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Reconstruction of Images into 3D Models using CAD Techniques

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ABSTRACT

This article aims to outline the importance of Reconstruction of images into 3D models in medicine. It is not a 3D model and reconstruction, it is a life to the patient. Adopting to this Methodology, will paves the way to the Doctors or Surgeon to do quickly, Accurate, Confident and Successful Surgery to the Patient. A Case study is analyzed.

Keywords: Rapid Prototype, Implant, Mandible, Casting

INTRODUCTION

In this advanced technology world, today in product research, product design and product development extensive range of applications are designed and developed by using different type of Rapid Prototyping technology with different type of composite materials. Few other technologies are versatile enough to aid the design and manufacture in industries so varied as medical, aerospace, automobile etc. In this We are discussing about the Importance of the CAD techniques in Medicine.

OVERVIEW OF THE PROJECT

In medical industry, the use of RP technology coupled with other techniques has led to improvement in services offered to patients by improvements in such areas as 3D visualisation of a specific anatomy, surgical planning, implant designs and prosthesis production. In this paper we report on investigations to develop Implant & prosthetic designs very effectively and yield the best design outcomes along with long-term biocompatible material. The approach adopted is to integrate image visualisation software, CAD systems and Rapid prototyping systems in the design of the implant or prosthetic design based on data obtained from Computed Tomography (CT) device. Surgeons nowadays can use the accurate replica of parts of anatomical structures of the human body for surgical planning, diagnosis and Implant /Prosthesis design and manufacturing.

Rapid prototype along with medical image based modeling technologies is used as an effective tool to generate complex 3D medical models of anatomical structure of human body based on information from CT, MRI or laser scanning.

RP is a layer by layer additive process that can make complex parts and can be used as a means of producing a biocompatible implant through Rapid tooling Process. Rapid tooling helps in the manufacturing of ready to use functional parts or molds which are used for manufacturing implants. Trauma, bone tumor are the main reasons for defects in human body. Example as follows,

a. Fracture on the skull due to trauma or tumor
b. Mandible fracture or resection of tumor or removal of cancer from affected portion
c. Hip implant design for replacement
d. Tibia bone reconstruction
e. Spinal cord reconstruction

We are here to share the interesting real time case study, which we designed for the defective patient.

DETAILED PROJECT WITH CAD DESIGN

Several research institutions and commercial organisations have integrated Computer-aided Design (CAD) and Rapid Prototyping (RP) systems with medical imaging systems to fabricate medical devices or generate 3D hard copy of these objects for use in surgical rehearsal, custom implant design and casting . However, working with RP technologies in the medical field differs radically from using them in manufacturing environments. In manufacturing, models are planned and conceived entirely on the computer screen, then converted to physical reality. In bio-medical applications, the objects normally already exist physically. Therefore building medical models essentially involves reverse engineering, starting with acquiring data such as a stack of Computed Tomography (CT) cross sectional images. Prior to building, this highly complex data needs extensive pre-processing to provide a format that a CAD program can utilise, before transferring to an RP system.

Successful integration of imaging and rapid prototyping technologies therefore depends on the ability to provide special purpose computer graphics software tools for efficient handling and modification of 2D and 3D data. Here we report on the design and implementation of tools for computer assisted RP medical applications. We demonstrate the application of the RP technologies to general medical practice.

A. MEDICAL MODELLING PROCESS

Before fabricating medical devices from medical data one has to ask the question "How can scanned data and processing technology be linked RP technologies to obtain the physical models?" The data has to undergo a number processes otherwise known as the medical modeling process. The medical modeling process is broadly split into three areas: - data acquisition, image processing and model production.

B. DATA ACQUISITION

In medical imaging, the two most common systems used in acquiring detailed anatomical information are Computed Tomography (CT), and Magnetic Resonance Imaging (MRI). Other systems used include Ultrasound System, Mammography and X-ray. The key feature of these imaging technologies is their ability to provide detailed information about the anatomical structure and abnormalities.

CT uses radiation in the form of a highly collimated Xray fan beam to slice a two-dimensional image or slice plane. Standard CT scanners achieve a resolution of 512 X 512 elements within a layer.

On the other hand, MRI, images are obtained based on different tissue characteristics by varying the number and sequence of pulsed radio frequency fields in order to take advantage of magnetic relaxation properties of the tissues. MRI differs from CT in at least two key aspects: (1) MRI measures the density of a specific nucleus, and (2) the MRI measurement system is volumetric (interrogation of the entire body, within the measurement volume, is done all at one time).

CT and MRI represent the finest resolution capability available in diagnostic systems achieving volumetric resolutions. During the scanning process, the patient is stepped through the measurement plane 2-3mm at a time. The information from each plane can be put together to provide a volumetric image of the structure as well as the size and location of anatomical structures. The scanned model becomes a virtual volume that resides in a computer, representing the real volumes of the patient’s bone(s). The virtual volume is displayed on-screen by reformatting the data to create orthographic projections, or by a creating a pseudo 3D representation using surface-rendering algorithms.

C. DATA RECONSTRUCTION/PROCESSING

When a series of CT images is reassembled to illustrate a 3D presentation of an anatomic structure, the medical practitioner or prosthetic designer can use this information directly and the overall shape of body structures is more clearly understood or visualised. However, visualisation requires good visualization software and so a number of dedicated software packages have been developed to enhance the visualisation of such 3D computer models and enable the surgeon to grasp the particular details of individual cases. Some of these software packages include Analyze biomedical image processing package , Surgicad Template from Surgicad Corp. and Intergraph corp. and Mimics from Materialise Software Company and Katholieke University, Leuven, Division PMA .

These software packages take anatomical data from CT and MRI scans and create computer models of anatomical structures. A user can modify the image by defining various tissue densities for display. This allows separation of data of interest from the general information available from the scanner. By combining the data generated with a traditional CAD system, design of new parts can be undertaken by comparison with the reconstructed 3-D anatomical shape. When segmentation and visualisation is completed the data can be translated into instructions for manufacture of parts often by RP. The de facto standard interface from CAD to RP is the Standard Triangulation Language (STL), though other transfer formats such as the Initial Graphic Exchange Specification (IGES), Standard for the Exchange of Product Model Data (STEP), Common Layer Interface (CLI) and Virtual Reality Modeling Language (VRML) are also possible [8].

D. RAPID PROTOTYPING TECHNOLOGY AND SURGERY

Given the visualisation provided by sophisticated software packages, the fabrication of physical models may at first seem superfluous; however, this is not the case, as the depiction of a 3D volume on a 2D screen does not provide surgeons with a complete understanding of the patient’s anatomy. The relationship between the patient and what is on the screen is not intuitive; surgeons must learn to interpret the visual information, in order to reconstruct mentally the 3D geometry. To that end, headmounted displays, stereoscopic glasses and holograms are beginning to complement the 2D screen in an effort to provide more realistic representation of 3D volumes models. The use of 2D or pseudo-3D electronics display systems can be augmented by overlaying images, graphics, text, and so on to aid the user as training guidance. However, current implementations do not feel natural or intuitive. Surgeons must learn to interpret screen displays, particularly when extracting 3D information from them.

It is therefore, clear that several visualisation issues are addressed but not yet resolved by virtual computer models:

2D screen displays do not provide an intuitive representation of 3D geometry.
· Unusual or deformed bone geometry may be hard to comprehend on-screen.
· The integration of multiple bone fragments is hard to visualise
· Planning of complex 3D manipulation on the basis of 2D images is difficult.

This provides the motivation for the construction of physical models of bones. The use of rapid prototyping for 3D physical models simplifies communication between surgeons, nurses and even immediate family of the patients. For example the extent of the damage to thebone can be demonstrated to the patients in a clear manner, so that they may evaluate the reconstruction options presented to them.

3D models are useful for diagnostic and treatment planning, more so, in cases of complex surgical procedures [17]. This reduces the risk to the patient owing to the shortened time of surgical procedures and is less expensive than the lternatives. The model accuracy and material properties provide the basis for simulating and evaluating alternative scenarios, so that optimization can be made prior to the actual surgery.

A physical model derived from CT or MRI data can be held and felt, offering surgeons a direct, intuitive understanding of complex anatomical details which cannot be obtained from imaging on the screen. Allowing surgical dry runs as well as marking out the vital areas to be avoided and predicting complications that might arise. Hence it increases the surgeon’s confidence in the operation, and reduces the search time for the correct entry of surgical tools. This will allow a surgeon, from the outset, to know what to expect when a certain surgical route is adopted. Thus it reduces the duration of the procedure and greatly reduces the risk of infection and the problems of uncertainty. Complex and sensitive surgery requires extensive planning. In a surgery as delicate and complex as a cranial osteotomy, for example, the displacement of bone segments can be more accurately evaluated. Surgical instruments identical to those used in the actual procedure can be employed on the models to determine the most conservative strategy. The model can be referred to during an operation for guidance during mock training procedures or for academic teaching of surgeons and young doctors. Three-dimensional bio-models have greatly enhanced the design and fabrication of medical implants. The RP models can also used as a 'negative' on which the implant is formed, or a 'master' from which the implant is duplicated.

E .MIMICS SOFTWARE

Mimics is a software suite that performs the segmentation of the anatomy through sophisticated three-dimensional selection and editing tools. The method adopted for visualisation is the conversion of 2D image slice data, as grey value images. The resolution can vary from 0.2 to 1 mm. The program also generates high-resolution 3D renderings in different colours directly from the slice information, as shown in Figure 1. Contrast enhancement can be carried out interactively to improve the model. The segmentation mask can be displayed in a different colour on top of the image. After visualisation, the data can be interfaced to CTM [7].

E. FLOWCHART DIAGRAM ON THE CONVERSION OF SCANNED DATA TO PHYSICAL 3D MODEL

Before performing segmentation of the anatomy, the data is loaded into Mimics by a front-end data input software, CT-convert. This software translates the data from the CT scanner into CT-Modeller's own proprietary data format.

The data in Figure 2 shows data in mimics own proprietary format. The image is processed by use of threshold value to differentiate regions of interest. The bone can be separated from soft tissue by setting a fixed threshold value. Typically, algorithms evaluate neighboring voxels to determine whether the differences in their intensities are within specific threshold values. An area of interest is selected by defining sets of voxels whose intensity is above the selected thresholds. Culling of the 'unnecessary' parts or unwanted noise is achieved with sophisticated dimensional selection and editing tools.

IV. CASE STUDY

Case 1:

Patient suffered from Trauma on the skull. He met in an accident, he got injured severely on his head. Due to the strong impact of this trauma, his Forehead got damaged. Its very difficult to bare the pain. It's the challenging work to the surgeon to do the surgery with all essential implant, It has to be Planned with customized design to make an Implant.

We both Engineer and Surgeon interacted more along with injured patient CT images to reduce the complexity of the surgery. Finally we succeeded to design the implant for the defective portion of the head using Images and RP with CAD software's This designed Implant done for AMRITA INSTITUTE OF MEDICAL SCIENCES, Cochin.

In order to make a bone substitute match the shape of the removed portion of the mandible easily, Rapid Prototyping(RP) and Rapid Tooling (RT) technology are used to fabricate a implant.

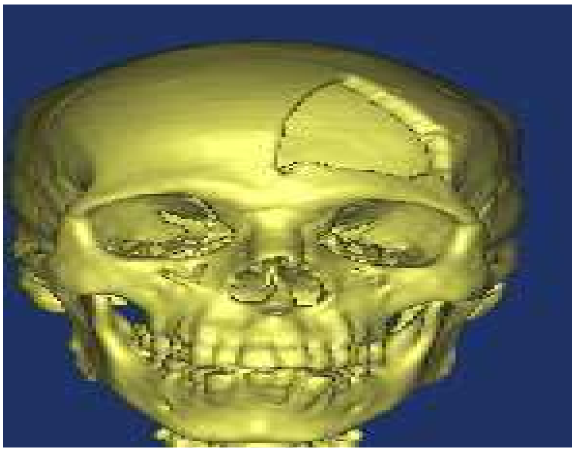

fig 4a : Defective Skull

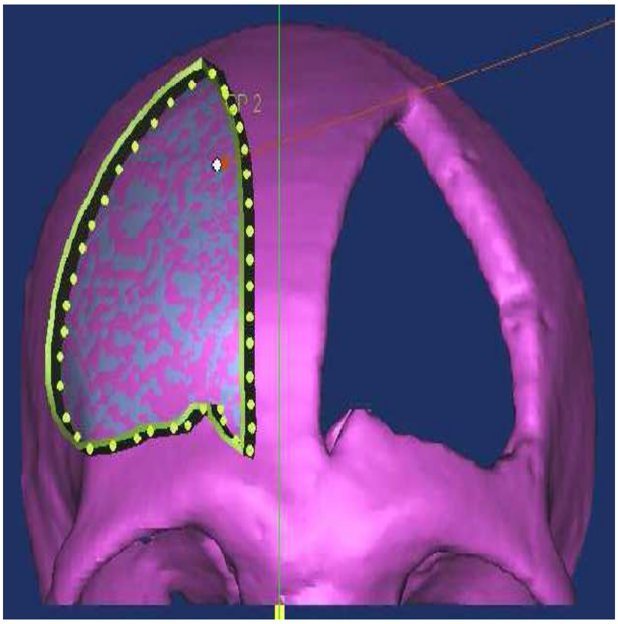

fig 4b : Mirroring the opposite side, being Symmetric in size

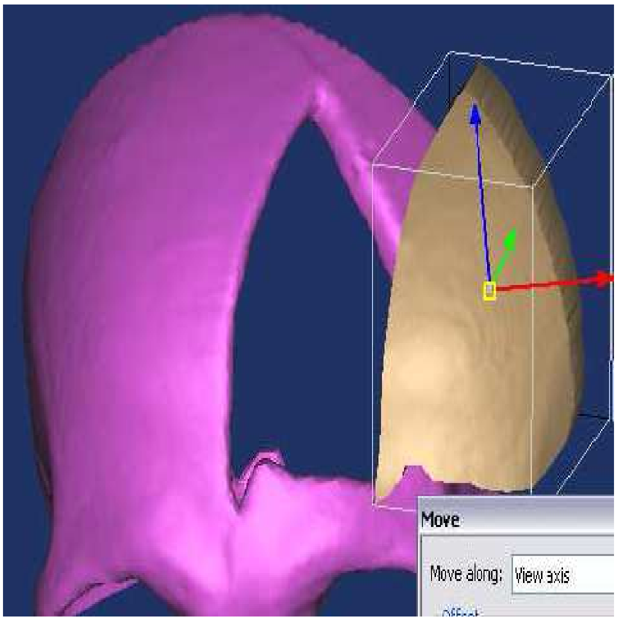

fig 4c : Implant Designed

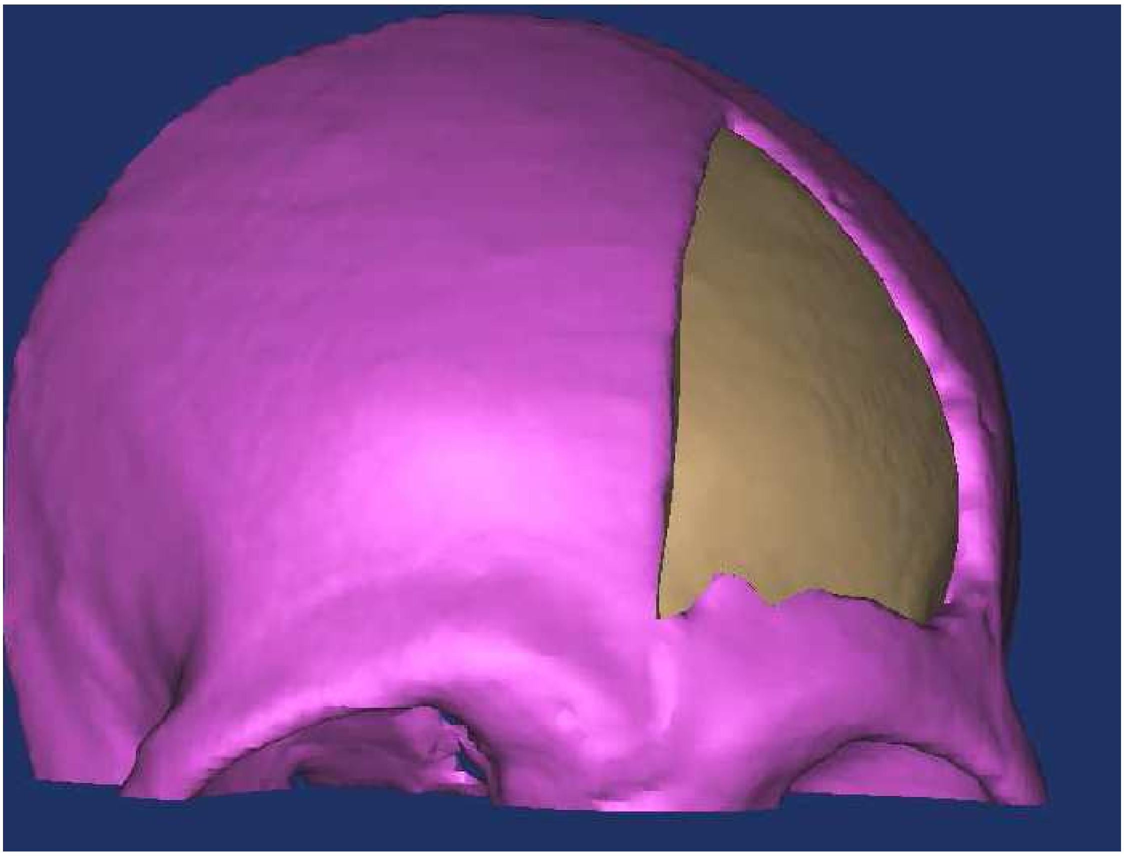

fig 4d : Designed implant fitted

Case 2:
Patient suffered from Mandible Tumor or Condile Tumor in Mandible. Its very difficult to Chew, Swallow and close the mouth. It's the challenging work to the surgeon to do the surgery, It has to be Planned with customized design & Implant. We both Engineer and Surgeon sat together and done this design. As per the surgical parameters and planned method on the designed prototype model. This designed Implant done for RAGAS DENTAL COLLEGE, Chennai.

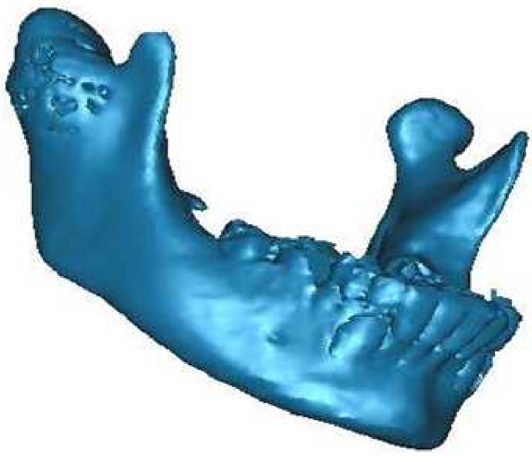

fig.4e : Mandible with tumor

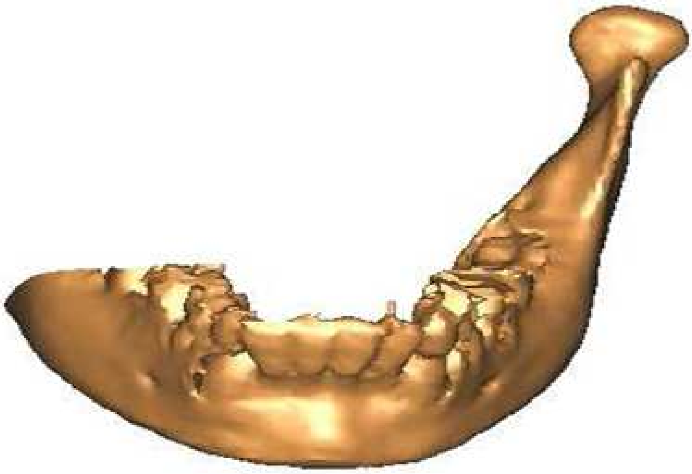

fig.4f : Mandible after Resection of tumor

fig.4g : Designed implant

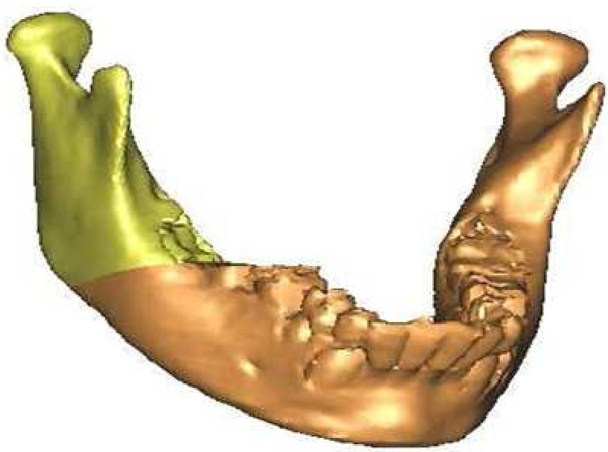

fig.4h : Mandible fitted with designed implant

CONCLUSION

Reconstruction of Images into 3D models in Medicine, these methods are presented and the process of design and manufacturing of bio-model and implants are discussed. The design of the implant was carried out for the case study and prototype of the implant was manufactured and details of how surgeons can put it into clinical use and cosmetic effect of surgery are discussed. The model of the implant are useful for surgeons to rehearse the surgery prior to the actual operation this enhances the surgeons skills.

The precision, safety and speed of the surgery are increased and finally the complexity of surgery is reduced which lead to reduction in the operation time and offers security to patient. This paper aims to outline the importance of Reconstruction of images into 3D models in medicine. Its not a 3D model and reconstruction, it's a life to the patient. Due to this Methodology, Its paves the way to the Doctors or Surgeon to do Quick, Accurate, Confident & Successful Surgery to the Patient. Its an excellent CAD technique to do Reconstruction, imaging, Visualisation, Rapid Prototype Model in a shorter time with more Accurate result

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REFERENCES

[1] Mikell P.Groover " CAD/CAM " Computer Aided Design and Manufacturing.
[2] Petzold R, Zeilhofer, Kalender WA. Rapid prototyping technology in medicine– basics and applications. Computerzied medical imaging and graphics **1999**;
[3] Abdul Kalam APJ. Evolution of technology Vision 2020, India's core competencies. In: Abdul Kalam APJ, Rajan YS, editors. India **2020** A vision for the new millennium 1st Ed. New Delhi: Rekha printers: **1998**. p. 46-58.
[4] Popat AH. Rapid prototyping and medical modeling. Niels moos, editor. Phildias Newsletter. Denmark: **2003**. p. 10-12.
[5] W. Sun, B. Starly, A. Darling, C. Gomez, *Biotechnology and Applied Biochemistry* 39/1 (**2004**) 49-58.
[6] J. Wang, V.M. Gharpuray, R.L. Dooley, Automated 3D Reconstruction of 2D Medical Images: Application to Biomedical Modeling, Proceedings of the 21st Annual Meeting of The American Society of Biomechanics, Clemson University, South Carolina, USA, **1997**
[7] K.L. Chelule, T. Coole, D.G. Cheshire, Fabrication of Medical Models From Scan Data Via Rapid Prototypig Techniques, Staffordshire University, UK, **1999**.
[8] R. Noorani, Rapid Prototyping: Principles and Applications, John Wiley and Sons Inc, **2005**.
[9] Kai, C.C., Jacob, G. G. K., and Mei, T., *International Journal of Advanced Manufacturing Technology*, 13, 566-570, **1997**
[10] Pommert, J. K. et al., "Three Dimensional Imaging In Medicine: Method And Applications", In Computer Integrated Surgery (Eds R.H. Taylor et al.), Ch. 9, 155-174, **1996**.
[11] Ionescu, I.; Conway, T.; Schinning, A.; Almutairi, M. & Nicholson, D.W., Solid Modeling and static Finite Element Analysis of Human Tibia, Summer Bioengineering Conference, Sonesta Beach Resort in Key Biscayne, Florida, **2003**.
[12] Radu, C., Applications of Computer Graphics in a 3D Reconstruction of Human Ankle, 1st International Conference ″Computational Mechanics and Virtual Engineering″ COMEC **2005**, Brasov, Romania
[13] Radu, C., Automatic Reconstruction of 3D CAD Models from Tomographic Slices Via Rapid Prototyping Technology, 10th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology" TMT 2006, Barcelona-Lloret de Mar, Spain, **2006**.