

The Effect and Application of 3D Printing Technology

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Abstract: *3 D printing also known as additive manufacturing technology and is considered a very big thing in the coming future. 3 D printers print objects from a digital template to a physical 3-dimensional physical object. The printing is done layer by layer (Additive Manufacturing) using plastic, metal, nylon, and over a hundred other materials. 3 D printing has been found to be useful in sectors such as manufacturing, industrial design, jewellery, footwear, architecture, engineering and many others. It has been found to be the fast and cost effective solution in whichever field of use. The applications of 3D printing are ever increasing and its proving to be a very exciting technology to look out for. In this paper we seek to explore how it works and the current and future applications of 3D printing.*

Keywords: 3 D printing, additive manufacturing, printing layers, applications, technology, cost effective.

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 [6][7]. In an additive process an object is created by laying down successive layers of material until the object is created. In this way 3D printing moves us away from the mass production line to a one-off customizable production [7]. You can literally make any object from a house to a bar of chocolate.

The initial 3D printers were used in 1980s where a pattern submerged in a liquid polymer would be traced by a computer. The traced pattern hardened into a layer, thanks to the laser, and that was how you build an object out of plastic [9]. Since then tremendous progress has been made in additive manufacturing such that material extrusion is now used. By this method, an object is build out of matter that is pushed from a mechanical head like the way in inkjet printers extrudes ink onto paper [9].

The cost of 3D printers has been decreasing with the advancement in technology. Domestic

usage of the 3D printers has been on the rise with the average cost ranging from a few hundred of dollars going up. However, one major drawback is that it requires expertise to print 3D objects [10]. In fact, it requires a competent person to make both the digital file and the final printing. Commercial usage of 3D printers has been on increase too [16] in sectors such as automotive industry and aerospace engineering.

In the current scenario, 3D printing or Additive Manufacturing has been used in manufacturing, medical, industry and sociocultural sectors which facilitate 3D printing or Additive Manufacturing to become successful commercial technology [2]. More recently, 3D printing has also been used in the humanitarian and development sector to produce a range of medical items, prosthetics, spares and repairs.

2. How it works

As shown in figure 1, 3D printing starts by making a virtual design of the object you want to create. The virtual design is used as a template of the physical object to be created. This virtual design can be made using a 3D

modelling program such as CAD (Computer Aided Design) to create a design from a scratch. Alternatively a 3D scanner can be used for an existing object. This scanner makes a 3D digital copy of an object and puts it into a 3D modelling program.

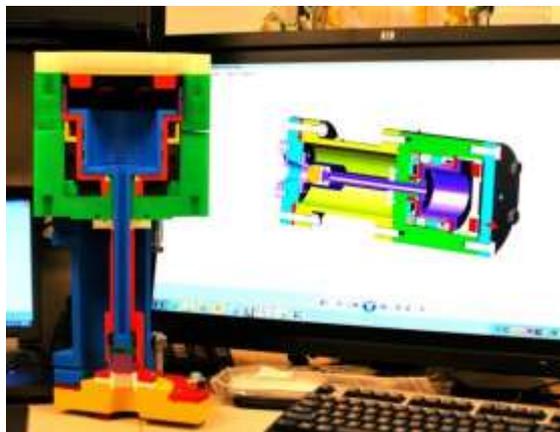


Figure 1. 3D object and digital model

The model is then sliced into hundreds or thousands of horizontal layers in preparation of printing. This prepared file is then uploaded in the 3D printer, which will see the printer creating the object layer by layer as shown in figure 2 below.

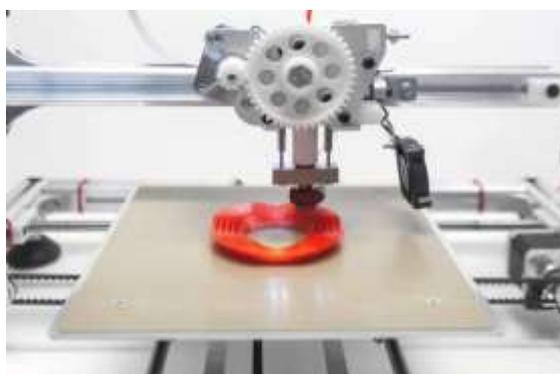


Figure 2: 3D printing layer by layer

Here, every slice (2D image) is read by the printer [5] and proceeds to create the object layer by layer and the resulting object has no sign of layering visible, but a 3 dimensional structure [6].

3. Applications of 3D printing

3D Printing applications cover various sectors from education to industry, and the whole value chain from prototypes to spare

part management. Figure 3 shows the various kinds of usages of 3D printing which include research, artistic items, visual aids, presentation models, device covers, custom parts, functional models, and patterns as well as series production.

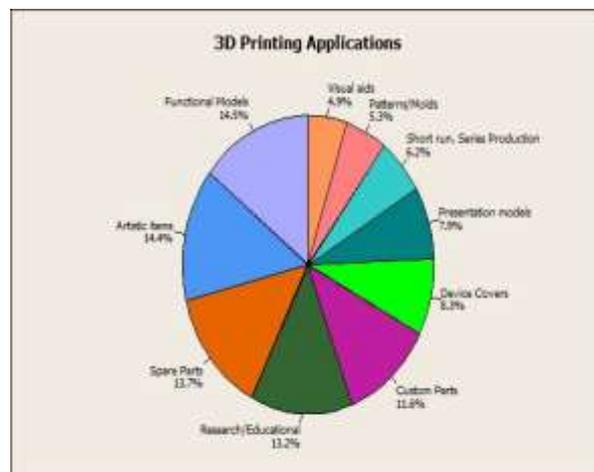


Figure 3: 3D printing applications

3.1 Construction

In the construction industry, 3D printing can be used to create construction components or to 'print' entire buildings. Construction is well-suited to 3D printing as much of the information necessary to create an item will exist as a result of the design process, and the industry is already experienced in computer aided manufacturing [18]. The recent emergence of building information modelling (BIM) in particular may facilitate greater use of 3D printing.



Figure 4: 3D construction

3D printing may allow, faster and more accurate construction of complex or bespoke items as well as lowering labour costs and producing less waste. It might

also enable construction to be undertaken in harsh or dangerous environments not suitable for a human workforce such as in space.

3.2 Medicine

3.2.1 Hearing aids

Hearing aids have been made using 3D printing technology.

3.2.2 Bio printers

Bio printing is an additive manufacturing process where biomaterials such as cells and growth factors are combined to create tissue-like structures [1] that imitate natural tissues. The technology uses a material known as bio ink to create these structures in a layer-by-layer manner.



Figure 5: 3D printed heart

Figure 5 shows a 3D printed human heart. New bio printers actually print human tissue for both pharmaceutical testing and eventually entire organs and bones [11].

Tissue engineering has made tremendous strides as they have been able to print 3D blood vessels [12]. This was achieved by combining advances in 3D bio printing technology and biomaterials through vascularisation of hydro gel constructs.

3.2.3 Digital Dentistry

People are getting 3D printed teeth customised for the individual [10]. Dental implants are being made on a commercial level and making the whole process faster

and more efficient. Before fake teeth used to be a one size fits all depending with age. Now the people of the same age can have different sized teeth resulting in people getting discomfort with ill-fitting fake teeth. Thus, customised implants have really brought a sigh of relief to the customers as they are now able to receive teeth suited to them.

3.2.4 Prosthetics

3D-printable prosthetics are changing the face of medicine, as engineers and physicians are able to develop prosthetics that are fully customized to the wearer. Consumer 3D printing is leading to an even bigger revolution: "DIY" assistive devices that can be printed by virtually anyone, anywhere.

Prosthetics has really done wonders to disabled people with the likes of Paralympics champion Oscar Pistorious being a world famous example. Oscar had his legs cut off as a child, but that did not stop him from running, let alone in the Olympics [10][2].

3.2.5 Bionics

Researchers from Princeton and John Hopkins were able to make a 3D printed bionic ear [10]. The hearing is done through electronics. This development could help deaf people to hear.

3.2.6 Artificial Organs

3D printing for the manufacturing of artificial organs has been a major topic of study in biological engineering. As the rapid manufacturing techniques entailed by 3D printing become increasingly efficient, their applicability in artificial organ synthesis has grown more evident. Some of the primary benefits of 3D printing lie in its capability of mass-producing scaffold structures, as well as the high degree of anatomical precision in scaffold products.

3.3 Manufacturing

3D printing has introduced an era of rapid manufacturing. The prototyping phase is now able to be skipped and go straight to the end product [8]. Car and aeroplane parts are being printed using 3D printing technology. The printing of parts is being done in a fast and efficient manner thus contributing immensely to the value chain [8].

Customised products are able to be manufactured as customers can edit the digital design file and send the manufacturer for productions. Nokia Company has taken the lead in the manufacturing in this era [12] by releasing 3D design files of its case to its end users so they can customise it to their specifications and get the case 3D printed.

3.4 Domestic Usage

Goods that used to be shipped around the globe can now be 3D printed locally by the consumers, not only saving money but reducing fuel emissions as well. Another benefit 3D printing at home is that your parts will only use the amount of material really needed.

3.5 Clothing

3D printing is offering great advantages for the fashion industry, from 3D printed clothes to 3D printed footwear and accessories, the possibilities are endless. In the first place, 3D printing was more used for an artistic touch, but the fashion industry is now developing 3D printed projects of wearable garments. Nike made the 2012 Vapour Laser Talon football shoe [9] and New Balance custom-fit shoes for athletes using a 3D prototype [7]. The production was done on a commercial scale.

3.6 Academia

3D printing is being integrated in the learning curriculum. With applications

from printed module models to plastic gears [4]. Students are now able to print their prototype module in 3D and it helps in the learning process to the students. Students are better able to understand concepts as it can be practically shown to them.

4. Benefits

3D printing has proven to have the following advantages:

1) Faster Production

3D printing is quicker than conventional manufacturing including injection moulds and subtractive production. Think the speed of a sports car versus the speed of a horse cart. Both will reach their destination, but the time difference is significantly huge. From a prototype to a final product, 3D printing tests ideas and designs quickly.

2) Easily Accessible

3D printing has been around for decades but it really did not take off until 2010. The explosion of 3D printing interests has brought easier to use software and hardware to consumers as more competition has entered the space. It's never been easier to learn the technology and you can incorporate it in a matter of days into your production cycle.

3. Better Quality

Products with an excellent surface finish are produced.

4. Tangible Design and Product Testing

There's no way seeing a product on the screen or virtually can compare to the actual feel of a prototype. 3D printing offers that benefit. It is possible to experience the touch and feel of the product prototype to physically test it and

find flaws in the design. If a problem is found, you can modify the CAD file and print out a new version by the next day.

5. Lower Cost

In China they were able to construct 10 one storey houses at less than \$5000 per house [8]. Construction of a similar house costs way more than the stipulated price.

6. Unlimited Shapes and Geometry

Old methods of manufacturing rely on moulds and cutting technologies to generate the desired shapes. Designing geometrically complex shapes can be hard and expensive with this technology. 3D printing takes on this challenge with ease and there's not much the technology can't do with the proper support material.

7. Less Waste Production

3D printing only uses material that is needed to create a prototype part – no more, no less. Additionally, reusing the materials from a 3D print is relatively straight forward. As a result, additive manufacturing creates very little waste, and saves a company a lot of money.

8. Functional Models

Real life functional models can be produced as opposed to working with paper of digital models. More realistic products are produced.

5. Future Work

The future looks bright in the field of 3D printing with the following areas to look out for:

5.1 Manufacturing

The 3D printing industry is set to see unprecedented growth with market analysts predicting a year on year 18

percent growth. As shown in figure 6, it is predicted that the 3D printed part market will grow to an 8.4 billion dollar industry by 2025 [11]. Automobile parts and aerospace will lead in the parts sales forecast.

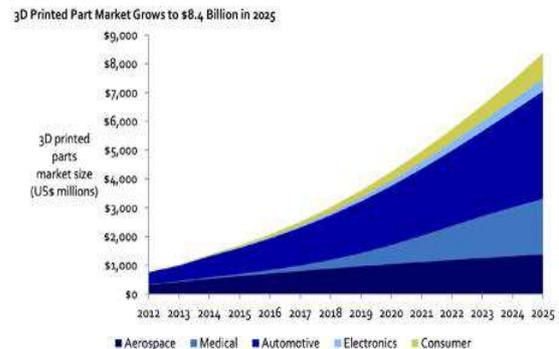


Figure 6: 3D printing growth prospects

5.2 Medicine

5.2.1 3D printed organs

The combination of stem cell research and 3D printing will result in transplantable body parts in the future. Real functional body parts will be able to be 3D printed [10] [3].

5.2.2 Skin Grafting

In skin grafting healthy skin from a part of the body is used to cover a damaged part of the body. The procedure is very well known to be a painful procedure. University of Toronto researchers have developed a method of skin grafting by loading skin cells and various polymers into 3D printer to artificially create layers of skin. They observed that most of the casualties of war were burn victims which had to go the gruesome operation of skin grafting. Hopefully in the near future all this research will turn into reality.

5.2.3 COVI-19 pandemic

These days the shortage of other health care products such as face masks and personal protective equipment for health care workers is also posing serious challenges and these things can be made with the help of 3D printers. Even a group of volunteers which includes doctors, biomedical professionals, academics and

engineers are trying to use 3D printing technology to design a device that allows a single ventilator to support multiple patients at a time.

6. Conclusion and Recommendations

The 3D printing industry is set on a growth trajectory as evidenced by the growth forecasts [11]. The applications of 3D printing are increasing as more and more research is carried out. 3D printing will change the way people acquire products as evidenced by the Amazon proposed model. The field is definitely a game changer with lots of prospects to look out for.

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