Avrupa Bilim ve Teknoloji Dergisi
Cilt. 3, No. 6, S. 3-5, Aralık 2015

Araştırma Makalesi

www.ejosat.com ISSN:2148-2683

European Journal of Science and Technology
Vol. 3, No. 6, pp. 3-5, December 2015

Research Article

Manufacturing of a Hand Bone Structure From CT Scan Data by Using 3D FDM Desktop Printer

Yılmaz GÜR[1*]
[1] Balıkesir University, Mechanical Engineering Department, Balıkesir, Turkey

Abstract

The aim of the study presented here is to fabricate a model of a patient's anatomical hand bone structure from CT scan data by using a 3D FDM desktop printer. This model can be used for pre-operative planning, to produce customised implant or medical teaching purposes. A case study is considered by in order to show the capability, flexibility and potential of the FDM technology in the medical field.

Keywords: Anatomical model**,** Additive manufacturing, 3D printer, Fused deposition modelling.

3B FDM Masaüstü Yazıcı Kullanarak CT Tarama Verilerinden El Kemik Yapısı Üretimi

Öz

Burada sunulan çalışmanın amacı 3B FDM masaüstü yazıcı kullanarak CT tarama verilerinden hastanın el kemik yapısının bir modelini elde etmektir. Bu model ameliyat öncesi planlama, kişiye özel implant üretimi için veya tıbbi eğitim amaçlı kullanılabilir. FDM teknolojisinin tıp alanındaki potansiyelini, esnekliğini ve yeteneğini göstermek için örnek bir vaka çalışması yapıldı.

Anahtar kelimeler: Anatomik model, Eklemeli üretim, 3B Yazıcı, Eriyik birikim modellemesi.

1. Introduction

Fused Deposition Modelling (FDM) technology is a layered additive manufacturing process which uses thermoplastic material such as ABS (Acrylonitrile Butadiene Styrene) and PLA (Polylactic Acid) to produce concept models, functional prototypes, manufacturing aids and low volume end-use parts. The FDM process begins by slicing 3-D CAD data into layers. Then the data is transferred to a desktop 3-D printer. The thermoplastic material is uncoiled slowly and extruded through heated extrusion nozzle. The material is precisely laid down upon the precedent layers. Following each sequence the building platform is lowered down by the thickness of one layer while the extrusion nozzle continues to move in a horizontal X-Y plane. The process is repeated, adding layer upon layer, until the object is finished (see Fig.1) (Hull, 1986, Crump, 1992, Giannatsis and Dedoussis, 2009). In this step, travel movements of the extrusion nozzle and if necessary support structure to hold the part upright position on the building platform and to support leaky connections, overhangs, cavities and bridges, are also generated. Once the part is completed these support scaffoldings can be removed off by hand. The slicing information is then exported to "x3g" file format that 3-D FDM printer can understand to print the model. FDM is utilised in a number of industries such automotive, aerospace, industrial engineering and medical world (Petrovic et al., 2012).

2. Building 3D Model from CT Scan Data

Computed tomography (CT) is an imaging process which uses X-ray to capture detailed pictures of areas inside the body (NCI, 2015). 113 DICOM files that obtained from the CT Scanning procedure are processed in 3D Slicer v4.2.2.1 software (Fedorov et al., 2009) during the hand bone stripping process (see Fig. 2). 3D Slicer, which is a multi-platform free and open source software package for visualisation and medical imaging, is used for elimination of soft tissues and stripping of hand bone structure.

[*] **Corresponding author: ygur@balikesir.edu.tr**

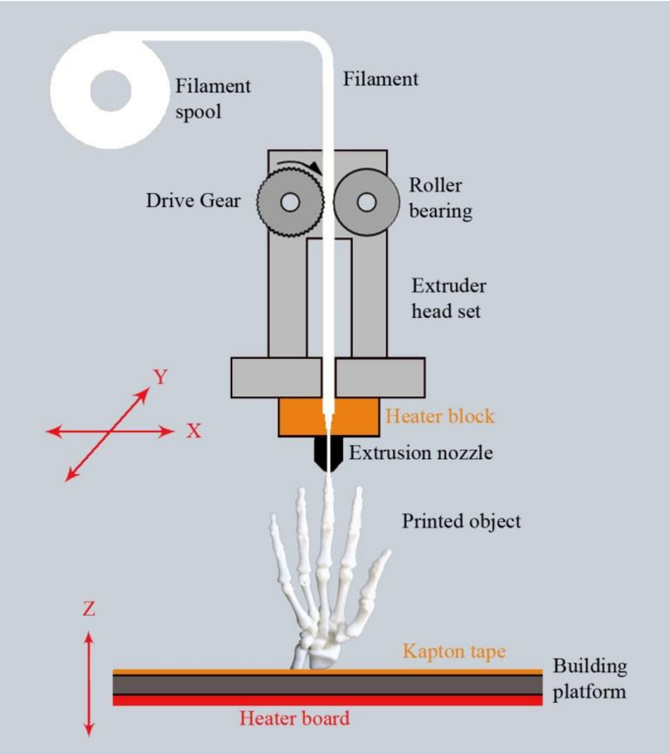

Figure 1. Fused deposition modelling process (Gür,2014)

3D Slicer has exporting facility of 3-D models as STL file format that is rapid prototyping's standard data transmission format to fabricate physical object of an anatomical model by using a rapid prototyping technology. The ".STL" file is further processed in open source MeshLab (MeshLab, 2014) processing and editing of unstructured 3-D triangular meshes software in order to remove floating substances not attached to the anatomic model and for smoothing (see Fig. 3).

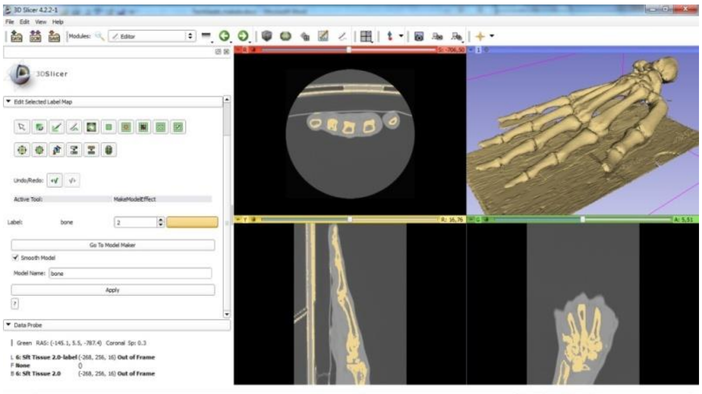

Figure 2. Hand bone stripping in 3D Slicer medical imaging program.

2.1 Manufacturing of the Hand Bone Structure

The anatomical hand bone model is printed on a FlashForge Creator 3-D FDM printer which is in the department of mechanical engineering of Balikesir University.

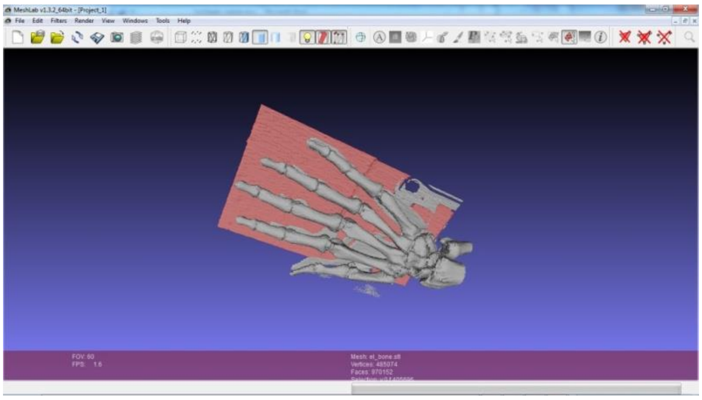

Figure 3. Removing of floating substances in MeshLab.

It uses fused deposition modelling principle. Layer thickness can be changed between 100 µm and 250 µm. As a building material Acrylonitrile butadiene styrene (ABS) $((C_8H_8)_x \bullet (C_4H_6)_y \bullet (C_3H_3N)_z)$ thermoplastic is used. Filament diameter it accepts is 1.75 mm. Open source MakerBot® MakerWare™ v2.4 3-D printing software [9] is used for pre-processing and slicing of the anatomical model. Initially, the hand model is located on the building platform, scaled to 1:2, and orientated. In the slicing step of the anatomical model, MakerWare™ slices the 3-D model into finite number of layers. In this case, 883 layers have been generated by the MakerWare™ slicing software (see Fig. 4).

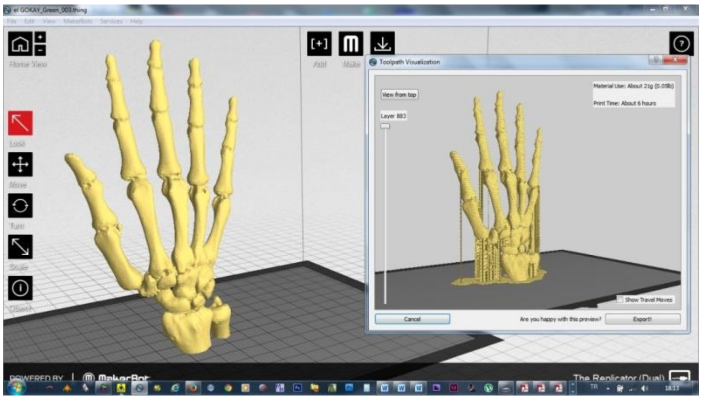

Figure 4. Slicing of the hand bone in MakerWare™ slicing - printing software.

The thickness of the each layer for the model is 150 µm. This slicing step not only contains slicing procedure but also consists of generating travel movements for the extrusion nozzle and model support structure that holds the model upright position and prevent the leaky connections, overhangs, bridges, internal cavities. The anatomical model requires support structure (see Fig. 4). For the creation of the model 21 g (including support material) ABS thermoplastic was consumed and building time took about 6 hours. The building platform of the 3-D printer heated up to 110 ºC before printing because ABS thermoplastic does not stick onto the building platform. On the other hand, the extrusion nozzle heated to 230 ºC in order to make flow the ABS thermoplastic smoothly. The hand model fabricated in the department of the University of Balikesir is presented in Fig. 5. Following the production of the anatomical model, support structures are removed by hand.

Figure 5. 3D FDM printed case study hand model

3. Conclusion

In this paper, the manufacturability of anatomical models from 2D Digital Imaging and Communications in Medicine (DICOM) CT scan data by a desktop 3-D FDM printer is validated. The case study showed that intangible digital medical data comes to life as a tangible object through the fused deposition modelling method.

Acknowledgements

The work described in this paper is supported by the Balıkesir University's Scientific Research Projects Unit through the Project No: Mak. BAP: 2013.96.

References

Crump, S.S., (Filed: Oct. 30, 1989 – Date of Patent : Jun. 9, 1992): U.S. Patent 5121329 "Apparatus and method for creating three-dimensional objects" U.S.Class: 364/468, ASSIGNEES: Stratasys, Inc., Minneapolis, MN.

Fedorov, A., Beichel, R., Kalpathy-Cramer. J., Finet. J., Fillion-Robin. J.C., Pujol. S., Bauer. C., Jennings. D., Fennessy. F., Sonka. M., Buatti. J., Aylward. S.R., Miller. J.V., Pieper. S., Kikinis. R., (2009): 3D Slicer as an Image Computing Platform for the Quantitative Imaging Network. Magn. Reson. Imaging., 30(9):1323-41. PMID: 22770690, DOI: 10.1016/j.mri.2012.05.001

Giannatsis, J., Dedoussis,V., (2009): Additive fabrication technologies applied to medicine and health care: a review, Int. J Adv. Manuf. Technol, 40, pp.116-127.

Gür, Y., Additive Manufacturing of Anatomical Models from Computed Tomography Scan Data, MCB: Molecular & Cellular Biomechanics, Vol. 11, No. 4, 2014, pp. 249-258.

Gurjar B.R., Butler T.M., Lawrence M.G., Lelieveld J. 2008. Evaluation of emissions and air quality in megacities. Atmospheric Environment 42, 1593-1606.

Hull, C.W., (Publication Date: 3/11/1986): U.S. Patent 4575330, "Apparatus for Production of Three-Dimensional Objects by Stereolithography".

MakerBot® MakerWare™ 3-D printing software. (Accessed : 30.09.2014): Retrieved from http://www.makerbot.com/support/makerware/documentation/slicer/

MeshLab, (2014): http://meshlab.sourceforge.net/, Visual Computing Lab – ISTI –CNR.

National Cancer Institute (NCI), (Accessed on 10.04.2015): Computed Tomography (CT) Scans and Cancer, http://www.cancer.gov/cancertopics/diagnosis-staging/ct-scans-fact-sheet.

Petrovic, V., Haro, J.V., Blasco, J.R., and Portolés, L., (2012): Additive Manufacturing Solutions for Improved Medical Implants, Biomedicine, Dr. Chao Lin (Ed.), ISBN: 978-953-51-0352-3, InTech.