Rapid filament prototyping of a bionic hand

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Abstract. No matter how we call it: additive manufacturing, fast manufacturing, fast prototyping, fabrication in layers or DMF (desktop manufacturing) manufacturing, 3D printing is rapidly developing due to the diversity of applicability areas. In this paper, we would like to introduce the way of realizing a bionic hand that imitates human hand movements with the help of the 3D printer. The actual function that can perform is the movement of the finger segments for closing and opening the fist. The imprint was made using the Creality 3D Direct Store 3D Ender 3 3D Printer Original. As components, we have the handprint, the print of servomotor holder, the Arduino uno board, the breadboard, 5 actuators, male jumpers and fishing thread for ligaments. For programming, the integrated development IDE environment based on the Processing project has been used, which includes support for the C and C ++ programming languages.

1. Introduction

The quick prototyping or additive manufacturing has been born to obtain rapid results. Prototyping has always been the expression of efficiency, as it is more advantageous to study and analyze a prototype and to launch at the production of the product rather than to simulate and the physical realization of the product to present problems.

In the present paper, it is desired to present a case study, namely obtaining a bionic hand on a fast filament printer.

There is an explosion of interest by the general public in 3D printing. 3D printing is also known under other names, more or less similar, such as additive manufacturing, fast manufacturing RM (rapid manufacturing), or rapid prototyping (RP). Other less used names are digital manufacturing, digital fabrication, layered manufacturing, or desktop manufacturing.

In recent years, engineering has taken a considerable dynamism, using increasingly powerful computers and mechatronic products becoming indispensable to the technique.

Increased competition has intensified, customer tastes can change very quickly, and the desire for a product to have an attractive look, to be innovative and with proper functionality is more significant than ever.

In obtaining prototype products, the basic is a CAD system that offers the possibility to design, simulate, and then print the desired product. A CAD system uses various data elements and structures to define a detail, but geometry is only part of the data being retained, followed by material, surface quality, production cycle, etc.

The rapid prototyping is a technological process in contrast to abrasive processes such as erosion, drilling, polishing and so on. This process is a generative or addition of material by which a product is formed by the addition of bulking elements as opposed to abrasive products through which the product is made by removing the material, [1].

The term rapid prototyping is most used to describe this generative process, even if it is not the most correct in terms of semantics.

More precisely, rapid prototyping is processes that are added to 2D contours of constant thickness. The layer is contoured in an x-y plane on two dimensions, the third dimension will result from the set of layers deposited on each other, but there will be a constant coordinate z. Thus, the models are made up of 3D parts arranged exactly on the working plane in the direction x-y which more accurately copies the desired product as the advance in the z direction is made in several layers.

Rapid prototyping can produce both positive and negative patterns. Negatives are molds and dies to produce other positive ones, this process being called a generative process of tooling or rapid prototyping of tools.

2. Imprinting using two 3D prototyping techniques: powder printing and filament printing

The primary purpose of a prototype is to serve as a support for testing certain aspects or features without cost and time. It will not be developed into a final product, but it provides information needed for iterative design, performance evaluation, study of errors and improved product. To obtain the desired product several rapid prototyping procedures has been studied starting with a study of FDM print job with a Zprinter 650 printer.

2.1. Imprinting using the 3D Zprinter printer

Typically, 3D printers do not offer greater precision and durability of a completed prototype, but the mechanical properties of these prototypes are sufficient to cope with design and product development.

For the study of printing, it was taken into consideration the 3D printer from Z Corporation, one of the simplest "jet" printers - the so-called Fused Deposition Modeling (FDM), figure 2. The FDM idea is very simple - the dispensing head pushes the heated droplets of the thermoplastic onto a cooling platform (as virtually any industrial thermoplastic material can be used as a material). The droplets solidify and stick together, forming the layers of the future object (printing is also in layers). The FDM process technology allows the production of finished and ready-to-use (with a minimum thickness of 0.12 mm) precision parts with large gauge sizes (up to 600 x 600 x 500 mm). The basics of this technology were developed in 1988 by Scott Crump.

Z Corp's 3D printing technology supports all major 3D formatted files, including STL, WRL, ply, and SFX files which can be exported.

Minimum element thickness: 2.5 mm the objects printed 3D in composite powder has the consistency of the ceramic and its hardness is determined by the application in question. It is suitable for design objects, prototypes and for studying the shape. The thickness of the walls is recommended to start from 2.5 mm.

Figure 1 Zprinter 3D [2]

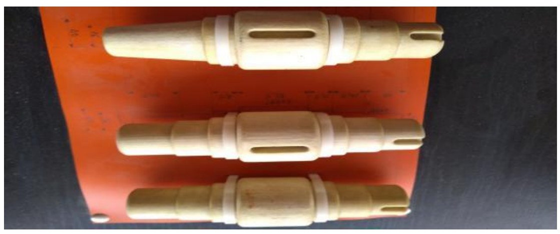

Figure 2 Case Study

We have done some projects on this printer to study the strength of the product and to see if we can print without the need for a support material on the geometry of the product. Due to the material from which the printed material is produced, we do not have the flexibility that we need to obtain a bionic hand. So, we gave up this system and switched to filament printing.

2.2. Printing using the Big Printing Bed High Precision print 3d Reprap Prusa i3 DIY 3d printer

Regardless of the print process, we always discuss composing the final object layer by layer. The process is slow, lasting at least several hours for an average complexity object. Under no circumstances, we are talking about fast printing in seconds, as is the case with a traditional printer. FDM models are plastics that are heated, melted, and laid in layers on the print platform using a three-dimensional digital model.

If we put the cost in the 3D printing in the balance of an ordinary object vs. purchase, we will most often find that the cheapest is to buy the product directly from the store. There are many steps to go before it is cheaper to print a plastic dish, so the advantages of 3D printing are quite different at the moment.

For our study, we used Reprap Prusa i3 DIY 3D Printer, figure 3.

When we chose it, it was taken into account:

- The volume and print area. The maximum print speed is expressed in width x depth x-height, with values in centimeters or millimeters. The volume is sufficient for the prototype.

- The print speeds. This depends not only on the machine's ability to heat and place the plastic filament on the surface of the object but also on its complexity (number of layers, corners, lines, and geometric details).

- The resolution - The quality of the final object is influenced by its number of layers and their thickness. A small resolution object will look like a 3D game from the beginnings of computers, meaning pretty pixelated. The higher the resolution is the resulting objects will have finer margins to touch, but the print speed decreases considerably.

- The extrudes - is the assembly of the melting nozzle, the motor that forces the filament through the nozzle, a temperature sensor and the cooling system. A 3D printer with more extruders will print faster and allow the use of different color materials in the same time.

- Connectivity

- The LCD display showing your machine's current status.

- The control software - is a very important component of the printer. Ease of use of the printer control program is very important because we usually talk about a complexity of the process higher than paper printing. Additionally, mistakes in the commands will be seen sometimes after hours of printing, when you will already have consumed a lot of material and precious time.

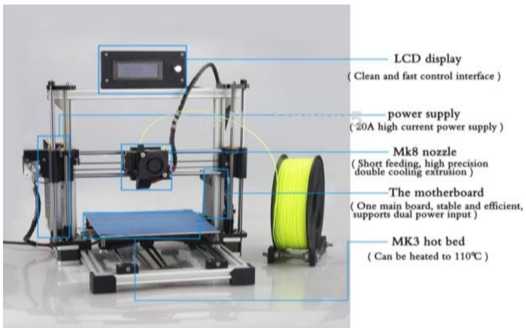

Figure 3 Big Printing Bed High Precision print 3d Reprap Prusa i3 DIY 3d printer

The filaments that can be used on this printer are:

- PLA (Polylactic Acid) is a thermoplastic material classified as polyester plastic. This is the most common 3D printing material. The PLA filament is easy to print 3D and is biodegradable. There are many different colors and varieties, and almost every filament manufacturer in the market deals with PLA production. Also, its properties allow the addition of other materials such as metal powders, hemp, coffee or wood. Acrylonitrile Butadiene Styrene (better known ABS) is the second most popular 3D printing filament. This thermoplastic is inexpensive, durable, lightweight, and easy to extrude - making it perfect for 3D printing. It's the same plastic used in LEGO parts and bicycle helmets. But there are drawbacks in using the ABS filament. This requires a higher temperature to reach the melting point, usually in the range of 210 ° C to 250 ° C. Moreover, a heated bed is required. This prevents the first layers of printing from cooling too quickly so that the plastic does not deform and collapse before the object print is finished. Another disadvantage of this 3D printer filament is the intense smoke that occurs during printing. The smoke can be dangerous for people (or pets) causing breathing difficulty.

3. Obtaining the bionic hand

3D printing is used in the medical industry to obtain 4D-printed artificial muscles, tissues with blood vessels, cheap prosthetic parts. The 3D printing opens a completely new way for people to advance their fields and provide patients with really useful alternatives for traditional medicine.

We did not want to get a prosthetic hand, but we just tried to get a bionic hand to study the conception, the print and the mobility of the product. In its realization we started from the examples on the internet, such as the baby's prosthetic hand in figure 4.

Figure 4 Prosthetic hand [3]

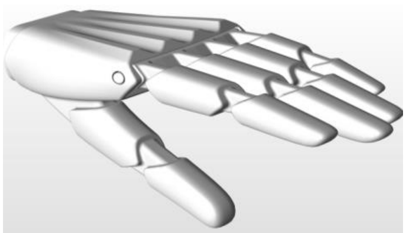

Figure 5 Hand drawing

It is known that the human hand has its bones, tendons, cartilage, nerves that work together for its mobility. In a robotic hand we have to replace all this with something that will allow us as natural as possible and as much mobility as possible.

For the 3D printing, parts of the hand: fingers, palm, wrist, and arm are all 3D printed.

The desired function is to move the finger segments to close and open the fist.

To achieve the goal, he following steps have to be followed:

- For this the drawing in Fusion was made and translated for the printer's software to make the imprint. The print lasted about 12 hours, because a better resolution was wanted, figure 5.
- Performing the support for servomotors using 3D printing too
- An Arduino plate has been used
- Breadboard
- 5 servomotors
- Male Jumper
- Fishing thread as tendons
- Making connections between Arduino uno, breadboard and servomotors
- Creating and loading the program for Arduino uno

The electric servomotor was chosen because it has the role of transforming an electric control signal into an electromagnetic torque, or in a rotating motion of its shaft, through which the mechanism that performs the desired operation is trained. Thus, they are included in automatic control systems as execution elements, working in a wide variety of conditions both in terms of load character, speed, power, voltage and frequency. I got the hand out of the figure 6.

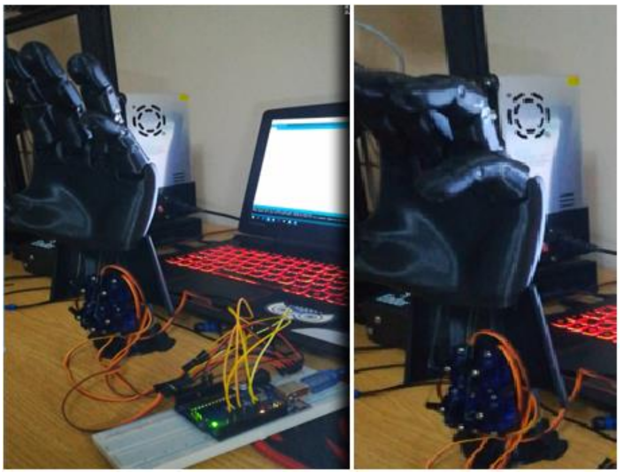

Figure 6 Bionic hand

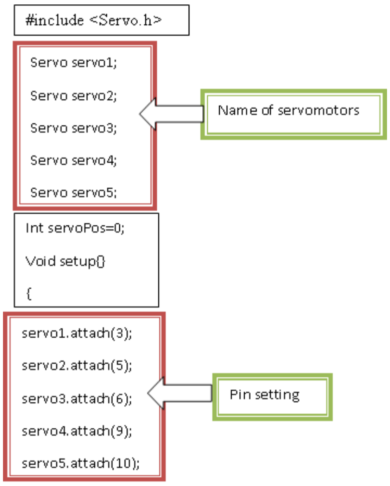

Figure 7 The current running program on Arduino Uno

The programming of the Arduino Uno board was done with the software offered by Arduino and can be seen in figures 7.The print quality was given by the number of layers in a print. The height of the layer is measured in microns. To achieve high resolution, thin layers should be used. With high-resolution printing, the subject's layers become difficult to observe, as they can be printed just as thin as a sheet of paper at a thickness of only 100 microns. The objects achieved have a lower resolution and thicker layers. They seem hard by touch and contain layers that are slightly more visible to the naked eye, similar to the rings of a tree or the texture of a vinyl disc. We have obtained a good resolution with a figure-like support that allowed the "tendons" to bind to the control plate.At the beginning satisfactory results were achieved, but the project is constantly developing.

4. Conclusion

The conclusion of our study to date is as follows: For the realization of a bionic hand, 3D filament printing is the most advantageous, as texture, resilience and mobility. Printing does not require support brackets and the combination of the printed model with the Arduino plates is a happy one, the connection is easy to make and the results are spectacular. The Arduino open-source programming allows appropriate programming for the intended purpose.

Even if we are still studying and wanting to get movements as close as possible to a human one, the phase we have reached gives us hope to use the prototype to obtain a functional didactic robot using the same procedure.

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