

3D Printing: Technology of the Age

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Abstract—Envisaging a future where a device connected to a computer can print a 3D object in few minutes. A future in which we can have tangible goods as well as intangible services delivered to our desktops or high-street shops over the internet. The 3D Model printing has enjoyed a considerable success in recent years. In printing system domains, they majorly use the CAD software to make the digital files and to validate and implement the printed model. We are mainly having four techniques for 3D model creation like - Selective Laser Sintering (SLS), Fused Deposition Modeling (FDM), and Stereo lithography (SLA). We present an illustrative study of the 3D printing techniques, working of 3D printer, their pro's and con's and its impact on the economy.

Keywords—3D, 3D Printing, 3D Graphics, 3D Printer, 3D Technology, 3D Modelling, 3D market.

I. INTRODUCTION

3D printing or additive manufacturing is a process of making a three-dimensional solid object of virtually any shape from a digital model. 3D printing is done through the additive process. Additive Process is the process in which the manufacturing process for rapid and flexible production of prototype parts and tooling are done layer by layer, directly from a CAD model. This method is repeated until the entire object is created. Each of these layers can be seen as a thinly sliced horizontal cross-section of the eventual object. 3D printing is also considered distinct from traditional machining techniques, which mostly rely on the removal of material by methods such as cutting or drilling.

The CAD design process replaces the need to design physical prototypes out of malleable material such as clay or Styrofoam. A designer uses the CAD program to make the model, which is then saved as a digital file in the computer. Much as a word processor is superior to the typewriter because it allows a writer to add, delete and edit text freely, a CAD program allows a designer to manipulate a design and get it according to the need of the consumer or the programmer itself. This feature of CAD helps the 3D modelling to be very dynamic in nature.

II. LITERATURE REVIEW OF 3D PRINTING

In 1984, Charles Hull developed the technique to physically print the 3D object from the digital data by inventing the method of stereo lithography. The technology is used to create a 3D model from a picture and allows users to test a design before investing in a larger manufacturing program. After the technique of stereolithography, the techniques of Fused Deposition Modelling (FDM) and Selective Laser Sintering (SLS) also became popular.

In 1993, Massachusetts Institute of Technology (MIT) invented and patented another technique for the 3D printing, "3 Dimensional Printing techniques", which is similar to the inkjet technology of 2D Printers. In 1996, three major products, "Genisys" from Stratasy, "Actua 2100" from 3D Systems and "Z402" from Z Corporation, were developed. In 2005, Z Corporation launched a breakthrough product, named Spectrum Z510, which was the first high definition color 3D Printer in the market. Another break through which came in 2005 was the open-source collaboration with 3D printing. Dr.

Adrian Bowyer at University of Bath founds RepRap, an open-source initiative to build a 3D printer that can print most of its own components. The vision of the project was to democratize manufacturing by cheaply distributing RepRap units to individuals everywhere, enabling them to create everyday products on their own.

III. 3D PRINTER WORKING

The 3D printing starts with the creation of a virtual design of the object you want to create. This virtual design is firstly created in a CAD (Computer Aided Design) file using a 3D modelling program (for the creation of a totally new object) or with the use of a 3D scanner (to copy an existing object). This scanner makes a 3D digital copy of an object and puts it to a 3D modelling program.

The 3D Modelling software slices the final model into hundreds or thousands of horizontal layers (such that each horizontal layer is taken as a 2D image). When this prepared file is uploaded in the 3D printer, the printer creates the object layer by layer. The 3D printer reads every 2D layering which were earlier sliced horizontally and proceeds to create the object blending each layer together with no sign of the layering visible, resulting in a three dimensional object.

IV. METHODS AND TECHNOLOGIES OF 3D PRINTING

The 3D printer uses different technologies to make the 3D model printed. The method available as of 2012 was mainly Additive Method. The additive method can be divided into sub categories like Selective Laser Sintering (SLS) and Fused Deposition Modelling (FDM). The SLS and FDM are presently the most common technologies for the work of 3D printing. Another method of printing is to lay liquid materials that are cured with different technologies. The most adept and used method with this technology is Stereo lithography (SLA). Multi-jet modelling is also another type of the printing techniques using the inkjet like technique to print the 3D model. This technique uses a spray on a binder solution that glues only the required granules together to hold the model up together.

(a). Selective Laser Sintering (SLS)

The SLS technology use the High Power laser for the fusion of the small particles of plastic, metal, ceramic or glass

powder into a model of desired 3D shape and dimensions. The Laser fuses the powdered material layer by layer. These layer's fusion directions are controlled by the computer with the directions provided by the digital file containing the program for the model where all the dimensions are saved. The unused powder that remains at the end of the printing results as the supporting structure for the object. Hence, there is no need for any support structure which is an advantage over SLS and SLA. Unused powder can be used for the next printing. SLS was developed and patented by Dr. Carl Deckard at the University of Texas in the mid- 1980s, under sponsorship of DARPA

(b). Fused Deposition Modelling (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 controls the flow from the nozzle. The nozzle is heated to melt the material and can be moved in all the directions by numerically controlled mechanism. It can be 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. After patenting this technology, he started the company Stratasys 1988. This is the software that can generate the support structure of the model automatically if required. The machine dispenses two materials, one for the model and one for the support structure.

(c). Stereo lithography (SLA)

Stereo lithography is the main technology which uses photo polymerization to produce a solid part from a liquid. 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. In this, the model is prepared one after the other layer. For each layer, the laser beam traces a cross-section of the part pattern on the surface of the liquid resin. The Exposure to the ultraviolet laser light cures and solidifies the pattern traced on the resin and joins it with the layer below the new layer.

On this new liquid surface, the subsequent layer pattern is traced, joining the previous layer. The complete 3D model is formed with the help of this process. The technique was invented by Charles Hull, who was also the founder of the company 3D systems, in 1984 and patented in 1986.

V. RECENT APPLICATIONS

The technology gifted to us in early '80s and has a wide variety of applications. This application may vary from high end use to even the basics of human life. 3D printing took over various applications in our daily life as we get to simplify our tasks in terms of capital and is a way effective method of producing tools and objects at small measuring parameters.

Some of the applications and use of the 3D technology has taken place in recent days and will be chronologized in near future. There are some recent uses of technology that may have a great impact on humanity in near future:

(a). NASA sends Ratchet Wrench in span of hours.

3D printing technology of International space station completes its first phase by delivering a ratchet wrench via email that was further cast by the use of 3D printer.



Fig [1]: Commander Barry "Butch" Wilmore shows off a ratchet wrench made with a 3-D printer on the station. The following wrench had dimensions 4.48-inch long by 1.29-inch wide, and will be soon returning to earth for testing. This demonstration may help the team to get through the long flawless Mars journey.

(b). Upcycle DVD drives with lower cost.

In case you are fed up of making use of old school disk drives, 3D printing technology gives you a better way to overcome it, i.e., a upcycle DVD drive will help.

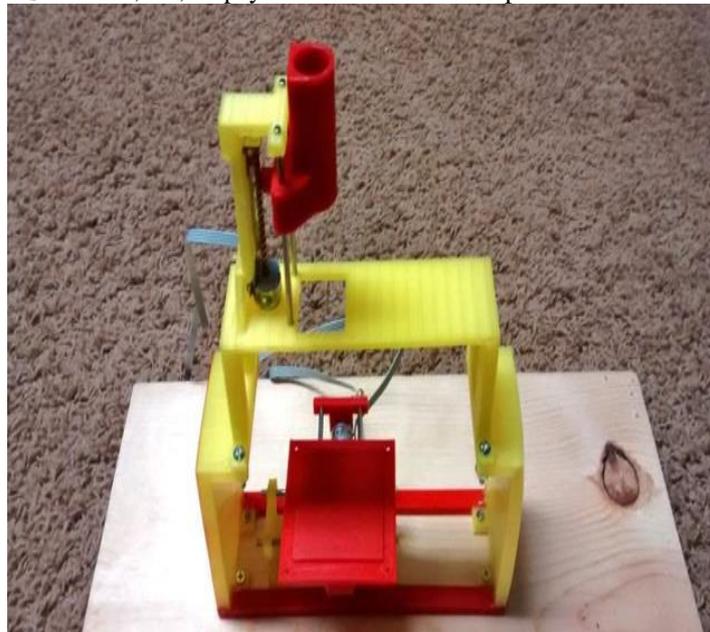


Fig [2]: Upcycle DVD drive casted using 3D printer. It consists of certain mechanical parts to be casted using the technology; the commands are available on the web. These parts are then assembled to get appropriate Upcycle DVD drive which would be cost and space effective.

(c). Titanium jaw for Syrian Soldier.

3D technology has now an impact on medical science. A Syrian soldier shot by a bullet directly in his lower jaw was fitted with the titanium printed jaw at RamBam Hospital in Israel.

The technology is helping in more and more fields now-a-days. It is now bringing the imagination to reality in certain cases and will really be substantial in near future.

VI. EMERGING ECONOMIES' EYE ON 3D PRINTING MARKET

The technology with such a great impact world-wide endeavours the nations to implement it in their regular life. Every nation is trying to be ahead of the other nations in the field of development. The 3D printing is the gleaming topic, the nations are working on. The 3D printing is not only responsible for the advancement in the speed of manufacturing, better use of resources and product customization but also in providing economic strength to the nations.

The emerging nations of the world such as China, India, South-Africa and Brazil are investing considerable shares in the 3D printing technology.

The Economic giant China had invested \$6.5m for the National High Technological Research and Development Program in April 2013 to increase the rate of adoption of 3D printing and technology.

The Indian market for 3D printing has more potential in the commercial segment. According to the market analysts, the Indian 3D printing market revenue may reach a height of \$46 million by the year 2019. The OEM (Original Equipment Manufacturer) Hewlett-Packard has announced that it is entering the 3D printing market in a big way.

The South Korea took an audacious step to go ahead as a leader of the industry in the near future by creating the 3D Printing Industry Development Council. The another move of the Korean government is to train 10 million "Creative Makers" by the year 2020 and hence invested \$2.3 million dollars in 3D printing equipment and facilities.

The New Zealand government is another one to claim that the 3D printing will be the part of their push, as stated in the in their paper called "Blueprint for the Future". It reads, "New Zealand imports around \$11 billion of manufactured products each year, around a quarter of our total merchandise exports. Producing more products domestically would have a positive impact on New Zealand's balance of payments and stimulate economic development."

The South Africa is another one to be attracted by the 3D printing market. The worldwide leader in desktop 3D printing-MakerBot has announced their expansion by the partnership with "Rectron South Africa" in the African continent. Another company called Open Hardware's owner Peter van der Walt is planning to launch affordable 3D printers in the markets soon.

The Analysts reviewed that the features of 3D printing have brought technology on a verge of revolution. The governments' involvement is a rising hand in the overall adoption of the technology and exploration in the field as it is in its nascent stage.

3D Printing Market in Emerging Economies

Size and Forecast (2013 - 2020)

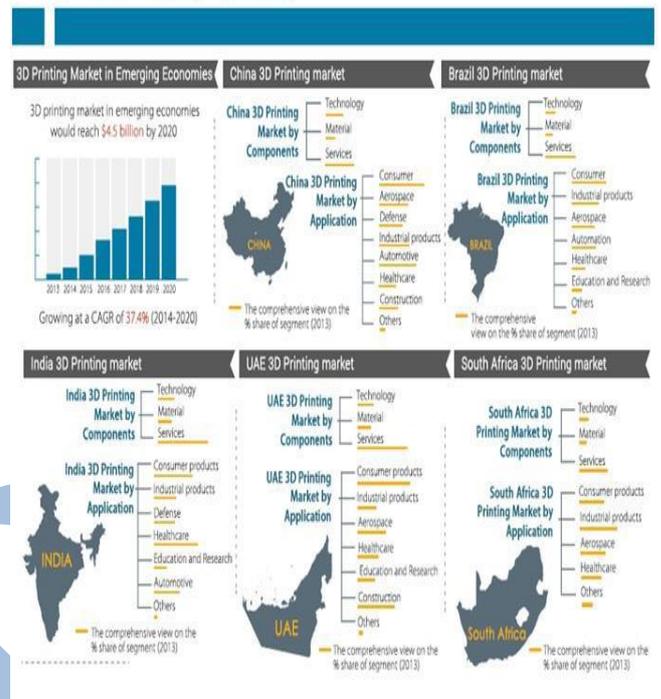


Fig [3]: Illustrating the 3D printing market in the emerging economies, growing at a promising rate.

VII. PROS AND CONS OF TECHNOLOGY

Technology is a boon, but is always available with the pros and cons. Similarly, the 3D printing also has certain advantages & disadvantages.

The Bright Side

3D printing technology has a wide range of advantages that cannot be counted on fingers. However, some of the major advantages can be underlined as-

(a). Get what you want.

3D printing technology provides us with the concept of mass customisation. It gives us the ability for product customization as per the end user requirement.

(b). No waste dump required.

3D printing works on the concept of layer by layer production of the article or the product which is on other hand reducing the requirement of dumping facilities and making it more economic. We can have some limitations with few parts that generate waste, but that limitation will be overtaken by the recycling process.

(c). End of stereotype.

3D printing is in full flow ending the stereotype kept in mind by the people that the development of tools and buy product may cost them much higher relatively. It is reducing the tooling cost. It identifies the manufacturing errors that may occur and reduces the production cost that may hike further in redevelopment.

(d).Dependency on production branch lowered.

Initially the business personnel were forced to wait for production team to end their task that took about a week or month long.3D printing is nothing more than an hourly task. It just requires the CAD model and further the command is given to the printer for casting.Hence, the speed is enhanced for any project to take place.

The Dark Side

The technology always have a dark side .It may be used for violation and misuse if in wrong hands.3D printing may be used by the competitors to bring down the competitions in several ways .With a great number of pros, 3D printing may face following cons:

(a).Copyright violation.

By using 3D printing one can easily print out the counterfeits of the copyrighted product which damage the authenticity and demand for competitive brand. This can be easily explained as the misuse of technology.

(b).Security breaches.

3D printing may be used to produce weapons like, plastic guns, knives etc. that may easily break the security. The transformation of technology may be used by the terrorists or the people with ill deeds to make the weapons that may lead to security breaches.



Fig [4]: Gun casted using 3D printing technology

(c). Frauds.

3D printing technology may also lead to fraud and also some security threats. Hence, the above point does not needs the explanation as the 3D printing technology can be used to cast fake IDs, car keys, etc.

(d).Health and Environmental hazards.

Researchers have declared that the 3D printing leads to the emission of harmful nano-sized airborne particles that may lead to calamity. According to the studies, while heating the

plastic to print small figures, the machine uses a PLA filament that may emit about 20 billion of ultrafine particles per minute, and the ABS may emit up to 200 billion of them. Hence, the employees working on the project may be affected, as the following particles may settle down in lung or bloodstreams, of especially to those suffering with asthma.

VIII. CONCLUDING WITH FUTURE EXPECTATIONS FROM 3D PRINTING

The 3D Printing technology can be expected as a magic hat having revolutionary change in the era of technology. There are various theories that may come live with the help of 3D printing technology.

The latest research by “HassoPlattner Institute” proved that the Teleportation is practically possible with the help of 3D printing. Teleportation is the transfer of matter or energy from one point to another without traversing the physical space between them. This invention can fulfil the dream of man to explore the universe by making the travelling speed even faster than our expectations.

Research collaboration between Stratasys’ Education, R&D departments, MIT’s SelfAssembly Lab and Autodesk, is developing a new process, known as 4D Printing. In 4D printing, shape transformation capability is provided which can transform 1D strand or 2D surface into 3D shape or it can transform a 3D Shape into another 3D morph. With the help of water, heat, light and other energy inputs the technology provides adaptability and dynamic response for systems of all sizes.

The 3D printing technology can also delete the word of handicap from the dictionary of the humanity.

As having both head and tail of a coin, 3D printing will also result in the advancement of armory and hence may have even more drastic effects than ever.

Science never let the curiosity die. There are many great possibilities hidden in the advancement of the technology. Some of them are explored and some are waited to be. It’s upon us how deep we can go.

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