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3D Printing Prosthetics and Beyond

Introduction

Technology is one of the fastest growing and most rapidly changing fields, and as it grows it impacts so many other aspects of society, from education to customer service to medicine. For the purpose of this paper, the focus will be on 3D printing technology and how it is currently affecting the medical field. 3D printing has been around since the 1980's, but within the last 10 years it has become something of a revolution in modern production, and it has recently started to affect medicine in a very important way. There is still a lot left to learn and gain with 3D printing, but there is no doubt that it has already made a remarkable impact on the medical field, and as it continues to grow and gain resources, 3D printing will be improved and continue to cause further improvements in medicine.

What is 3D printing?

In order to understand how 3D printing affects medicine, it's important to know the basics of what 3D printing is. 3D printing is the process of using an automated system to

produce a fully three dimensional object from a digital file. It requires what is essentially a blueprint of an object, which can be obtained in various ways. Methods of obtaining a design include scanning an existing object using a 3D scanner and uploading the scan, developing a new design in a 3D design program and creating a Computer Aided Design (CAD) file, or simply using one of the many CAD files that are available online. Once a virtual design is prepared, the 3D modeling software breaks the image into horizontal layers. This way, when the file is uploaded in a 3D printer, the object can be created layer by layer. The 3D printer reads every layer and creates the object, blending each layer with hardly any visible sign, and the result is the three dimensional object. There are many 3D printing programs available, and there are new types of printers produced everyday. The most significant difference between each printer are the type of materials used and the way that the “ink” is distributed and formed in the layering process, so while all processes are additive the way the object is built could potentially differ between each machine.

Printing Prosthetics

Prosthetics are one of the many things that are being positively affected by 3D printing. Printing prosthetics is still relatively new, and as such is currently going through a lot of new development. There are quite a few organizations looking to take advantage of 3D printing and use it to make prosthetics more widely available, especially to developing countries where current methods of prosthesis are too expensive. Since each person and amputation is unique, current methods of fabrication and fitting of prosthetics are time consuming and costly.

Typically, a plaster mold is taken of the amputation site, and this mold then serves as a template for a prosthetic limb. It can take up to 5 days or longer to form the mold and make adjustments to ensure the comfort of the patient as well as the function of the prosthetic. This is a costly procedure, with the price being anywhere from \$5,000 to \$50,000 per prosthetic, which need to be replaced regularly throughout a patient's life. This holds true even more so for younger patients who will have to be continually refitted for their prosthetic as they grow. 3D printing allows the prosthetist to take a 3D scan of the amputation site, and use the resources and virtual engines to form the prosthetic, reducing the time and the cost of the procedure. After taking a scan of the amputation site, a prosthetist is able to fabricate and form the socket and prosthetic directly through a virtual program, and a printer is able to produce the new limb in a single day.

The 3D printing method takes the time necessary to create the prosthetic from 5 days to one day, and will eventually allow for a greater level of customization. However, this isn't a perfect solution. The rigid plastic material that is currently being used as a printing material is still less effective than the typical carbon fiber material used in modern prosthetics. There is also a bit of a learning curve for prosthetists who must learn to use a new software in order to format a new prosthetic in a virtual environment. It is because of these factors that 3D printing is not a full replacement for current methods of designing artificial limbs.

Currently, since the components that are popular for prosthetics in the developing world are very similar to the 3D printed plastic materials that are used in prosthetic printing, the focus of the development of printed prosthetics is in Uganda. It has become more common to see printed prosthetics in poorer countries where there is a very high need for cost effective

solutions and where the 3D printed prosthetics can be put to good use while they are developing new methods and ideas for improvement. There are many organizations that are currently developing innovative new methods of prosthetics, most of them focusing on a single facet of development, such as prosthetic hands, arms, legs, or the socket for the amputation site. As these organizations are not competing with each other, and they all have a common goal, much of their research and technologies are open and available to the public.

Bioprinting

Bioprinting is one of the most fascinating things that can be done using a 3D printer. There are still many things that cannot be printed, but there have been leaps and bounds made in this technology very recently. The process for bioprinting generally begins with a biopsy of the tissue that is going to be printed. Using this, certain cells can be isolated and multiplied in preparation for mixture with other special liquid substances called microgels which provide oxygen and other nutrients to keep the cells alive. The results are a printable biomaterial, or “bio-ink” which is living material that is then fed into a 3D printer cartridge just like normal ink. The 3D printer then begins the process of dispensing the freshly made material onto a biocompatible scaffolding, layer by layer, until the 3D tissue is ready. This form of printing is the most cutting-edge, the leading method in organ and tissue printing.

An earlier form of bioprinting is ink-jet printing, which is a very similar method but lacks the versatility of bioprinting. The ink-jet method loads cells into multiple ink cartridges and dispenses them layer by layer, and allows for multiple cell types and components to be used for

printing, but the printers have to be programmed to place the cells in a particular order to create tissue. It leaves a much larger chance for error. The ink-jet method has since been adapted in such a way that it allows a team of researchers to use the printer to print skin grafts directly onto burn victims, leaving the organ printing to the newer models of printers.

The process of bioprinting is quite similar to traditional 3D printing, with a few extra requirements because organs have need of more than one type of material, as well as a supply of things like oxygen and nutrients to keep the tissue alive. 3D bioprinters will have to have some special modifications to keep the biomaterials healthy. Regardless of some of the challenges, bioprinting can lead to the development of viable organs that can be transplanted into patients, and that is something that could potentially happen very soon. Research and trials are already well underway to making the printing of living tissue a technique that could benefit hundreds of thousands of people all over the world.

Just as with prosthetics, though, there are drawbacks to bioprinting that need to be recognized. Bioprinting is a very complicated process, because of the need to supply oxygen, blood, and nutrients to the tissues being built. There are many methods being used to try and build a vascular network within the organs, but it is a difficult process and it is still highly experimental. There is also the chance that a patient can reject a 3D printed organ, just as with any transplant. Though there is less risk, since the cells come from the patient's body, there is still a chance for rejection, and it is important to recognize the risks associated with rejection of transplanted organs.

Other Uses of 3D Printing

There are many other valuable applications of 3D printing that are currently in use. It's possible to print medical models that can greatly improve a surgeon's ability to practice and perform a surgery. With the ability to scan and model a patient's exact issue, such as a tumor or a body cavity, a doctor can be much better prepared for the actual surgical process. Having this highly detailed medical model could easily help reduce surgical time and complications. This is also true for medical students who can practice on extremely accurate models of human anatomy, or have access to complex visual aids that have been designed and printed to enhance their understanding. These types of model prints are readily available, and are already helping to improve the understanding of certain diseases and afflictions by creating much more intricate visual aids.

Another incredible benefit of 3D printing is the ability to print affordable medical equipment and distribute it to rural or poorer areas. Just as with prosthetics, there is a high need for medical equipment in developing parts of the world where there are not enough resources to buy or build extremely expensive medical equipment. 3D printing gives people access to medical supplies they otherwise would not have, which greatly improves success rates of surgeries and overall quality of life. There are many more benefits to this technology, the possibility for tailor made implants for individual patients, 3D printed bones that can support weight and grow with surrounding tissue, skin grafts that could greatly improve the healing rate and recovery time for burn victims, and more. These benefits are incredible and they will continue to improve as 3D printing improves.

Conclusion

There is so much that 3D printing will be able to change, particularly in medicine. It is apparent that 3D printing is a growing industry, and it is clearly going to change the way that objects are built, how products are developed and produced, and how people gain access to many different things. People are printing anything from food to car parts, and within the next 10 years, there could very well be viable transplant organs and prescription medication being printed as well. As this method of production continues to gain traction, there is no doubt that it will continue to have an effect that is far reaching. While the benefits are clear, there are still many drawbacks that need to be addressed, and many limitations that come with 3D printing. However, there are many who say that 3D printing is the future, and that it is going to change the world. With the profound impact it has had on a field as important as the medical field, time will tell how this technology will continue to grow and bring new changes.

Resources

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