Reconstruction of human femur bone from CT scan images using CAD techniques

To cite this article: Mohammed Khaja Nizamuddin and S. Kirthana 2018 IOP Conf. Ser.: Mater. Sci. Eng. 455 012103

View the article online for updates and enhancements.
Reconstruction of human femur bone from CT scan images using CAD techniques

Mohammed Khaja Nizamuddin1* and S. Kirthana2
1PG Student, Department of mechanical, VCE, Hyderabad, 500031, India
2Assistant Professor, Department of mechanical, VCE, Hyderabad, 500031, India
*nizammohdk@gmail.com

Abstract. From last few years, the development in the area of design and techniques of surgical methods made the surgeons easy to handle the surgeries by reducing the risk of the patient. The main aim of this work is to develop a 3D CAD model of femur bone from CT scan images, which can later be used in 3D printing, the design of implants and replacement of bone. The femur model is developed from 3D Slicer and Blender software. The femur model obtained is saved in STL file format for further processes.

Keywords: Femur bone; CT scan images; 3D Slicer; Blender; STL.

1. Introduction
Development of technology in medical applications made the surgical methods easy by reducing the time factor to cure a patient. Doctors along with engineers worked hard for the better understanding of surgeries.

One of the important issues in surgical operations is the fracture of bones. Sometimes heavy damage of the bones leads to the whole part replacement. To understand the condition of bone weather to replace it or fix it with the implants, a 3D Model of bone is to be generated.

In this paper, a patient-specific femur bone is modeled from CT scan data. The step by step procedure is as follows:

- Collection of dicom images from the hospital.
- Importing the dicom images in 3D Slicer.
- Enabling the volume rendering option to show the 3D view.
- Selection of the type of bone, which removes all the unwanted things like skin, muscles.
- Adjusting the frequency range to get a clear 3D image of the part.
- Cropping the volume to the required part.
- Editing the cropped part, for the better 3D model.
- Adjusting the threshold frequency.
- Enabling model effect option to get a final part.
- This part is saved in STL file format.
- This file is imported into another software called Blender.
- In this software, the nonlinear elements and errors are removed.
- Softening of the part is done to get a better surface finish.

2. **Construction of a 3D model of femur:**

3S Slicer and Blender are the two software’s used in this work for the construction of 3D CAD model of femur bone from the DICOM (Digital Imaging and Communications in Medicine) files or CT (computed tomography) scan images collected from the hospital.

2.1. **3D Slicer**

3D slicer is a free and open source software that is extensively used in clinical or medical applications for the visualization of images.

In this work, 3D slicer is used to build the CAD model of the human femur from the CT scan images collected from the hospital.

The collected DICOM files are imported into this software and necessary editings are done to arrive at the best 3D model of femur bone as explained below.

After uploading the DICOM files and enabling the volume rendering feature we can observe the visualization of the files on the slicer window in 4 views i.e., axial view, three dimensional view, sagittal view and coronal view as shown in figure 1.

![Figure 1. 3D Slicer window showing 4 views](image)

After this, the preset selection is done to select the type of bone. In this work as we have taken CT scan images, so a preset selection of CT bones is selected and it can be observed that in three-dimensional view only bones are visualized removing all the other unwanted material which is shown in figure 2 (a). Another option called shift is used to adjust only bone selection by removing the extra material that is captured at the time of scanning, which is shown in figure 2 (b). After this, cropping is done by using the crop volume module. Here the cropping is done to get the right femur bone of the image. After cropping a new volume is created where further work is carried to get the model built. The cropped new volume is shown in figure 2 (c).
Figure 2. Showing (a) preset selection, (b) shift selection, (c) cropping volume (new volume)

After creating a new volume editing is done from editing module. In the editing module threshold frequency for bone is adjusted to get only the bone part highlighted. After this model effect is applied to get the CAD model of the right femur bone, shown in the figure 3.(a) & (b).
Figure 3. Showing (a) threshold effect and (b) model effect.

From the obtained CAD model it is observed the model is with a lot of obstructions, irregularities and discontinuous as it is already gone for a prosthesis with implantations. So to obtain the best model without any errors paint effect is used in editor module. After using the paint effects the best 3D cad model of right femur is as shown in figure 4.
This obtained model is saved in STL file format as to import the model into blender. The obtained model is with some errors and the surface achieved is rough. To remove this, software called Blender is used.

2.2. Blender

Blender is free and open source software which is generally used for animations. This software accepts only STL file format. Here in this work, the software is used to remove the errors and to achieve the smooth surface finish. The obtained CAD model from 3D slicer is imported into Blender, which is shown in figure 5.
After importing the model, from the selection mode, the continuous and inverted links are selected by vertex selection and the inverted links are deleted to obtain an error-free femur bone without any obstructions which are shown in figure 6. (a) & (b)

![Figure 6](image.png)

**Figure 6.** Showing (a) inverted links & (b) obtained model without errors.

The obtained model has a rough surface finish so to achieve smooth finished model smoothening option is used from object modifiers. After applying the smoothening option the final 3D CAD model of the femur with the good surface finish is shown in figure 7.

![Figure 7](image.png)

**Figure 7.** Final 3D CAD model of right femur with the good surface finish.

The obtained model is exported in STL file format which can be later used for other applications.
3. Conclusion

3D Slicer and Blender software are effectively used for the reconstruction of human femur bone from the patient-specific DICOM or CT scan images. The obtained model is used for further applications like 3D printing of a femur bone to use as a prototype, for carrying different analysis on femur bone, impanation study on femur bone and in other medical applications to ease the surgeries of doctors.

References

[1] N. D. Deokar and Dr. A. G. Thakur. Design, development and analysis of femur bone by using rapid prototyping, International journal of engineering development and research, 2016, ISSN: 2321-9939.
[2] Baradeswaran. A, Joshua Selvakumar. L and Padma Priya. R. Reconstruction of images into 3D models using CAD techniques, European journal of applied engineering and scientific research, 2014, 104(1): 1-8.
[3] George Z. Cheng, Raul San Jose Estepar, Erik Fokeh, Jorge Onieva, Siddhu Gangadharan and Adnan Majid. Three dimensional printing and 3D slicer-powerful tools in understanding and treating structure lung diseases, CHEST, 2016, 149(5): 1136-1142.
[4] Emmanuel Rios Velazquez, Chintan Parmar, Mohammed Jermoumi, Raymond H. Mak, Angela van Baardwijk, Fiona M. Fennessy, John H. Lewis, Dirk De Ruysscher, Ron Kikinis, Philippe Lambin & Hugo J. W. L. Aerts. Volumetric CT-based segmentation of NSCLC using 3D-Slicer, Scientific Reports | 3:3529 | DOI:10.1038/srep035.
[5] Xishi Wang, Tian Ying Wang, Fuchuan Jiang, Yixiang Duan. The hip stress level analysis for human routine activities, Biomedical Engineering Applications, Basis & Communications, 17, 2005, pp.153-158.
[6] D. Bubesh Kumar, Dr. K.G. Muthurajan. Finite Element Analysis of Equivalent Stress and Deformation of Cementless Hip Prosthesis, A Review on Energy Saving Using Green Computing System| ISSN: 2321-9939, pp. 93-97.
[7] 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.
[8] 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.
[9] 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
[10] 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.
[11] Xing Chen, Jesyy K. Possel, Catherine Wacongne, Anne F. Van Ham, P. Christiaan Klink, Pieter R. Roefsenna. 3D printing and modelling of customized implants and surgical guides for non human primates, Journal of Neuroscience Methods 286 (2017) 38-55.
[12] R. Oyama, M. Jakab, A. Kikuchi, T. Sugiyama, R. Kikins , S. Pujol. Towards improved ultrasound based analysis and 3D visualization of the fetal brain using the 3D Slicer, Ultrasound Obstet Gynecol 2013;42:609-610.
[13] Ron Kikinis and Steve Pieper. 3D Slicer as a tool for interactive Brain tumor segmentation, ConfProc IEEE Eng Med Biol Soc. 2011; 6982-6984.
Acknowledgments

The authors would like to thank management and Department of mechanical engineering of Vasavi College of Engineering for providing resources in successful completion of the project.
The authors would like to thank Dr. Shirish Chandra Gampa, MBBS, MDRT, Radiation Oncologist, KIMS Hospitals, Hyderabad, who helped to complete the project by providing the necessary files.