A Novel Prosthetic Hand Support for Physically Disabled

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Abstract: Prosthetics is that area of medical industry which deals with artificial limbs. These are used for those who lost their limbs. But there are many people who have their limbs and cannot use them due to neurological disorders. The current work aims at achieving a solution to the people who have neurological Disorder problem by using Additive manufacturing technology i.e. 3D Printing. The mechanism is initially modeled in Pro/Engineer. The models are then fabricated in 3D printing using PLA material.

Keywords*: Prosthetics, 3D Printing, PLA, Additive Manufacturing, Fused Deposition Method (FDM)*

1. INTRODUCTION

Prosthetics is area of large importance in Medical industry. There are many physically challenged persons who require artificial limbs and a lot of work is performed in this region. The work in the area of prosthetic arm design is detailed by Paul Ventimiglia [11]. He summarized the work and presented designs of various existing prosthetic hands. He also suggested a new design having articulated fingers and motorized joints. All the work detailed in his thesis shows that the existing prosthetic arms are for those who lost their limbs. But there are many people who have their limbs and yet cannot use them due to neurological disorders. The aim of the current work is to make use of now emerging Additive manufacturing technique i.e. 3D printing for generating a solution to the foresaid problem.

A lot of research is performed in the area of 3D printing in both industries as well as universities. Proto Labs [15] explored injection molding, CNC machining and additive manufacturing (3D printing), and weighed each technology's strengths and weaknesses relative to prototyping and low-volume production for the medical industry. According to this paper,a medical device developer typically will use 3D printing to identify design flws, make changes and then make second-generation machined parts or invest in tooling to create injection-molded parts. Use of Stereolithography (SL), Selective laser sintering (SLS), Direct laser sintering (SLS) are discussed. 3D Systems [13] discussed 3D printing applied to product design. Siddharth Bhandari, et al [3] gave a detailed introduction to 3D printers and their applications. Willis Karl, et al [10] illustrated with examples, the use of 3D printing for generating optical elements, printed Optics, embedded in interactive devices to display information and sense user input, light tubes and optical sensors. STRATASYS DIRECT MANUFACTURING [14] gave detailed discussions regarding the materials used for 3D printing. Applications of the same are also presented in their article. Mcor Technologies Ltd [6] discussed the use of paper as build material for 3D printing. Selective Deposition Lamination (SDL) is used during this process. The advantages and applications of this material for various materials are discussed in this paper. Ashok Khanna, et al [12] of TCS presented the advantages, Outcomes and Challenges of 3D printing in Medical Industry in their articles.

Dr. Shyam Thangaraju, et al [4] discussed the application of 3D printing the area of medicine. These include precise arrangement of human embryonic stem cells, printing organs, blood vessels, skin etc, and orthopedic applications. C. Lee Ventola [5] detailed the use of 3D printing in medical applications. According to this author, Medical Applications is classified into several types namely: 1. tissue and organ fabrication; 2. creation of customized prosthetics, implants, and anatomical models; 3. Pharmaceutical research regarding drug dosage forms, delivery, and discovery. The benefits of 3D printing in medical industry are also listed. They include: the customization and personalization of medical products, drugs, and equipment, cost-effectiveness; increased productivity, democratization of design and manufacturing and enhanced collaboration.

Mika Salmi [8] Demonstrated the use of 3D printing in simplyfying surgical procedures. The area on which surgery is to be performed is 3D printed so that proper planning of surgery can be made and thus avoid unnecessary complications during surgery. Medical 3D modeling and design, use of additive manufacturing techniques and estimating usability and dimensional accuracy of the process are discussed. www.3ders.org[7] illustrated the use of 3D printing for determining Hip bone replacement surgery procedure for complicated cases. The Hip bone model generated

from CT scans is initially 3D printed. This 3D printed model is then used in planning the surgery. Mohamad Lazkani, et al [1] used 3D Printing technology for proper selection of surgical procedures. Heart model is 3D printed to assess the problem and identify the location of the hole in the heart so that proper tools and procedures can be selected.

Regulatory Issues, Intellectual Property, Tort Liability, Environmental Effects and Health Risks in the Work Place, Insurance Issues, Reimbursement, Litigation and Legal Issues pertaining to the use of 3D printing in Medical industry are discussed in detail by Colleen T. Davies, et al [2]. The advantages and applications of CAD/CAM and Rapid Prototyping technology in medical industry, speeding the time to market and conversion of other format files into CAD format for analyzing and easily manufacturing the products is discussed in this paper by Mandar M. Deo, et al [9].

2. OBJECTIVE OF THE WORK

As mentioned earlier, the current work is aimed to generate a supporting mechanism for physically disabled persons who can still move their fingers but cannot achieve grip. In other words, the work is related to prosthetic arm. Very little research is carried out in this area. The current work is aimed at designing and fabricating a supporting mechanism for those who cannot move their hands freely due to neurological disorder. Pro/Engineer is used for modeling the support mechanism and Additive manufacturing is used for fabrication. PLA is used for 3D printing.

3. 3D PRINTING

3D printing also known as Additive Manufacturing is a process of manufacturing 3D objects. 3D printing is basically a Stereolithographic process which is invented by Chuck Hull [17]. Stereolithography is the first commercial Rapid prototyping process. A range of 3D printing technologies now exist which are used depending on the application. Fused Deposition Modeling (FDM)[18] is now commonly used 3D printing technique. FDM works on an "additive" principle by laying down material in layers; a plastic filament or metal wire is unwound from a coil and supplies material to produce a part. The filament is passed through a heated nozzle. During this passage, the material, if plastic is heated above glass transition temperature and deposited by the extrusion head in the form of layers. This is illustrated in figure 1.

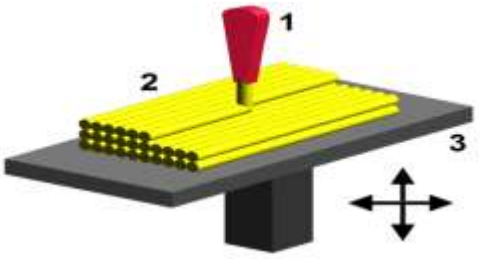

Figure 1: Fused Deposition Modeling principle (1. Molten Material, 2. Deposited Material, 3. Movable worktable) [19]

There are many commercially available 3D printers using this principle. In this work, WANHAO Duplicator i3 Desktop 3D printer (figure 2) is used. The process of preparing the model for printing involves three steps. Exporting the 3D model into '.stl' file, using the generated 'stl' file for slicing the model and thus generating the toolpath, exporting the toolpath into G-Code. Most of the FDM 3D printers use conventional G-codes.

Figure 2: WANHAO Duplicator i3 Desktop 3D Printer

Various software tools are available for slicing the 3D model. These software use various slicing engines (algorithms) like Cura, Slicer3D etc. In the current work, 'Repetier-Host' 3D printing software with 'Cura' as slicing algorithm is used. Figure 3 shows an example of sliced component giving the toolpath of the extruder.

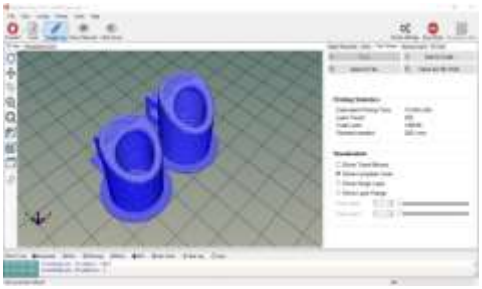

Figure 3: Sliced components in Repetier-Host software

It may be noted here that the 3D printed components are basically are shells with infills. Various infill patterns like grids, lines, Honeycombs, 3D Honeycombs exist and options

for these are available based on the slicing engines/algorithms chosen.

4. PROSTHETIC SUPPORT FOR HAND

As mentioned earlier, the aim of the current work is to design and fabricate support for a disabled hand (due to neurological disorder). 3D models of the components are initially generated using Pro/Engineer. Figure 4 shows the model of the prosthetic support of hand. Each component is exported into 'stl' format. The stl files are then imported into Repetier-Host software where slicing of the components is done to generate 3D printing tool path generation and thus the G-Code for the same. Cura Slicing engine is used during slicing process. Wall thickness of the components is maintained as 1 mm and infill pattern is chosen as 'Grid'. 20% infill is maintained during 3D printing. Raft is selected for Adhesion Type and the 3D printing is done in such a way that no supports are required. Figure 5 shows the image during printing of finger caps.

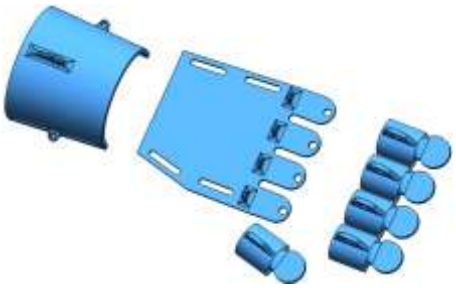

Figure 4: 3D Models of the support

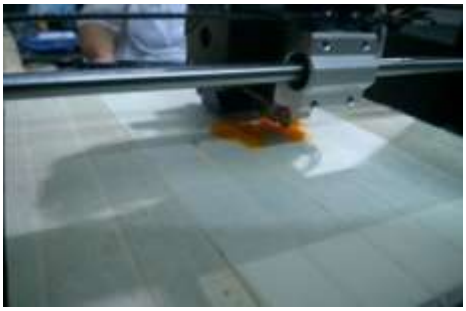

Figure 5: Finger Caps during 3D Printing

The finger caps in the assembly shown are connected to arm support using thread and springs. Springs give the necessary force to hold the fingers straight. The complete assembly is shown in figure 6.

Figure 6: Fabricated arm support complete assembly.

5. CONCLUSIONS

Prosthetics, in the current medical industry, involves making of artificial limbs for those who have lost their natural ones. Very little work has been done in the field of making prosthetic supports for hands for those whose disability is primarily due to neurological disorder. 3D printing technology offers in designing custom solutions to these kinds of problems. In the current work, a novel design of prosthetic hand support is proposed for those whose disability is primarily due to neurological disorders. The designed components are 3D printed and assembled. The images of the complete assembly are presented in the previous sections.

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