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3D Printing and Its Applications

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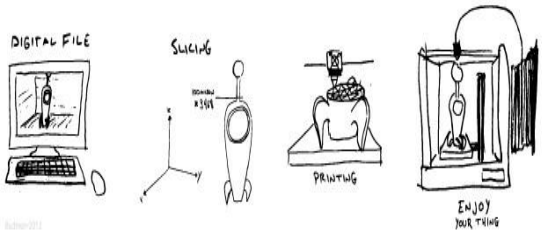
Abstract: ***3D printing which has turned into a remarkable point in today's innovative exchange. In this paper, we will look at additive manufacturing or 3D printing. We will firstly characterize what we mean by this term and what is so noteworthy about it. We will dive a bit into the history. At that point, we should see about the procedure of 3D printing and the materials utilized as a part of the production of 3D printed objects. We might likewise see the focal points and burdens of 3D printing. We should watch the various applications it is being out to utilize today. At last, the future capability of this innovation is illustrated.***

Keywords: 3D printing, 3D printers, polymers, Stereolithography, Additive manufacturing

1. Introduction

3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file. The creation of a 3D printed object is achieved using additive processes. In an additive process an object is created by laying down successive layers of material until the entire object is created. Each of these layers can be seen as a thinly sliced horizontal cross-section of the eventual object.

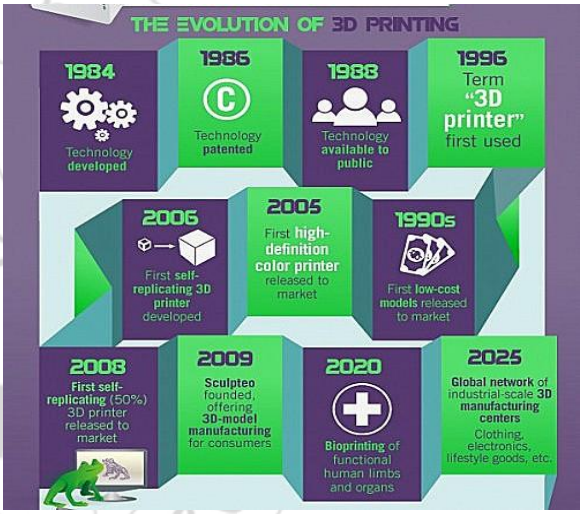


2. History

In the history of manufacturing, subtractive methods have often come first. The province of machining (generating exact shapes with high precision) was generally a subtractive affair, from filing and turning through milling and grinding.

Early AM equipment and materials were developed in the 1980s. In 1984, Chuck Hull of 3D Systems Corporation invented a process known as stereolithography, in which layers are added by curing photopolymers with UV lasers. Hull defined the process as a "system for generating three-dimensional objects by creating a cross-sectional pattern of the object to be formed." He also developed the STL file format widely accepted by 3D printing software as well as the digital slicing and infill strategies common to many processes today. The term 3D printing originally referred to a process employing standard and custom inkjet print heads. However, as the years go by and technology continually advances, additive methods are moving ever further into the production end of manufacturing. Parts that formerly were the sole province of subtractive methods can now in some cases be made more profitably via additive ones.

However, the real integration of the newer additive technologies into commercial production is essentially a matter of complementing subtractive methods rather than displacing them entirely. Predictions for the future of commercial manufacturing, starting from today's already - begun infancy period, are that manufacturing firms will need to be flexible, ever-improving users of all available technologies in order to remain competitive.



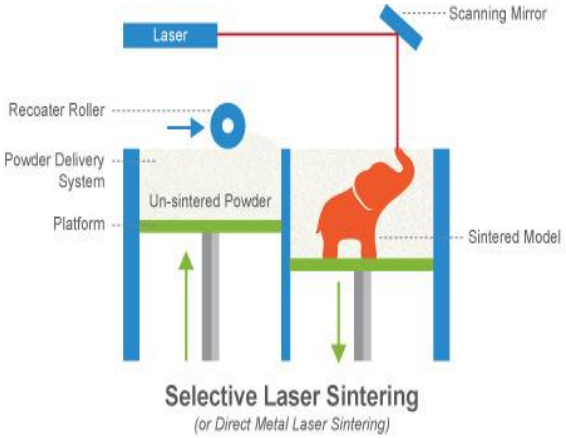
3. Methods and Technologies

Not all 3D printers use the same technology to realize their objects. There are several ways to do it and all those available as of 2012 were additive, differing mainly in the way layers are build to create the final object. Some methods use melting or softening material to produce the layers. Selective laser sintering (SLS) and fused deposition modeling (FDM) are the most common technologies using this way of printing. Another method of printing is to lay liquid materials that are cured with different technologies. The most common technology using this method is called stereolithography (SLA).

Selective Laser Sintering (SLS)

This technology uses a high power laser to fuse small particles of plastic, metal, ceramic or glass powders into a mass that has the desired three dimensional shape. The laser selectively fuses the powdered material by scanning the cross-sections (or layers) generated by the 3D modeling program on the surface of a powder bed. After each cross-section is scanned, the powder bed is lowered by one layer

thickness. Then a new layer of material is applied on top and the process is repeated until the object is completed.

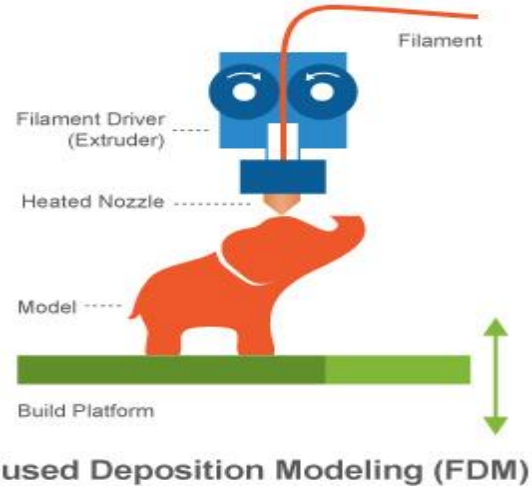


Fused Deposition Modeling (FDM)

The FDM technology works using a plastic filament or metal wire which is unwound from a coil and supplies material to an extrusion nozzle which can turn the flow on and off. The nozzle is heated to melt the material and can be moved in both horizontal and vertical directions by a numerically controlled mechanism, directly controlled by a computer-aided manufacturing (CAM) software package. The object is produced by extruding melted material to form layers as the material hardens immediately after extrusion from the nozzle.

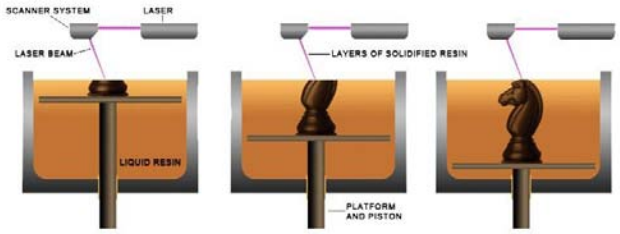
FDM was invented by Scott Crump in the late 80's. After patenting this technology he started the company Stratasys in 1988. The software that comes with this technology automatically generates support structures if required. The machine dispenses two materials, one for the model and one form a disposable support structure.

The term fused deposition modeling and its abbreviation to FDM are trademarked by Stratasys Inc. The exactly equivalent term, fused filament fabrication (FFF), was coined by the members of the RepRap project to give a phrase that would be legally unconstrained in its use.



Stereo Lithography (SLA):
The main technology in which photo polymerization is used to produce a solid part from a liquid is SLA. This technology employs a vat of liquid ultraviolet curable photopolymer resin and an ultraviolet laser to build the object's layers one at a time. For each layer, the laser beam traces a cross-section of the part pattern on the surface of the liquid resin. Exposure to the ultraviolet laser light cures and solidifies the pattern traced on the resin and joins it to the layer below.

After the pattern has been traced, the SLA's elevator platform descends by a distance equal to the thickness of a single layer, typically 0.05 mm to 0.15 mm (0.002″ to 0.006″). Then, a resin-filled blade sweeps across the cross section of the part, re-coating it with fresh material. On this new liquid surface, the subsequent layer pattern is traced, joining the previous layer. The complete three dimensional object is formed by this project. Stereolithographic requires the use of supporting structures which serve to attach the part to the elevator



4. Applications

Applications include design visualization, prototyping/CAD, metal casting, architecture, education, geospatial, healthcare and entertainment/retail.

Other applications would include reconstructing fossils in paleontology, replicating ancient and priceless artifacts in archaeology, reconstructing bones and body parts in forensic pathology and reconstructing heavily damaged evidence acquired from crime scene investigations.

In 2007 the use of 3D printing technology for artistic expression was suggested. Artists have been using 3D printers in various ways.

As of 2010 3D printing technology was being studied by biotechnology firms and academia for possible use in tissue engineering applications where organs and body parts are built using inkjet techniques. Layers of living cells are deposited onto a gel medium and slowly built up to form three dimensional structures. Several terms have been used to refer to this field of research like: organ printing, bio-printing, and computer-aided tissue engineering.

Industrial Printing
In the last couple of years the term 3D printing has become more known and the technology has reached a broader public. Still most people haven't even heard of the term, while the technology has been in use for decades. Especially manufacturers have long used these printers in their design process to create prototypes for traditional manufacturing and research purposes. Using 3D printers for these purposes is called **rapid prototyping**.

Why use 3D printers in this process you might ask yourself. Now, fast 3D printers can be had for tens of thousands of dollars and end up saving the companies many times that amount of money in the prototyping process. For example, Nike uses 3D printers to create multi-colored prototypes of shoes. They used to spend thousands of dollars on a prototype and wait weeks for it. Now, the cost is only in the hundreds of dollars, and changes can be made instantly on the computer and the prototype reprinted on the same day.

Besides rapid prototyping, 3D printing is also used for **rapid manufacturing**. Rapid manufacturing is a new method of manufacturing where companies are using 3D printers for short run custom manufacturing. In this way of manufacturing the printed objects are not prototypes but the actual end user product. Here you can expect more availability of personally customized products.

Personal Printing

Personal 3D printing or domestic 3D printing is mainly for hobbyists and enthusiasts and really started growing in 2011. Because of rapid development within this new market printers are getting cheaper and cheaper, with prices typically in the range of $250 – $2,500. This puts 3D printers into more and more hands.

The RepRap open source project really ignited this hobbyist market. For about a thousand dollars people have been able to buy the RepRap kit and put together their own personal 3D printer, complete with any customizations they were capable of making. What really speeds the development is the open source idea. Everybody working on the RepRap shares their knowledge so other people can use it and improve it again.

This rapid development of open source 3D printers is gaining interest in both the developed as well as the developing world and it enables both hyper-customization and the use of designs in the public domain to fabricate open source appropriate technology through conduits such as Thing verse andCubify. This technology can also assist unsustainable development as such technologies are easily and economically made from readily available resources by local communities to meet their needs.

5. Advantages

- **Accessibility:** In the past, only tech experts and professionals had access to this technology. 3-D desktop printer is accessible virtually anywhere such as at home, businesses, hospitals and schools.
- **Affordable pricing:** promoted greater accessibility allowing everyone to benefit from this emerging technology. Additionally, the economical pricing of 3D printing will also result in an increase in the number of users interested in this cutting edge technology.
- **Huge Variety/Customization:** Any object can be easily printed regardless of whether it is a toy, decorative item, or office supply. It does not matter how complex the design, 3D printing has opened the door to an infinite possibility of shapes and sizes that can also be customized to the customer's needs.

Constant improving prototyping/ increasing productivity can boost productivity with a high number of prototypes in less time than conventional methods. Designers can instantly improve their prototypes, increasing efficiency and the effectiveness of an organization. Perfection can be achieved in a matter of hours; businesses that use this technique can achieve comparative advantage over their competitors.

- **Improved Life Quality & Welfare:** 3D printing has the potential to increase the quality of life and welfare since any essential parts or models can easily be created for the use of education, medical & health, military, automotive, lifestyle and a variety of other purposes.
- **Eco-friendly:** 3D printing is also considered environment friendly since it produces less waste compared to other techniques.

6. Disadvantages

- **Violation of copyrights:** Technology such as this can be misused resulting in the rise of many ethical concerns. As any desired object can be printed, an owner of a 3D printer can print objects that are protected by copyrights. By cutting off the availability of 3D printer design of the protected work can help to protect the copyrights. However, it is nearly impossible to remove the availability of all the existing design files on the internet.
- **Harm authenticity:** 3D printing will also give rise to copyright infringement increasing the amount of counterfeit products that will damage the authenticity and demand for many brands. As a result, many businesses producing a unique product may suffer from the growth of 3D printing.
- **Printing Weapons:** Another major disadvantage is the ability to print dangerous objects such as plastic guns, knives, or any other object that could be used as a weapon. This transformation technology will make it easier for criminals and terrorists to bring weapons in public places such as an airport with ease and without the possibility of detection.
- **Scan & Fraud:** 3D printers can be used to scan and print I.D., credit cards, car keys, as well.

7. Conclusion

It is predicted by some additive manufacturing advocates that this technological development will change the nature of commerce, because end users will be able to do much of their own manufacturing rather than engaging in trade to buy products from other people and corporations.

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