Development of 3D printed model using medical CT scan data with optimum build time

T.N.Aditya[1]
Department of Mechanical Engineering
Chaitanya Bharathi Institute of Technology, Hyderabad, Telengana, India

Dr.Md.Aleem Pasha[2]
Department of Mechanical Engineering
Chaitanya Bharathi Institute of Technology, Hyderabad, Telengana, India

K.Gurubrahmam[3]
Department of Mechanical Engineering
Chaitanya Bharathi Institute of Technology, Hyderabad, Telengana, India

A.Chandrakanth[4]
Department of Mechanical Engineering
Chaitanya Bharathi Institute of Technology, Hyderabad, Telengana, India

Abstract- The work aims at providing a 3 D model of a mandible, by taking medical CT scan data. The scan data is converted to 3D model in the form of STL file using 3D slicer software. The 3D model is then edited to the specific part such as mandible. The model is then imported into Cura software to optimize parameters such as layer thickness, print speed and build orientation.

Keywords – 3D printing, layer thickness, print speed, build orientation.

I. INTRODUCTION

3D Printing or Additive manufacturing is a process in which a material is printed layer by layer. Although there are many ways this can achieved but the basic principle remains same. It involves conversion of 3d model into STL file, which divides object into multiple layers and then the part is printed layer by layer according to the geometry. The most commonly used 3D printing is Fused Deposition Modeling (FDM) as many 3d printers are evolved based on this technology with cheaper price. The use of this technology in medical field is very beneficial as any complex object can be 3d printed as it becomes easy for surgeons to visualize the defects and design implants specific to needs of the patient. Dina Radenkovic has used 3D printing technology for development of organs using CT or MRI Scan data and laid the importance of properties required for the material to be implanted.[1]. Dayeong Hong has studied the effectiveness of 3 different 3D printers based on CT images and also 3d printing of lung model using fused deposition [2]. Rengier.F .et.al has explained the importance of parts which can be graspable with aid of 3d printing and how effective it is in case of visualizations compared to flat screens[3]. Mitsouras, D, et,al. has explained the need for rendering Digital Imaging and Communications in Medicine (DICOM) images as 3D models[4]. Ventola, C. Lee has emphasized on use of 3D printing technology for various organs including hard and soft tissues.[5]. In this work, a 3D model of mandible is designed and optimum parameters for minimum build time is established.

II. METHODOLOGY

2.1 Analysing Medical Data using 3D slicer software

3D slicer software is used to import the medical data. In this case a medical data from the 3D slicer library has been taken . After the model is imported , it is viewed in different views as well as in 3D.Fig 1. Shows the 3 D model of imported part.

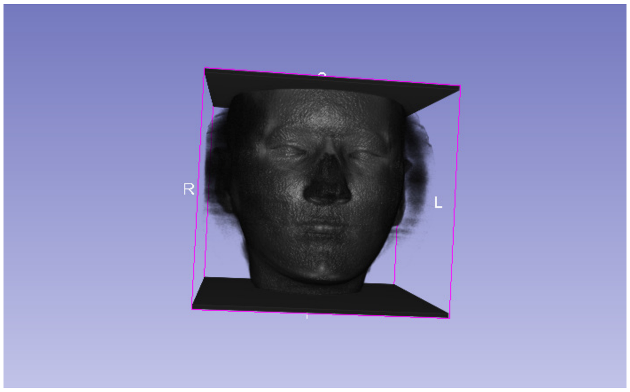

Figure 1. 3D model of imported part

In next stage volume rendering of model is done and preset of CT bone is selected. .Figure 2 shows the model in different views.

.

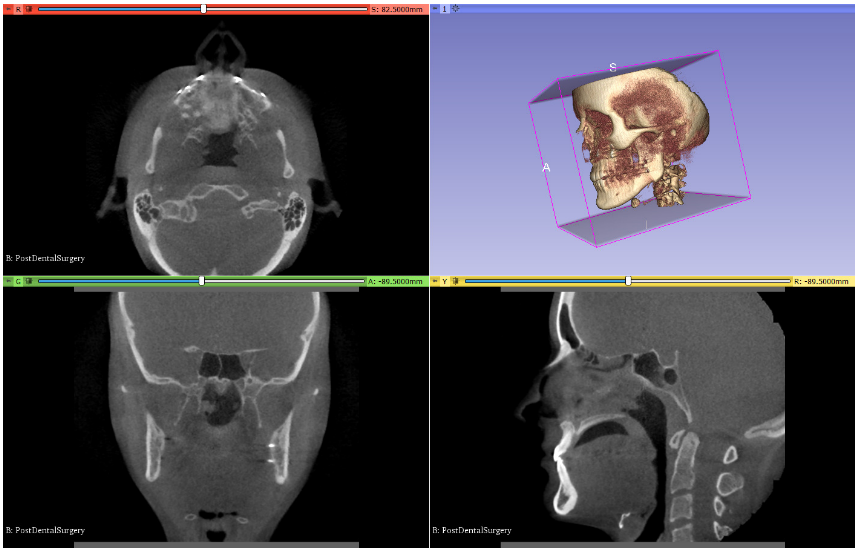

Figure 2. Model in different views

Then process involves segmentation of model to required part.Here mandible part is to be designed,hence segmentation is done accordingly.Figure 3 shows the segmented part.

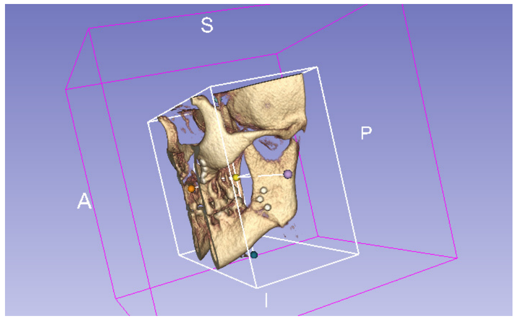

Figure 3. Segmented part

2.2. *Importing segmented model into Cura –*

The segmented model is converted into STL file and exported into Cura software. Figure 4 shows the imported part.

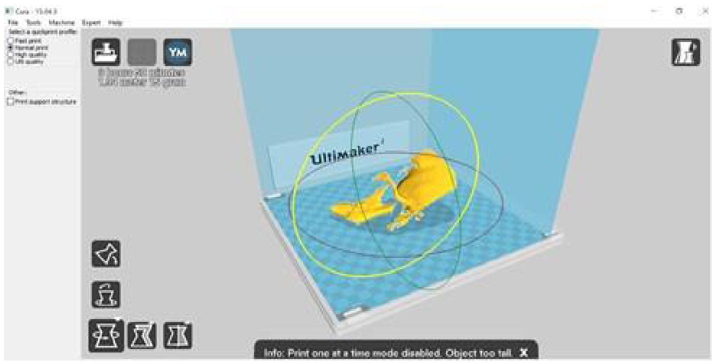

Figure 4. Imported model in Cura

The model can be oriented in different possible ways, the optimum parameters which will lead to minimum build time need to be evaluated.

III. Experiment and Result

The parameters chosen are layer thickness, print speed and build orientation. Three levels for each parameter is selected. Table 1 shows levels for each parameter.

Layer thickness (mm)	Print speed(mm/sec)	Build orientation (angle in deg)
0.1	50	0
0.2	70	45
0.3	90	90

With all the combinations build time is computed. Table2 shows build times for different combination of parameters.

Layer Thickness (mm)	Print speed(mm/sec)	Build orientation (angle in deg)	Build time (hrs)
0.1	50	0	4 hrs 22 min
0.1	50	45	4 hrs 14 min
0.1	50	90	5 hrs 23 min
0.1	70	0	3 hrs 43 min
0.1	70	45	3 hrs 39 min

0.1	70	90	4 hrs 45 min
0.1	90	0	3 hrs 26 min
0.1	90	45	3 hrs 24 min
0.1	90	90	4 hrs 29 min
0.2	50	0	2 hrs 12 min
0.2	50	45	2 hrs 8 min
0.2	50	90	2 hrs 43 min
0.2	70	0	1 hr 53 min
0.2	70	45	1 hr 51 min
0.2	70	90	2 hrs 25 min
0.2	90	0	1 hr 44 min
0.2	90	45	1 hr 44 min
0.2	90	90	2 hrs 18 min
0.3	50	0	1 hr 29 min
0.3	50	45	1 hr 29 min
0.3	50	90	1 hr 53 min
0.3	70	0	1 hr 16 min
0.3	70	45	1 hr 18 min
0.3	70	90	1 hr 40 min
0.3	90	0	1 hr 11 min
0.3	90	45	1 hr 13 min
0.3	90	90	1 hr 35 min

Table 2

The minimum build time of 1 hr 11 min is obtained for layer thickness 0.3, Print speed 90 mm/sec and build orientation of 0 deg.

IV.CONCLUSION

The optimum parameters for the build time are obtained and the model can be 3 d printed and better visualization of part is achieved. Further actual defected part of the patient can be taken and implant can be designed following the procedure explained.

REFERENCES

[1] Dina Radenkovic, Atefeh Solouk, Alexander Seifalian,Personalized development of human organs using 3D printing technology,Medical Hypotheses,Volume 87,2016,Pages 30-33,ISSN 0306-9877.

[2] Hong, D., Lee, S., Kim, G.B., Lee, S.M., Kim, N., Seo, J.B.: Development of a CT imaging phantom of anthromorphic lung using fused deposition modeling 3D printing. Medicine 99(1), e18617 (2020) A. A. Reddy and B. N. Chatterji, "A new wavelet based logo-watermarking scheme," Pattern Recognition Letters, vol. 26, pp. 1019-1027, 2005.

[3] Rengier, F., Mehndiratta, A., von Tengg-Kobligk, H. et al. 3D printing based on imaging data: review of medical applications. Int J CARS 5, 335–341 (2010).

[4] Mitsouras, D., Liacouras, P., Imanzadeh, A., Giannopoulos, A. A., Cai, T., Kumamaru, K. K., ... & Rybicki, F. J. (2015). Medical 3D printing for the radiologist. Radiographics, 35(7), 1965-1988..

[5] Ventola, C. Lee. "Medical applications for 3D printing: current and projected uses." Pharmacy and Therapeutics 39.10 (2014): 704.

[6] Bertassoni L, Cecconi M, Manoharan V, et al. Hydrogel bioprinted microchannel networks for vascularization of tissue engineering constructs. *Lab on a Chip.* 2014;14(13):2202.

[7] Gross BC, Erkal JL, Lockwood SY, et al. Evaluation of 3D printing and its potential impact on biotechnology and the chemical sciences. *Anal Chem.* 2014;86(7):3240–3253

[8] Ursan I, Chiu L, Pierce A. Three-dimensional drug printing: a structured review. *J Am Pharm Assoc.* 2013;53(2):136–144..

[9] Sun S, Wu C (2004) Using the full scale 3D solid anthropometric model in radiation oncology positioning and verification. Conf Proc IEEE Eng Med Biol Soc 5: 3432–3435Tek P, Chiganos T, Mohammed J, Eddington D, Fall C, Ifft P, Rousche P (2008) Rapid prototyping for neuroscience and neural engineering. J Neurosci Methods 172: 263–269

[10] Suzuki M, Ogawa Y, Kawano A, Hagiwara A, Yamaguchi H, Ono H (2004) Rapid prototyping of temporal bone for surgical training and medical education. Acta Otolaryngol 124: 400–402.

[11] Knox K, Kerber C, Singel S, Bailey M, Imbesi S (2005) Rapid prototyping to create vascular replicas from CT scan data: making tools to teach,rehearse, and choose treatment strategies. Catheter Cardiovasc Interv 65: 47–53

[12] Jamróz, Witold, et al. "3D printing in pharmaceutical and medical applications–recent achievements and challenges." Pharmaceutical research 35.9 (2018): 1-22.

[13] Yan, Qian, et al. "A review of 3D printing technology for medical applications." Engineering 4.5 (2018): 729-742.

[14] Choonara, Yahya E., et al. "3D-printing and the effect on medical costs: a new era?." Expert review of pharmacoeconomics & outcomes research 16.1 (2016): 23-32.

[15] Tappa, Karthik, and Udayabhanu Jammalamadaka. "Novel biomaterials used in medical 3D printing techniques." Journal of functional biomaterials 9.1 (2018): 17.