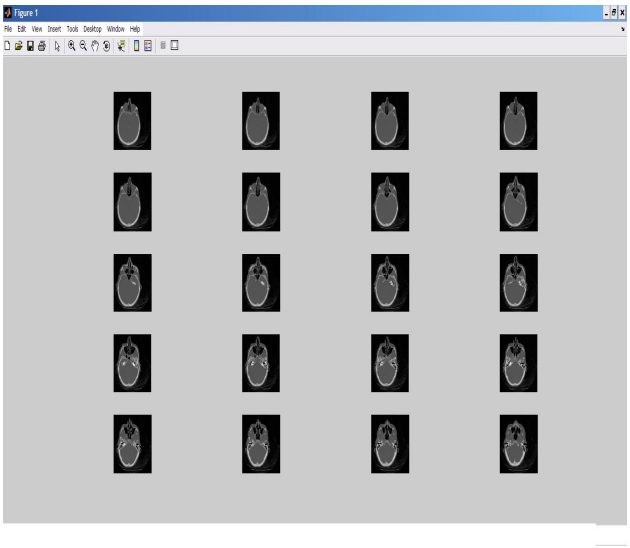

Figure 10. Data Set of CT Scan of a Human head

VI. CONCLUSION

A basic three dimensional model of a patient's face is developed from a dataset of two-dimensional CT scan of head using algorithm of iso-surface reconstruction. Internal structures of a human head are extracted and developed in 3D view from skin to hard tissues layer by layer using the proposed method by defining the iso-value. Three dimensional models of different parts of head are developed giving importance to ROI(Region Of Interest).The three dimensional models of whole face with region selected, the region selected and remaining portion after its removal are developed separately with region of interest highlighted as per surgeon's interest. The 3D Reconstruction based on ROI is used to extract a portion suspected to be infected by the surgeon in 3D view from a given number of 2D slices. The three dimensional view will show the different inner layers in head affected by the infection. The ROI approach can be used to extract a particular cross section of head. The ROI based 3D modeling is further extended to extract different layers inside the cross sections of head.

ACKNOWLEDGEMENT

The authors thank Dr Sherry Peter and Dr G N K Kamath of Amrita School Of Medicine, Cochin for the help and guidance provided by them for the entire work.

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