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A review on 3D Printing

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Abstract— A 3D printer is a machine that uses a CAD (Computer Aided Design) model to perform rapid prototyping. While traditional 2D printers use ink to print digital information onto paper in two dimensions (x and y axes), 3D printers have the ability to print in three dimensions (x, y, and z axis)

I. INTRODUCTION

[1]-[2],[4]The processes involved can be categorized as additive manufacturing methods. To gain better understanding, one may compare 3D printing to milling, which is a subtractive manufacturing method. Rather than take away from a model, a 3D printer adds mass to form a model. Utilizing cutting-edge technology, a 3D printer has the ability to create a model using many types of materials, such as plastic, polymer, metal, and composite materials. 3D printing is currently being used in many professional career fields, especially those associated with engineering and biology. 3D printing is changing our life, allowing many types of products to be designed faster and easier, right where they need to be. The beginning of 3D printing can be linked to the studies of photography, sculpting, and landscape design, taken place in America over a century ago.

II. LITERATURE REVIEW

[3]3D printing was known as "rapid prototyping". Chuck Hull, of 3D Systems Corporation, created the first working 3D printer in 1984. Later in the 80's, Selective Laser Sintering (SLS) technology was developed by Dr. Deckard at the University of Texas at Austin during a project sponsored by Defense Advanced Research Projects Agency (DARPA). In the 1990s, the technology was further improved with the development of a method that used ultraviolet light to solidify photopolymer, a viscous liquid material.

In the late 20th century, 3D printers were extremely expensive and could only be used to print a limited number of products. The majority of the printers were owned by scientists and electronics enthusiasts for research and display. Although it was still in limited development, the printing technology was a combination of modeling both science and construction technology, using some of the newest technological advancements of the time. Consequently, 3D printing began to lead a worldwide manufacturing revolution. In the past, surface design was mainly dependent on the production process. However developments in the field of 3D printing have allowed for the design of products to no longer be limited by complex shapes or colors .

II. BLOCK DIAGRAM AND FLOW CHART:

The block diagram of 3D printer can be explained with reference to below fig. 1, which shows the software part, represented by desktop. The software '.stl' file is written on Arduino 2560, which is interfaced with the 3 dimension motors and the extruder. Depending on the design of output product, the Arduino 2560 locates the 3 dimension motors and thereby, locates position of extruder. Finally, the extruder deposits the polymer on the surface. Fig. 2 gives the software flow chart of the 3D CAD file.

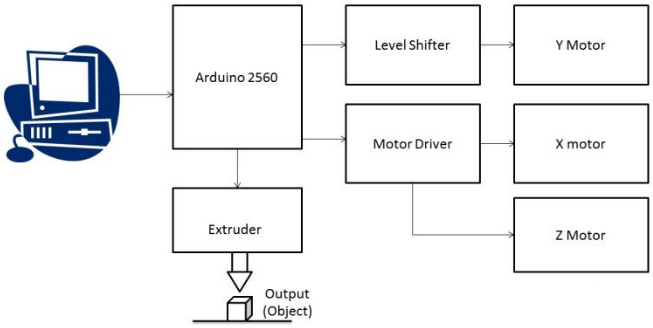


Fig. 1 System Block Diagram

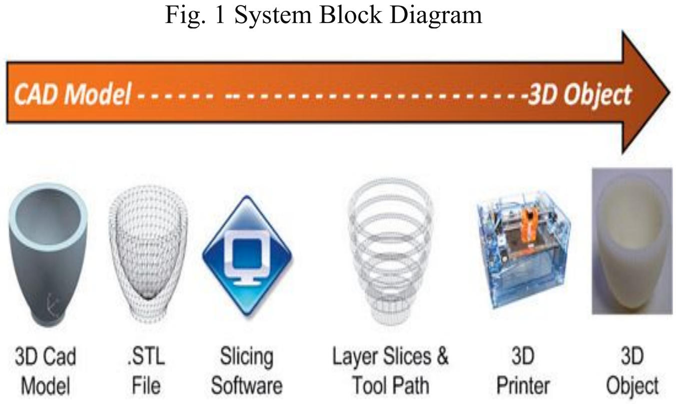


Fig. 2 Software Flow Chart

III. PRINTER DESCRIPTION:

Printer is briefly divided into three sections,

Electronics: Includes the Arduino 2560, with RAMPS (motor drivers), extruder, stepper motors, their interfacing with drivers and power supply (SMPS). Stepper motors are needed to be precisely interfaced with Arduino 2560, with no delay between any of the 5 motors to prevent misalignment of extruder.

Mechanics: It consists of the majority portion of the project. The chassis is designed by acrylic sheet, which is handy to design. Entire assembly is supported by a set of number of guide bars, threaded rods (for levelling in z-axis), bushings for motion along any single axis (x or y), a belt and pulley mechanism for controlling position of extruder in x-axis. Other complementary components include washers, M8 nuts, muff type sleeve couplers, etc.

Software: Consists of CAD design tools and slicer tool. 3D object designing tool is open source software and needs no special license for its use and distribution. This CAD file is not machine readable and thus needs an intermediate software, slicer. This intermediate software deals with extruder heating, layer thickness, and calculates co-ordinates in three axes for the motor ultimately creates a '.stl' file, which is machine readable (Arduino 2560).

The printing technology used is fused deposition modelling. Scott Crump, the founder of FDM technology, was instrumental in its development and revolution. The main material used in FDM technology is thermoplastic, examples include wax, ABS plastic, and nylon. The entire procedure can be explained with the help of following fig. 3 and fig. 4. The first step of the FDM process is to heat up the thermoplastic material until it is at a semi-liquid state (usually 1°C higher than the solidification temperature). Then, the 3D printer uses digital modeling data from a CAD file to create the 3D product layer by layer. These layers are created using software which "slices" the CAD file in to layers that are fractions of a millimeter. The majority of FDM printers only print the actual product. This is particularly useful during the build process when parts have overhang that cannot support itself. The thermoplastic usually has a filamentous shape (diameter would be around 0.25 to 0.75mm) which benefits heat transfer and is easy to move with a print head that moves in the x and y directions. After each layer is printed, a piston moves the extruder up (z-axis) the distance of the thickness of the printed layer. This process repeats itself until the entire model is printed. There are many benefits of FDM technology; it is easy to control, use, and fix. In addition, the cost of the machine and material are relatively low.

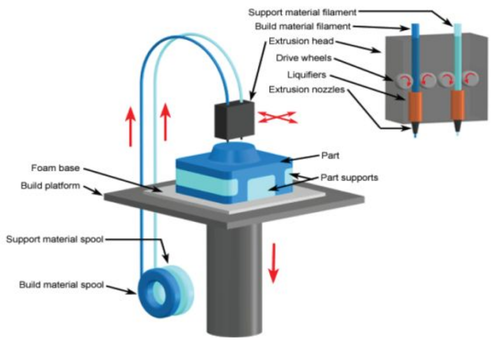
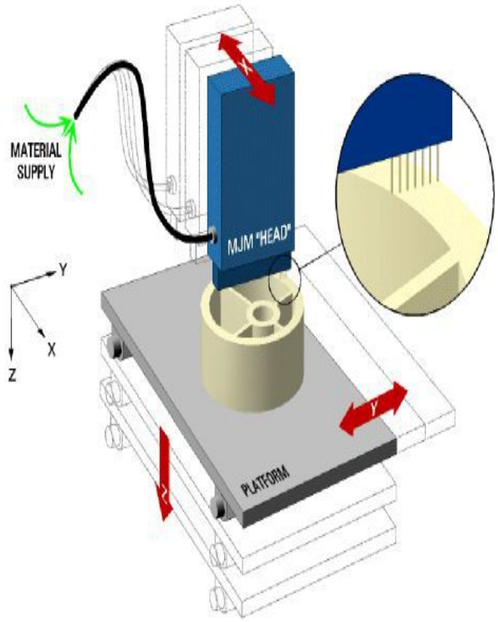


Fig. 3 FDM along with sectional view of extruder



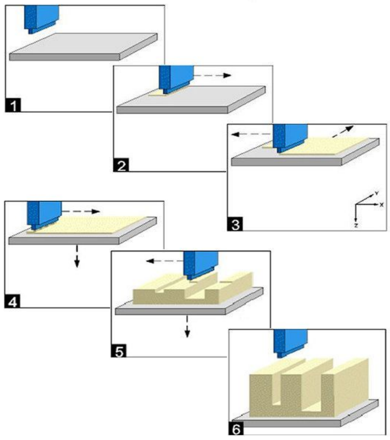


Fig. 4 Detailed steps of FDM printing

IV. G-CODE

G-code is a CNC based tooling language that is used to describe the motions of a tool and the functions of the tool itself in the production of 3D objects. It is a script-based language, where each line usually conveys one type of machine movement or machine setting.In the grand scheme of 3D printing, G-code is what is created, usually by software, after analyzing a specific part that is to be made. The G-code is generated so as to describe movements that will make a part, including dimensions such as extrusion width, speed, etc. This code is what is sent to the CNC-mill or 3D printer that actually handles manufacturing the specified part. Over the years, more and more devices adopted G-code, and as a result, G-Code evolved. G-code originally only described motions of a CNC based milling machine, but is now widely used for 3D printing. The production of G-code is also referred to as "slicing" in 3D printing.

This technology can be implemented to create anything with great geometrical complexity, with ability to personalize every product with individual customer needs. It can produce products which involve great level of complexity that simply could not be produced physically in any other way. Additive manufacturing can eliminate the need for tool production and therefore reduce the costs, lead time and labor associated with it. Additive Manufacturing use up to 90% of standard materials and therefore creates less waste. Lighter and stronger products can be printed. Also, production has been brought closer to the end user or consumer. Spare parts can be printed on site which will eliminate shipping cost. Wider adoption of 3D printing would likely cause re-invention of a number of already invented products. 3D printing can create new industries and completely new professions. Printing 3D organs can revolutionize the medical industry. Rapid prototyping causes faster product development.

IV. DISADVANTAGES

Since the technology is new, limited materials are available for printing. It consumes more time for less complicated parts. Size of printable object is limited by the movement of extruder. In additive manufacturing previous layer has to harden before creating next layer. Curved geometry will not be much accurate while printing.

V. FUTURE SCOPE

In future 3D printers would be available at a very low cost and can be even used in household applications as it would be affordable and also highly accurate and a multicolor extruder can be used and also the printers would be made portable

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VI. APPLICATIONS

3D printing is a new and developing technology, and as with all developing fields the possibilities for improvement and advancement are seemingly boundless.

A. NASA

Nothing exudes innovation and progress like our space program. In July 2013, NASA designed, printed, and tested rocket engine injectors by exposing them to extreme pressures and temperatures of over 6,000 degrees Fahrenheit. The 3-D printed parts actually exceeded those made of traditional materials. A key advantage of printing in 3-D is eliminating the need for welded seams in an object, and a great project direction would be to identify and print traditional objects or design components that would normally require welded seams. In fall 2014, NASA has planned to launch and deliver a 3-D printer to the International Space Station, which will allow astronauts to print replacement tools directly in space.

B. BIOTECHNOLOGY

There is endless potential to create new products and designs, it is only a matter of developing new machines that have different capabilities and work with different materials. The industry is already trending to smaller scales, with some work happening even at the nano-scale. In 2012, an elderly woman in Belgium received a 3-D printed jawbone, transplanted and specifically tailored to her facial structure. This year, engineers at Princeton were able to craft an ear imprint, using a culture of animal cells and silver nanoparticles; the experimental version was able to pick up audio beyond the scope of human levels, making this a “bionic” ear . With this technology, humans now have the ability to actually craft improvements for their bodies. Soon, we will even be able to print food. A sample of animal stem cells could be cultured and multiplied, forming a type of “bio-ink” made up of hundreds of living cells, which could then be utilized to print living tissue. Using this method, leather could be synthesized and eventually even meat.

C. REPLICATION

A key idea in the growing field of 3-D printing is the ability for printers to replicate themselves, or to create as many essential components as possible that are necessary to build a machine. Many consumer 3-D printers now come assembled with parts that were themselves printed in 3-D. As the technology advances and the industry develops, more and more essential machine components will be able to be printed. Soon we will find ourselves able to print all the components necessary to making things with complex structures, such as houses, cars, and more 3-D printers. This year, a functioning pistol was designed and printed, with the computer automated drawing schematics made readily available online. As you can imagine, this has led to a myriad of legal questions and moral debates. How can this industry be regulated, if the consumers themselves are using these machines to make anything and everything? The scope of replication can be daunting, because there is no telling where it will end. Soon, we will be printing machines that will be printing machines.

D. CARS

The automotive industry was one of the earliest adapters of 3-D printing to produce parts. But we could soon start seeing whole cars (or at least their bodies) printed. That's the business model for Urbee ("urban electric"), a startup auto company that wants to make the greenest car on earth. Stratsys, one of Credit Suisse's top stocks for investing in 3-D printing, just signed on as Urbee's sponsor for digital printing.

E. DEFENSE

A company called EOIR Technologies developed a way to mass produce camera gun sights for M1 Abrams tanks and Bradley fighting vehicles using 3-D printing. According to CSC, that cut the cost of manufacturing the gear by 60%. The Air Force is also in the initial stages of pumping out components of otherwise highly sensitive and expensive systems, like drones, in order to use them in training exercises.

F. AIRPLANES

Boeing now uses 3-D printers to create 300 different parts for its products. For instance, according to CSC, Boeing's environmental control ducting (basically specialized tubes) used to have to be assembled from 20 small parts; now it's pumped out as a single piece. This reduces inventory and maintenance costs, and also lowers fuel costs since the part is lighter. Some aerospace manufacturers are also deploying on-site printers for certain parts, reducing shipping costs.

G. BRICK AND MORTAR RETAIL

If some storefront retailers are on the brink, 3-D printing may push them over the edge. Thanks to at-home printers - as well as places like UPS that have begun setting up printers at their stores - you may soon be able to print pretty much any relatively simple consumer good that would fit on your desktop. We've previously discussed what some of those objects are. CSC has a great, illustrative story of how at-home 3-D printing could accelerate the decline of storefronts: "Recently, one of our researchers faced the prospect of a 14-hour flight holding an ebook reader, with no time to buy a reader stand before leaving for the flight. After a few minutes searching on Thingiverse.com [a site offering 3-D printing files], he was able to download a foldable stand design, print it in 45 minutes, and use it on the flight that night."

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