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Review Article

3D Printing Technology: A systemic Review

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ABSTRACT

Along with extensive research on the three-dimensional (3D) printing, 3D printing of medical field is now the latest trend to come under the spotlight. Since, there is a high demand for organ transplantations 3D printing acts as a major clinical challenge in worldwide. Thousand replacements are implanted every year and in some cases patients with specific parts have been made. 3D printers has successfully recreated body parts as complex as blood vessels with low cost, high quality, prosthetic lens for the patient who couldn't received.

Keywords: Bioprinting, Computer-Aided Design, Selective Laser Sintering, Stereo lithography, Fused Deposition Modeling, Laminated Object Manufacturing

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INTRODUCTION

Medical 3-D printing is an emerging area of technology that explores how 3-D printing can be used to replace or support an existing biological structure. A related area of 3D printing called bioprinting, involves sprinting human tissue and organs by layering living cells instead of plastic or titanium. 3D printing was first used for medical purposes as dental implants and custom prosthetics in the 1990s. Eventually scientists were able to grow organs from patient's cells and used a 3D printed scaffold to support them, in 2008, Scientists were able to produce the first 3D prosthetic leg.

The 3D printing technology is a rapid prototyping method it is a part of the innovative process called additive manufacturing which means the production of three dimensional solid objects from a digital file. The printer uses a kind of layering process, by which one layer is added after the other until a full object is formed. 3D printing is used for the development of new surgical cutting and drill guides, prosthetics as well as the creation of bones, organs, and blood vessels nowadays, the 3D printing technology represents a big opportunity to help pharmaceutical and medical companies to create more specific drugs, enabling a rapid production of medical implants, and changing the way that doctors and surgeons plan procedures.
There is a global shortage of organs available for lifesaving transplants. There's a similar shortage of liver, lungs and other organs. Around 900,000 deaths a year. Or around one-third of all deaths in the US, could be prevented .the demand is endless and 3D printing is making its way to offer a solution to the problem. By using materials we can print human organs such as cells, skin, liver, heart, teeth, Ear, kidney.

HISTORY

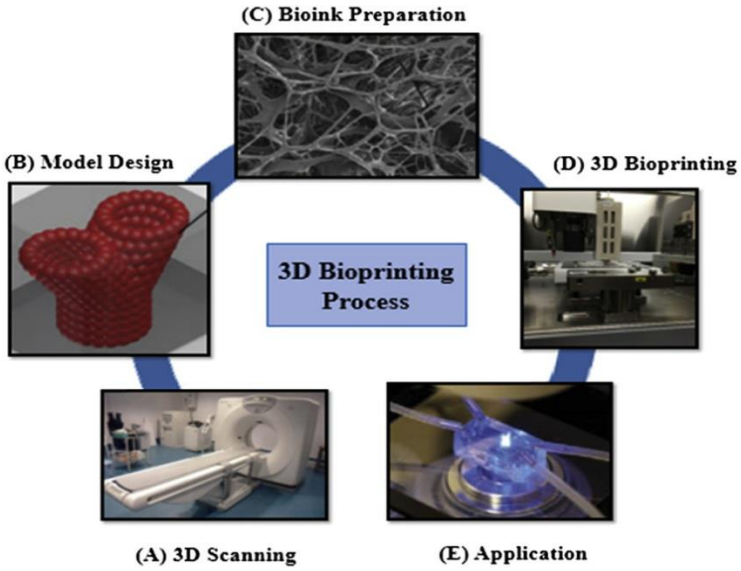
The first patent was given to Chuck Hull in 1986 for stereolithography apparatus (SLA) [1]. He is the cofounder of 3D systems corporation. When he got the first patient issue then he started his own company in California.3d printed human organs began in 1983 when he invented selective laser sintering (SLS) the 3D Printing was first used for medical application as dental implants and custom prosthetics in the 1990s. The scientists were able to grow organs from patient's cells and used a 3D printed scaffold to support them. Eventually, in 2008, scientists were able to produce the first 3D prosthetic leg.

GENERAL PROCESS

The general process involved in 3D printing is divided into different categories they are:-

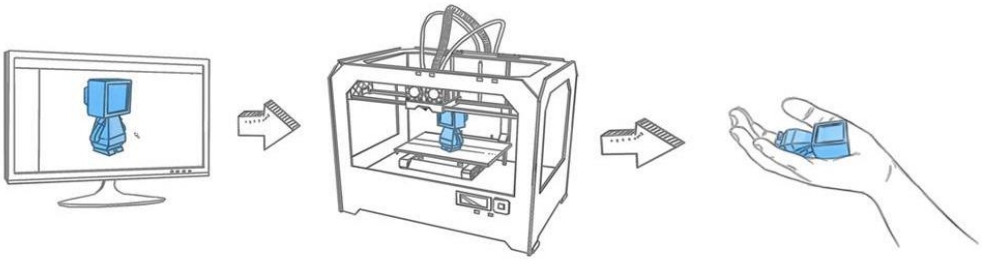
1. Modeling process
2. Printing process
3. Finishing process

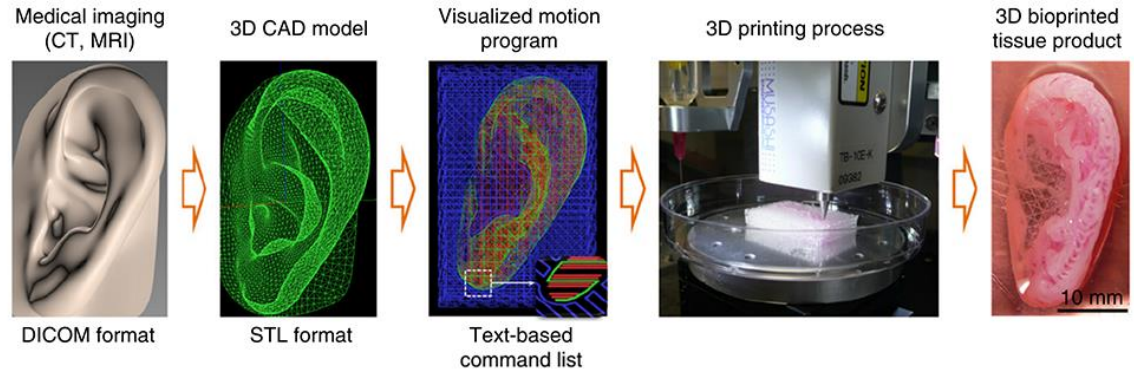
Steps Involved: In the first step design of object is created by using computer. The computer should require a software such as CAD (Computer-Aided Design) only skilled person can design object well known about that software. Many softwares are available choose the good software it depends on requirement of what you are designing. After designing this file is sent to the printer. Then the printer slices that design into number of layers of thickness. The printer creates the object from that design. The printer head moves in both directions a horizontal and vertical direction to eject the material layer by layer to form a desires shape. At last step when a complete object is formed open front part of the machine and remove the object from platform.



PROCESS:

It begins with making a design of the object. This design is for instance a CAD (Computer- Aided Design) file. This CAD file is created using a 3D scanner (to copy an existing object). A 3D scanner can make a 3D digital copy of an object.





TYPES OF 3DP TECHNOLOGY:

1. Selective Laser Sintering (SLS)
2. Stereo lithography (SLA)
3. Fused Deposition Modeling (FDM)
4. Inkjet printing (IJP)
5. Laminated Object Manufacturing (LOM)

Selective Laser Sintering: Selective laser sintering is an additive manufacturing technique that uses laser as power source to sinter powdered material (typically nylon or polyamide) aiming the laser automatically at points in space defined by a 3D model, binding the material together to create a solid structure. SLS is a new technology so far mainly used for additive manufacturing at low volume production of parts. The CandyFab (Candyfab, 2014) applied a low velocity hot air to melt sugar bed [2]. The powdered bed is melted below its material melting point. This technology is suitable for sugar and fat materials with low melting range.

Advantage:

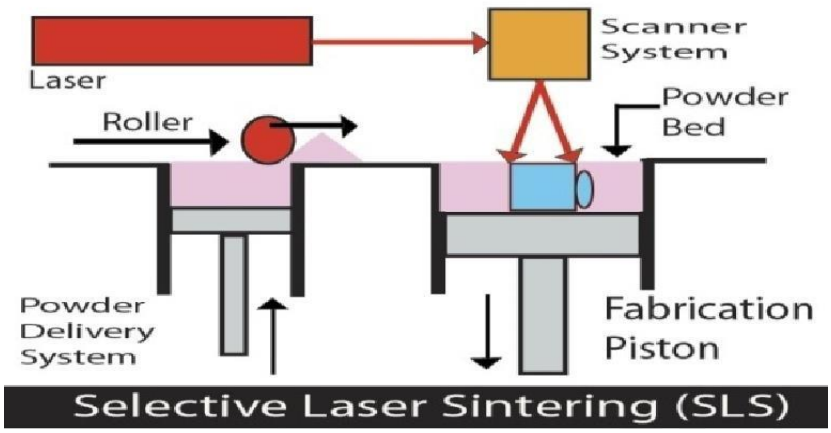
1. Prints are strong
2. Many materials are available

Disadvantage:

1. Printers are expensive
2. Rough surface finish

Examples of Medical Application:

1. Heart
2. Brain



Stereo Lithography: Stereolithography technique is widely and early used in 3D printing technology.SLA is famous for being the first 3D printing technology. In SLA an object is created by selectively curing a polymer resin layer by layer using an ultraviolet laser beam. The materials used in SLA are photosensitive thermoset polymers that come in a liquid form. Stereo lithography apparatus converts liquid plastic into solid objects. Were the light causes chains of molecules to link together forming polymers [3].

Advantage:

1. Moderate cost
2. Good surface finish

Disadvantage: Curing resins need to be handled with care

Examples of Medical Applications: Prosthetics

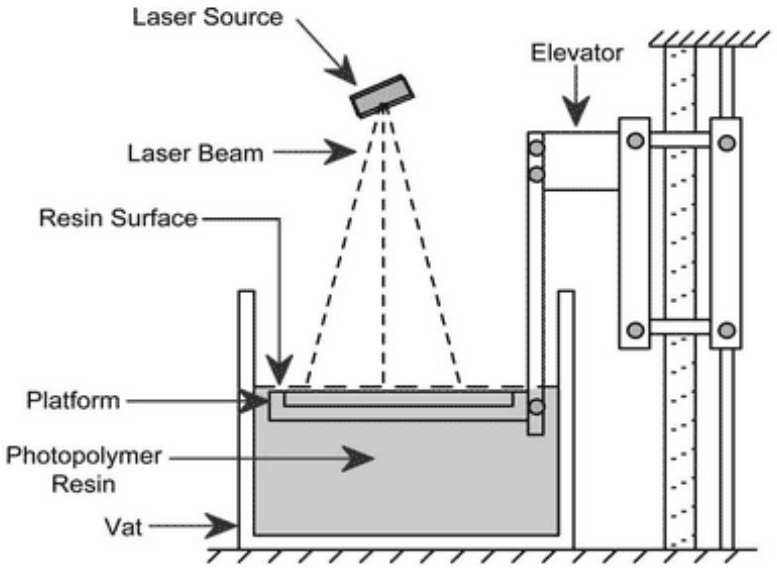


Diagram of SLA printing process

Fused Deposition Modelling: Fused Deposition modelling is also known as fused filament fabrication or fused deposition method. This method is invented by Steven Scott Crump in 1980s and designed in 1990 [4]. Crump invented and patented FDM technology in 1989 [5]. A theremoplastic filament or wire is wound into coil to material supply to an computer-controlled extrusion nozzle head. FDM technology is low cost and most commonly used in economical consumer printers, but rarely used for in medical applications.

Advantage:

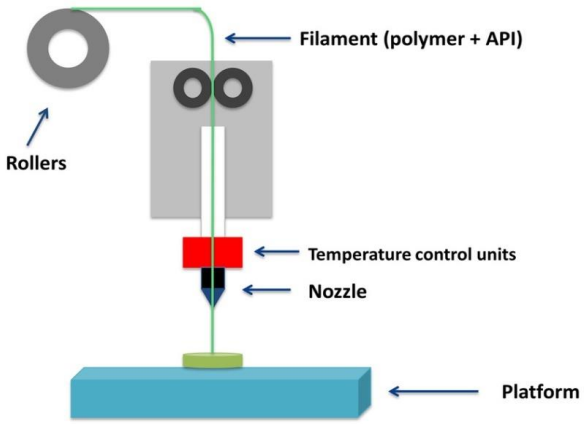
1. Low material costs
2. Low cost printers are available
3. Simple to use

Disadvantage:

1. Rippled and porous surface
2. Fragile along z-axis

Examples of Medical Application:

1. Kidney
2. Liver
3. Sinus



Inkjet Printing: Inkjet printing technology was developed in 1950s and commercialize of CAD. IJP is took place after the 1970s, the main companies such as HP and Canon [6]. It is a type of computer printing that recreates a digital image by propelling droplets of ink onto paper, plastic, or other substances [7]. Inkjet printers are the most commonly used type of printer, and range from small in expensive consumer models to expensive professional machines. Inkjet printer scan also use

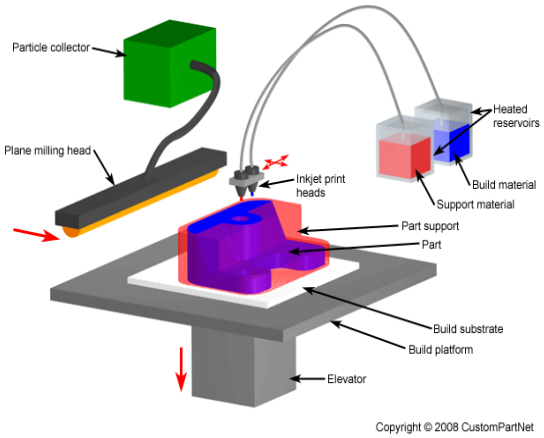
with different types of tissues by printing as living cells and biomaterials [8, 9].

Advantage:

1. Electronic control of drop size and ejection rate
2. Concentration gradient of cells, and growth factors in the construct

Disadvantage:

1. High viscous bio-inks cannot be used
2. Weak mechanical integrity of the construct



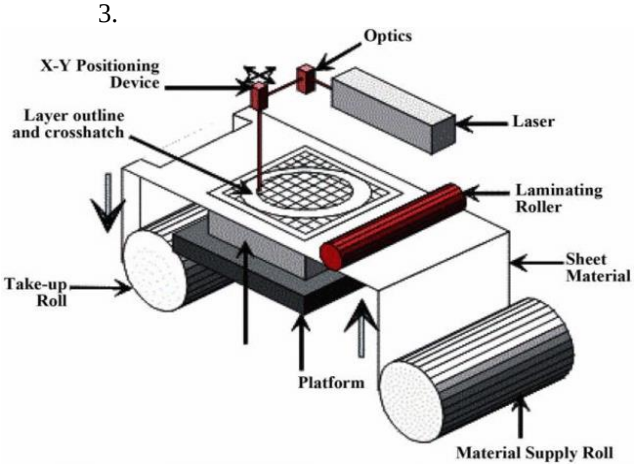
Laminated Object Manufacturing: Laminated object manufacturing (LOM) is a method of 3D printing. It was developed by the Helisys Inc in 1986 [10] (cubic technology) the application for manufacturing of ceramics was first developed by griffin and co-workers in 1994 [11,12] during the LOM process, layers of plastic or paper are fused or laminated together using heat and pressure, and then cut into the desired shape with a computer-controlled laser or blade.

Advantage:

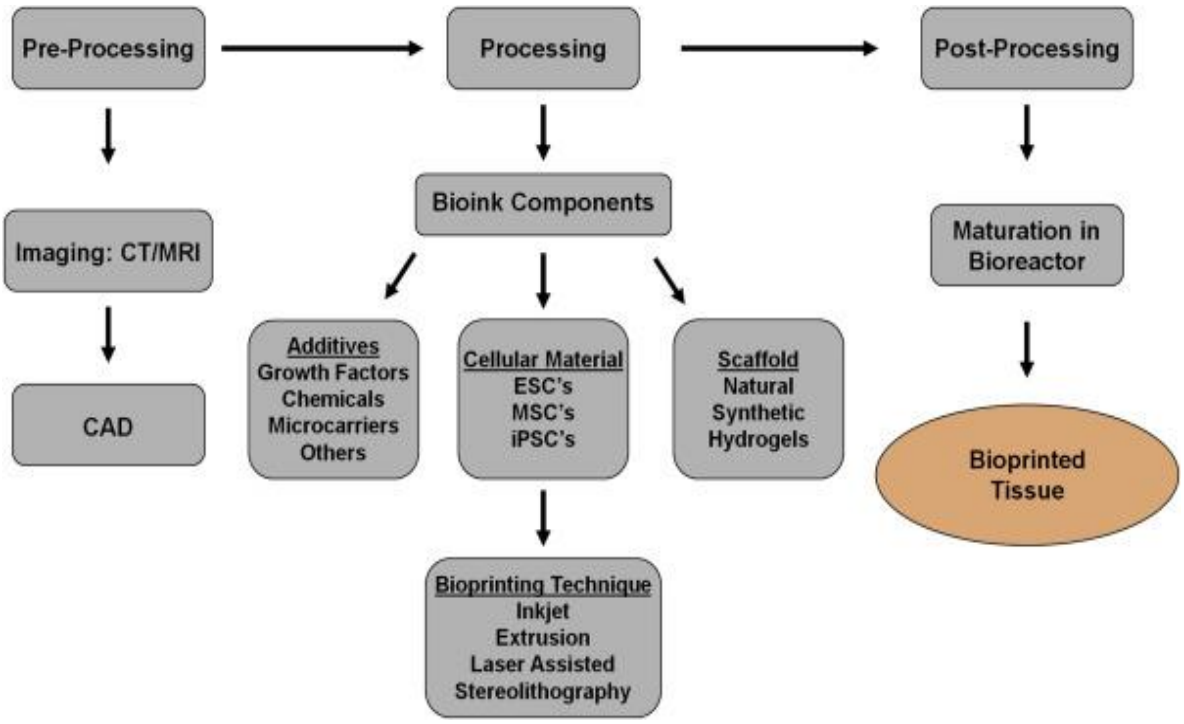
1. Relatively high speed process
2. No additional support structure is required (the part is self-supported)

Disadvantage:

1. Limited material
2. Need for sealing step to keep moisture out
3.



DEVELOPMENT PROCESS:



MATERIALS

Many different materials can be used for 3D printing. Such as Acrylonitrile Butadiene Styrene (ABS) filament is another common 3D printing filament. If the product need strength, flexibility, then nylon and ABS are good [13] Plastic, poly lactic acid (PLA) filament has become one of the most common materials for 3D printing because it easy to print, biodegradable material and it is derived from organic resources like corn or sugar cane. PLA material has the great feature is that shows biocompatibility with human body. Polyamide (nylon), the materials used for stereolithography is silver, titanium, steel, wax, photopolymers and polycarbonate. This made the 3D printing a universal tool because it can able to print 3D objects like transparent, rubber type , plastic, glass, opaque with any type of color of our choice [14,15-18].

CHOOSING THE RIGHT PRINTER

For selection of the right printer it is the biggest problem for the beginners. It depends on how the final object is formed. The 3D printers are many and new type of 3D printers is available in the market with the low cost. It depends on product and usage of human body inside or outside. Depending on physical properties and functions of end product should choose the 3D printer technology such as SLA, SLS and FDM [19]. In industry most commonly used printers for manufacturing purpose are SLA/FDM, SLS printers [20].

APPLICATIONS OF 3D PRINTING:

They are classified into different categories:

Manufacturing Applications.

1) Distributed Manufacturing: - There is a service to put people needing 3D printing in contact with owners of printers.
2) Mass customization: - This is now allow consumers to create custom cases for their mobile phones. Nokia has released the 3D designs for its case so that owners can customize their own case and have it 3D printed.
   3) Rapid Manufacturing:- It is a new method of 3D printing manufacture.

Industrial Applications:

1) Construction:- By using of 3D printing materials we can construct to build buildings. Faster construction at lower cost.
2) Computers:- To make laptops and other computer parts including cases, motherboard.

Socio cultural Applications:

1) Art:- Critical making refers to the hands on productive activities that link digital technologies to society.
2) Communication:- Terahertz devices which act as waveguides, couplers and bends have been created. It is to achieve complex design.

Advantages:

1) Easy to handle
2) Prints movable parts
3) Artificial arms and legs for disabled persons
4) Better quality (materials used are strong)
5) Unlimited shapes and structures

Disadvantages:

1) Cost of printers
2) Limitations of object size
3) Limitations of raw material
4) Skilled person required
5) It takes more time to create a single object

CONCLUSION

The 3D printing technology has brought a new era. 3D printing has an application in almost all the categories of human needs. 3D printing has some limitations such as cost of printers involves hardware and software and size of models and printing, materials. The world is forever changing with the help of 3D printing. The use of 3D printing for medical purposes today is beyond astonishing but what the future holds is unknown. However it is certain that additive layer manufacturing will be a large corporate in solving our problems. 3D printing really is limitless and only the surface has been scratched. 3D printing bones is still new and continuously improving and adjusting but it has already enhanced the life of many patients around the world. 3D printing is forever unpredictable. “If a picture is worth a thousand words a prototype is worth a thousand pictures”.

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