

Three Dimensional Printers and Their Usage

3 Boyutlu Yazıcılar ve Kullanımı

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Review

Abstract: Developing technology appears as a dynamic fact in all fields which may increase the quality of life and widen the comfort zone of people in the world we live in. This dynamism leads people to constant development, change and innovation. The innovative and entrepreneurial characteristic of humans is an undeniable reality. Three-dimensional printing technologies have started to gain an important place in our lives thanks to their condition caused by entrepreneurship. Three-dimensional printing operation is the acquisition phase of three-dimensional concrete and solid objects from a three-dimensional file prepared in computer environment through different graphic design programs.

Keywords: Three dimensional printer, filament, technology, medical, health field, modeling, slicer

Özet: Üç boyutlu yazdırma işlemini en basit haliyle anlatmak istersek, bilgisayar ortamında oluşturulan üç boyutlu dosyadan, üç boyutlu katı obje üretme süreci olarak tanımlayabiliriz. Günümüzde 3 boyutlu yazıcı teknolojisi birçok sektörde ve alanda kullanılmakta, her geçen gün kullanım alanları genişlemektedir. Tıp ve sağlık, eğitim, havacılık, endüstriyel imalat, mimarlık ve inşaat, tekstil, gıda ve hobi alanlarını örnek olarak gösterebiliriz. Bu çalışmada 3 boyutlu yazıcıların çalışma prensibi, kullanılan materyaller ve sağlık alanına katkıları incelenmiştir

Anahtar Kelimeler: Üç boyutlu yazıcı, filament, teknoloji, medikal, sağlık alanı, modelleme, dilimleyici

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1. Introduction

Developing technology appears as a dynamic fact in all fields which may increase the quality of life and widen the comfort zone of people in the world we live in. This dynamism leads people to constant development, change and innovation. The innovative and entrepreneurial characteristic of humans is an undeniable reality. Three-dimensional printing technologies have started to gain an important place in our lives thanks to their condition caused by entrepreneurship [1, 2].

Three-dimensional printing operation is the acquisition phase of three-dimensional concrete and solid objects from a three-dimensional file prepared in computer environment through different graphic design programs. In other words, it is a quick prototype manufacturing operation in which you can transform three-dimensional objects into tangible objects. The machines producing the objects are called three-dimensional printers. Three-dimensional printer is a machine which transforms computer data into a physical, real and tangible object [1,2].

The piece or pieces to be manufactured should first be modeled and drawn on three-dimensional design programs to perform three-dimensional printing. These modelings can be conducted through computer-aided professional three-dimensional softwares such as Blender, 3DS MAX, AutoCAD and web-based design softwares such as Tinkercad and SketchUp [7,8]. Following its designing and drawing, the model is first exported and recorded and a file is formed on the computer. The file forming the model is generally saved as a file with OBJ or STL extension and is transferred to three dimensional printing editing and slicing program. The model is sliced and layered by this program and a "gcode" file in a language which can be understood by the three-dimensional printer is formed. Gcode is a software language transmitting the three-dimensional printer a lot of information such as which route should be followed at which pace at coordinate plane, transforming our 3D model into a software language understandable by the machine to perform three-dimensional printing. Printing operation is performed through transferring the formed gcode file to the three-dimensional printer through USB drive, memory card or wireless network. In three-dimensional printing operation, the object is formed through piling up in layers [5, 8].

2. Three Dimensional Printer Types

Three different three-dimensional printing technologies are commonly used today. These are FDM (fused deposition modeling), SLA (stereolithography) and SLS (selective laser sintering) technologies. FDM technology is the most

commonly used manufacturing method for prototypes and end-products due to comfort of use and lower cost. FDM is a printing method in which the material advanced through extrusion (filament) is heated at an adequate level and sprayed from the thin end called nozzle and its upward piling up in layers. Starting from the table and moving the nozzle upwards on x, y and z axis through the guide and shafts, a solid object is formed. Nozzles may have different shapes and dimensions but all have the same function. 0.4 mm nozzles are most commonly used. Different nozzle types extending up to 1.2 mm are available. Minimum spraying nozzles are 0.15 mm and their calibration and use are difficult but they provide good results for very complicated printings [4,5].

The first three-dimensional printer was developed by Charles Hull in 1984 using stereolithography (SLA) technology. Three-dimensional printer technology has rapidly developed since 1984. Its large scale covers many different fields such as automotive, health sector, hobby products and medical materials.

2.1. Operation

Printing operation in three-dimensional printers is performed when the 'extruder' section of the printer which we can define as the head section of the printer reaches adequate temperature. To perform printing operation, the filament should reach adequate temperature in extruder and melt down. Filament leaving the nozzle in liquid form hardens and solidifies upon reaching the printer table. This operation continues until all horizontal and perpendicular layers are machined and thus 3-dimensional printing operation is completed. [4, 5]

3. Materials (Filaments)

Filament is the raw material used by three dimensional printers while printing. It is thermoplastic and has many filament types with different characteristics and should be operated at different temperatures. The quality and diameter of the filament and even the moisture of the environment are factors directly affecting the printing quality. Filaments have two different preferred diameters as 1.75 and 2.85.

3.1. Filament Types and Characteristics

PLA, ABS, Flex, TPU and PETG are the mostly preferred filament types for three dimensional printing operations. PLA and ABS are the most commonly used ones among these types.

3.1.1. PLA (Polylactic Acid) Filament

Polylactic Acid (PLA) is known as the filament type with organic root. PLA filament type is the most commonly preferred type especially in domestic three dimensional printers. PLA is more ecological compared to many other filament types and has a rigid and robust structure. Printing temperature range is between 190-220 centigrade degrees. Printer table temperature should be within the range of 60 and 70 centigrade degrees. PLA filament can be used for printing products contacting human body since it is not unhealthy. With its bright surface which is appealing to the eye, it is a type also preferred in hobby products [5, 6].

3.1.2. ABS (Acrylonitrile Butadiene Styrene) Filament

One of the two most commonly preferred filament types, ABS filament is a little bit harder to print than PLA. This is caused by the raw material characteristics of ABS filament type. But ABS is a filament type which is superior to PLA in many aspects. Printing operation is performed with high temperature and has high durability. It has low flexibility and the printing temperature is between 230-260 centigrade [5, 6].

4. Use o Three-Dimensional Printers in the Field of Health

A comprehensive research showed a large scale of usage areas for three-dimensional printers. They are used in many fields such as engineering, health, hobby and entertainment and education [3, 9].

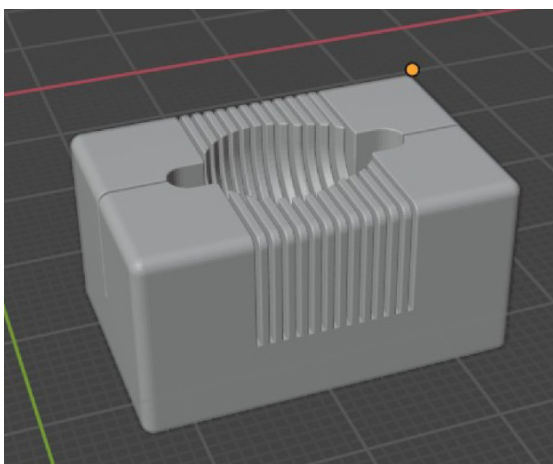


Figure 1. Mouse Brain Matrix Coronal 3D Model

Medical and health sector is among the most common usage areas of three-dimensional printing technology. Even the risky operations can be performed using three-dimensional models with a patient-specific design. [3, 9, 10] Patient tomography files are scanned through different programs and anatomic models are acquired through transforming them into a 3-dimensional file. These models provide many educational and practical advantages. Individual medical and surgical products and prostheses for face and limbs such as arm and leg can be made with the help of these printers. Apart from these, dental implant applications in oral and dental health field and tooth alignment objects are among the most commonly used applications. Three-dimensional printers are also commonly used in soft tissue manufacturing, cell print-out and also the manufacturing of products like biomedical materials. [11-12].

5. Mouse Brain Slicer Model Design and Printing Operation

Slicer object was designed with three dimensions using Blender program among the most preferred three-dimensional design programs. A rectangular object with a length of 6 cm, a width of 4 cm and a height of 3 cm was formed. Equal vertical cuts were made downwards on a width of 4cm to give the object its slicer form and 12 walls of 12 mm were formed. 6 cm height of the object was vertically cut in two equal parts. Giving a downward oval slope to the middle section, the object was hollowed and the slicing modeling was completed. (Figure 1)

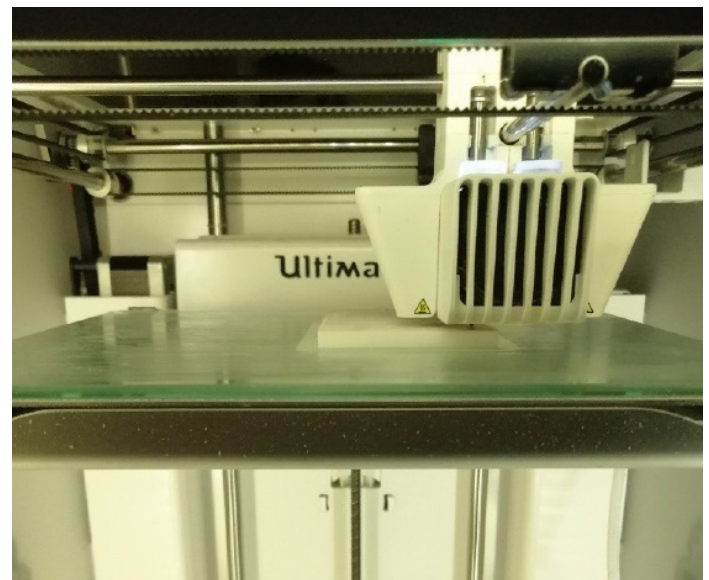


Figure 2. 3D Printing Process in Ultimaker 3 Extended

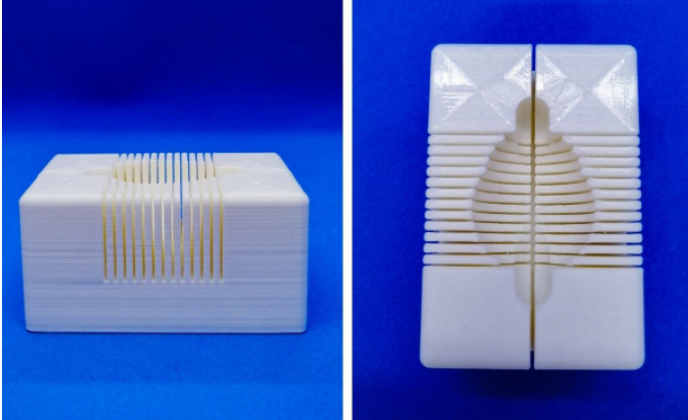


Figure 3. Mouse Brain Matrix Coronal 3D Printed Model

The model was exported and recorded in stl format and was transferred to “Cura” program which slices and layers three dimensional models and transforms them into gcode. The printing quality, flow rate, inner core density, printing speed and similar adjustments were made on Cura. As PLA type filament should be used, the slicing was performed by adjusting extruder to a temperature of 200 centigrade and printing table to 50 centigrade and was recorded in gcode. Then gcode file was transferred to Ultimaker 3 Extended branded device using usb drive. Using white colored PLA filament material with a diameter of 2.85 mm with this device and passing it through the nozzle with a 0.4 mm end, the printing operation lasting nearly four hours was performed.

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