

3-D Printing: The Dawn of Tomorrow

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Introduction

It goes by many names. Stereolithography, Additive manufacturing, or more commonly known as 3-D printing. It is a concept in which a 3-D object is created from a digital file. The purpose of this research is to construct a better understanding how this new and exciting technology of 3-D printing can create the future. By looking into its past we will gain a better understanding of how it can affect the future. Currently, innovators are looking for ways to further the benefits of 3-D printing. Though 3-D printing has already sparked a new revolution in the realm of information technology, the benefits, legal, ethical, security and social issues concerns of 3-D printing will also be analyzed. The conclusion of this research will bring together all the ideas that were put together in all the sections and how it can revolutionize the world.

Background

The year 1983 was filled with excitement because for the first time in history a man by the name of Chuck Hull invented the first 3-D printer. Chuck Hull then realized the full potential of this innovative invention, and in 1986 he founded his own company called, 3-D systems. At 3-D systems they were the first to create rapid-prototyping and created the first rapid prototyping system called, SLA 1. Not only that, but Chuck and 3D systems created the .stl file to connect the CAD (Computer-Aided Design) software to print the 3-D object (<http://www.3dsystems.com/30-years-innovation>). They were the pioneers of this technology. This was a newborn concept that would benefit all types of businesses. After the successful launch of 3D Systems, many other companies sprouted up from this new concept. These companies are: MakerBot Industries., Materialise NV, and Stratasys. All these companies have

created a standard on how to make all these magnificent objects. the more companies that engineer 3-D technology device and systems, the better the device will eventually become.

Forming a 3-D printed object is quite simple. One could wonder why this technology wasn't readily available sooner. "The 3-D printer is guided by instructions in the design file, squirts out or solidifies powdered, molten, or liquid material into a specific flat pattern. After the first layer solidifies, the 3D "print head" returns and forms another thin layer on top of the first one" (Lipson & Kurman , 2013, p.12). This repetitive process may seem like it would take a lot of work, but it gets the job done faster than a manufacturer would, hence why when they first invented it, 3D systems used it for *rapid*-prototyping. The most common material to print 3-D objects with is plastic. "3-D printers produce objects using wheels of filaments made of biodegradable plastic PLA (Polylactic acid), an environmentally friendly material derived from corn starch, or ABS (Acrylonitrile butadiene styrene) polymer found in fossil fuels " (Canessa & Fonda, 2013, p. 12). Since the creation of 3-D printing in 1983, we have developed other materials in order to print a plethora of objects. The materials that can be printed vary. These include but not limited to: Nylon, wax, ceramics, chocolate, steel, titanium, silver, and bioink (later discussed in ethics). This is just a background on the impressive advancements that 3-D printing has made. It's amazing to think that it has only been around for thirty-one years. The benefits to 3-D printing are evolving every day.

Potential Benefits

The wonderful benefits of 3-D printing are limitless. One of the ways 3-D printers benefit society is that they were primarily used for rapid prototyping. Rapid-Prototyping is creating a functioning concept-model that reduces the cost by thousands and gives companies a head start

from their competitors (<http://www.3dsystems.com/30-years-innovation>). This rapid-prototyping contributed to the increase of technological growth because companies are able to come out with a product faster than they did on previous projects. One aspect of the prototyping stage is human error, which slows down the process of getting a project or product complete. That hurts businesses. "The modern-day form of automated 3D printing also lessens the probability of human errors" (Thomas, 2014, para. 3). Another potential benefit of 3-D printing is how businesses revolutionizes how we manufacture products. Cathy Lewis (2013), Vice-President of Global Marketing at 3-D Systems commented in an interview, "People started to talk about the benefits of the applications beyond rapid prototyping. At that point, we along with our clients realized not only was there a market for rapid prototyping but also rapid manufacturing, which was high value but low volume 'production printing' using 3D technology " (as cited in Ramos, 2013, para. 10). This would decrease the amount of cost that a company spends on manufacturing, as well as first-class customization. A huge benefit of 3-D printing is the rise of customer customization to everything that is printed out. Take for example the pioneering efforts and potential benefits the world's first 3-D printed car has on society. "One day, in the not-too-distant future, you'll be able to walk into a car dealership, choose a design — including the number of seats — and have a 3D printed car by the end of the day. This is Jay Rogers' vision. Rogers is the CEO of Local Motors, the company that just built the world's first 3D printed car known as the Strati" (<http://mashable.com/2014/09/16/first-3d-printed-car/>). This improves customer and manufacturer relations. In previous years, the manufacturer gave their customers options to choose from. Now, due to the CAD and then through 3-D printing, customers have an opportunity to receive exactly what they want , the way they want it. Lastly, the accessibility the 3-D printer creates, not only help government entities, but also helps the average farmer. NASA

is looking at bringing a 3-D printer onto space missions to reduce the load on missions. "The agency hopes to demonstrate that, with the printer making spare parts on the fly..." (Ramos, 2013, para 11). This is not only innovative to NASA standards, but also cuts cost. The agency could spend more money on future missions, rather than losing money fixing current ones. This seems like something NASA would do, however the average farmer could also use a 3-D printer. Instead of picking up a spare part that would take time out of a farmers already busy day, he could just print it from home. "They foresee a future where, if you need a tool or an object such as a wrench or a vase, whether at home or at work, the computer will just make you one. If you no longer have need of that object, it can be recycled on-site back into the raw materials to build the next object"(Wehrspann, 2013, para 15). This impressive benefit would create more efficient farms, which in turn would increase food production. From businesses using rapid prototyping, to manufacturers increasing the quality of their product without costing them more money, to the ever-hungry consumer. Everyone, from the profession of astronaut to farmer will benefit from 3-D printing.

Legal

Though there are certainly numerous benefits to 3-D printing, there are also legal aspects to be aware of when creating this magnificent technology. On April 26, 2013 The United Nations (UN) celebrated World Intellectual Property Day. Not everyone is getting hyped about the technological sensation. "...The Geneva-based WIPO organized an exhibit and panel discussion featuring three dimensional (3D) printing. In a statement, WIPO said that 3-D printing is both a manufacturing and a digital technology, and as such, it makes the unauthorized copying of objects easier, raising a number of challenges to intellectual property protection" ("On world intellectual property day," 2013, para 4). How 3-D printing can make a copy out of anything is

one of the most commonly questioned aspect to 3-D printing. There are those who create the idea, and those who want to steal it and make selfish fortunes. One could question if this technology poses more of a problem than a solution. The 3-D printing market is growing significantly. It is only a matter of time until everyone has one in their homes." The global 3D printing market was worth USD 2,200 million in 2012 and is expected to grow at a CAGR of 16.8% from 2013 to 2019... infringement of intellectual property rights has increased the number of laws and regulations adding another restraint to the market"("Research and markets," 2014, para 1). Just because the 3-D printer has not clinched itself to the everyday use of the world , it doesn't mean there will be people who are plainly uninformed of the laws. There are people who have already felt the repercussions of copying a manufacturer's design . " Thomas Valenty bought 3-D printer and printed WarHammer figures with his own modifications to it, he posted the design on Thingiverse.com, and soon after Games Workshop, the company that owns WarHammer, issued a takedown notice for his design because it violated the Digital Millennium Copy Right Act" (Thompson, 2012, para 1). These takedowns are only the beginning because these issues that will explode into larger problems. Phoebe Li is a Lecturer at Sussex University and Stephen Mellor, James Griffin, Charlotte Waelde, Liang Hao, and Richard Everson are from Exeter University and their case study about 3-D printed chocolates helped solidify that: The laws do not apply only to those objects that are 3-D, but to those that are also 2-D as well. "What is relevant about an artistic work for 3D printing is that representing a two-dimensional artistic work in three dimensions is a reproduction for the purposes of copyright infringement, as is representing a three-dimensional work in two dimensions. So, for example, a drawing of a cartoon figure protected by artistic copyright which is represented in three dimensions in chocolate is a reproduction of the drawing for the purposes of copyright. Similarly, a three-

dimensional cartoon character protected by artistic copyright represented in the form of a flat chocolate is also reproduction for the purposes of copyright" (Li et al., 2014, para 18). People must be aware of certain laws about trademark and patents as well because those play a huge factors in legal battle. Michael Weinberg (2010), the author of *It Will Be Awesome if They Don't Screw it Up: 3D Printing, Intellectual Property, and The Fight Over The Next Disruptive Technology* and also a senior staff attorney with Public Knowledge puts it plainly. Printing a trademark of a company or printing a product patent is illegal (p.7-8). In an interview, Michael Weinberg expresses a loophole in the aspect of patent printing, "Printing in 3-D is a disruptive technology that raises a lot of intellectual property issues...however, the legal situation might actually favor the amateurs... disputes over copies of physical objects are often fought using patent law, which is far less strict than copyright. For example, patents last only 20 years, which means many cool everyday objects (Lego bricks!) are long out of patent. What's more, patent law generally governs only a complete assembled product, so creating replacement parts--a thriving pastime among hobbyists--is probably legal" (Thompson, 2012, para 2-3). As long as people know the laws of copyright, trademark, and patent laws, there won't be a problem. Those who hosts a design file for 3-D printing must be careful about what material they upload and how it is distributed. There are two kinds, an open model is when users are free to upload anything, and do whatever they want to the model. Contrast to an open model is a money model. A money model it is a site that sells 3-D designs. Subcategories of the open models and money models are indirect and direct infringement. The author of the article, *The Next Napster? Copyright Questions as 3-D printing Comes of Age*, Peter Hanna (2011), also defines the types of infringements sites can produce. Indirect infringement is when one supports another to infringe a patent, whereas direct infringement copy the patent and sell them through the site itself.

However, Peter Hanna also commented on the reason why there hasn't been as much lawsuits filed. "...but it's probably because so few people have 3D printers and any takedown might be bad PR..." (pg. 2) It's really not a matter of when laws will affect the 3-D printing industry, but it's a matter of how. Laws are laws. They are there for a reason. Just because a new technology arises does not mean we will always bend the rules for it. Perhaps one day, 3-D printing technology might push law makers to pass laws about the ability to copy our organs.

Ethics

Bioprinting is a form of 3-D printing that uses live cells. The bioprinter uses bioink, which applies layers upon layers of these cells to eventually create an organ or a tissue. At a click of a button one can prevent health issues, and possibly prevent premature death. For example, "In Hangzhou Dianzi University in China announced it had created biomaterial 3D printer Regenovo, which printed a small working kidney that lasted four months. Earlier in 2013, a two-year-old child in the US received a windpipe built with her own stem cells" (Williams, 2014, para. 2). This type of technology is rapidly gaining momentum because of the successes of the examples stated above. However this raises an ethical issue in which people have to figure out the limits of how much technology will interfere with the natural occurrence of life. Gartner, a information technology research company, believes that by as early as 2016 we will see a growing debate in regulating technology or banning it for both human and nonhuman use (Sinclair, 2014, para. 11). One must keep in mind the needs of those who desperately need bioprinting to stay alive. The point of technology is the make our lives better. However a point that Pete Basiliere (2014), research director at Gartner, brought up was: "3D bioprinting facilities

with the ability to print human organs and tissue will advance far faster than general understanding and acceptance of the ramifications of this technology " (as cited in Williams, 2014, para.5). This statement is accurate because bioprinting has not made it into the public agenda. It is not an issue we have to worry about because it is still in its trial phase. Though, it is still in its infancy, engineers, scientist, doctors, and IT specialist, can all modify this technology. The ethical questions of bioprinting will only continue to layer up as this rapidly growing technology comes into the minds of the public.

Security and Social Issues

In a world where there are potential cyber threats at any moment, those who use this technology must analyze the security of 3-D printing. Even the Pentagon is looking at bringing a 3-D printer onboard U.S Navy ships. "Printing comes with a number of security concerns, including some related to cyber security" (as cited in Mishory,2014, para. 2). If these Navy ships would depend on 3-D printers to one day print parts for the ships, those who are in command need to be cautious about those who could use it against them. Therefore, the security risks of 3-D printers are relevant. Just because they are printers it does not mean that hackers would not be interested in hacking these devices and possibly shutting these devices down, hence posing a threat to national security.

The security risk that is intertwined with the social issues are that these 3-D printers are proven to create fully functioning guns. The plastic from 3-D printers can withstand the heat that guns fire off. "Cody Wilson, the founder of Defense Distributed, fired the first shot from his 3D-printed gun a few days ago, he created a flutter across the technology world with experts weighing down the pros and cons of 3D printing. After the blueprints for the plastic gun were

downloaded 100,000 times, the US government has now demanded designs for a 3D-printed gun be taken offline" ("Are 3D-printed guns really dangerous?", 2013, para.1). The astounding number of times that the file has been downloaded is shocking to the public, however, the amount of times it was downloaded does not correlate to the amount of criminal incidents involving 3-D printed guns. There has been no reports to be cited about 3-D printed gun incidents, because no incident has occurred. Yet, the public is still skeptical of what it does not understand. Yes, the risk of 3-D printed guns raises some eyebrows, however through proper regulation, the 3-D printed gun would become more of a benefit than a concern. For example, police forces would be able to buy 3-D printed guns for half the cost of guns made by more expensive material. This is a potential risk that has been brought to light , and because of that, people can enjoy their second amendment rights given in the United States Constitution.

"Defense distributed focuses on making a double lower receiver, which houses the trigger... ATF approved Federal Firearms license" (<http://www.youtube.com/watch?v=DconsfGsXyA>).

Because the ATF approved their license, Defense Distributed now has the ability to make their product accessible to the public. This information may be shocking to the public, yet it can be a benefit. The more cheap affordable guns, the more protection one can have. This social issue will be a continuous debate amongst the left and right wings of the political spectrum. However, the people must eventually have to choose, and regulate properly, as to how this technology will affect their lives.

Conclusion

3-D printing is still a young form of technology. Like all the great technological inventions, 3-D printing will only become more affordable. The research of this technology is

rapidly evolving, and 3-D printing is already showing signs of its ability to bring good into the world. The dawn of 3-D printing is here. We only anticipate for the days to come when our lives are positively affected by 3-D printing.

Bibliography

A Journey of a Lifetime. (2013) 3D Systems, Inc. Retrieved from:

<http://www.3dsystems.com/30-years-innovation>

This is a direct website to the company that created the 3-D printer. It includes the 30 year history of the company. There the website describes the origins of the 3-D printer as well as the .stl file that connects to the CAD file.

Are 3D-printed guns really dangerous? (2013, May 10). *CIOL*, Retrieved from

<http://search.proquest.com/docview/1460273257?accountid=14541>

Hod Lipson, an associate professor and the director of the Creative Machines Lab at Cornell University examines the way Cody Wilson revolutionized the 3-D printing industry by creating the first 3-D printed CAD file. The government even shut his file down when he had reached 100,000 downloads. The fact that anyone who has a 3-D printer can now create a gun is under the radar of both security and social issues.

Canessa, E., Fonda, C. Zennaro, M. (2013). *Low-Cost 3D Printing For Science, Education & Sustainable Development.*

The Abdus Salam International Centre for Theoretical Physics. This article talks about the type of plastic material that is commonly used in the 3-D printers. It describes how the process of a 3-D printer works and the chemical compositions of the plastic cartages.

Carr, E.L., (2013, March 25). *3D Printing Guns* [Video File]. Retrieved from

<http://www.youtube.com/watch?v=DconsfGsXyA>

Vice interviews Cody Wilson, founder of Defense Distributed. This video shows how

Cody is able to run his company. He goes through the process of how his product goes from a simple CAD file to something that sparked a social issue in the world having created the first 3-D printed gun to fire over 600 rounds of ammunition.

Hanna, P., (2011). The next Napster? Copyright questions as 3D printing comes of age.

arstechnica. Retrieved on September 22, 2014, from <http://arstechnica.com/tech-policy/2011/04/the-next-napster-copyright-questions-as-3d-printing-comes-of-age/3/>

The author talks about how 3-D printers have already caused some problems over copyright infringement on [www. thingibot.com](http://www.thingibot.com). However, he believes that the legal battles that will come from companies will be slower than most people will think. Due to the fact that not a lot of people have 3-D printers in their homes yet, Hanna believes this will only be bad PR for companies.

Li, P. ,Mellor, S., Griffin, J., Waelde, C., Hao, L. Everson, R. (2014). Intellectual property and 3D printing: a case study on 3D chocolate printing. *Oxford Journals*, 9(4). 322-232.

Retrieved from:

http://jiplp.oxfordjournals.org.mutex.gmu.edu/content/9/4/322.full?maxtoshow=&hits=10&RESULTFORMAT=&fulltext=3D+printing&searchid=1&FIRSTINDEX=0&resource_type=HWCIT

In this Journal they describe the laws that go into 3D printing. The authors of the journal also created a case study in which they examined how the use of chocolate designs can infringe on intellectual property. The relevance of this journal in the paper is because they describe how making 2-D drawings into 3-D drawings are also subject to copyright infringement.

Lipson, H., Kurman, M. (2013). *Fabricated: The New World of 3D Printing*. Indianapolis, IN: Wiley.

This book is essential to my research because it describes the process of how the 3D printer melts the plastic material. The book describes the vast array of components this device has. The book also talks about how the CAD file converts the creation into the object.

Mishory, J. (2014). Pentagon closely examining 3-D printing benefits, security concerns.

InsideDefense.Com's SitRep, Retrieved from

<http://search.proquest.com/docview/1492526100?accountid=14541>

The article examines the high possibility that the Pentagon will be bringing 3-D printers to be cost saving devices that can repair the United States military equipment. The connection to this paper and this article is how cyber security is greatly examined.

The possibility of enemy hackers could be trying to infiltrate our technology systems.

On world intellectual property day, UN honours creativity and innovation. (2013, Apr 29). *M2*

Presswire Retrieved from

<http://search.proquest.com/docview/1346569927?accountid=14541>

The UN celebrated world intellectual property day and shared with their participants the importance of creativity. The one thing that this article emphasized on was how creativity does not mean infringing on other people's intellectual property. They give a prime example on how 3-D printing can over step the boundaries of Intellectual property.

Ramos, D. (2013). Gains in 3-D printing technologies. *ImageSource*, 15(5), 18-21. Retrieved

from <http://search.proquest.com/docview/1459233141?accountid=14541>

This article talks about the advancement that 3-D printers affected different aspects of technology. The article stated that NASA has already planned to use 3-D printing on board several of their missions. They state that NASA will be printing repair parts in space, rather than spending millions just bringing several parts into space

Research and markets: Global 3D printing market 2013 - 2019: Polyjet, FDM, SLS, SLA analysis. (2014, May 02). *EFYTimes.Com*, Retrieved from

<http://search.proquest.com/docview/1529159739?accountid=14541>

The article examines the rise of Intellectual property being infringed because people are now accessible to a device that will allow that to happen. Laws are now being created to stop such crimes from being committed. In the paper, the statistic about how the 3-D printing market is on the rise is brought into the light through this article.

Sinclair, S. (2014). WHAT'S TRENDING IN TECHNOLOGY: Predictions vs. profit.

ImageSource, 16(6), 8-10. Retrieved from

<http://search.proquest.com/docview/1535256503?accountid=14541>

The author in this article is skeptical about how the public will react to bioprinting. Bioprinting is when cells are layered together to create an organ or tissue. In the paper, it connects to this citation because it examines how the use of human and nonhuman cells to create tissue or organs by the year 2016 will not be well approved just yet.

Thomas, E., (2014, September 16). Benefits of a 3D printer. *Blacknet*. Retrieved on September

22, 2014, from <http://www.blacknet.co.uk/component/content/article/178-bn->

[articles/personal-development/5012-benefits-of-a-3d-printer.html](http://www.blacknet.co.uk/component/content/article/178-bn-articles/personal-development/5012-benefits-of-a-3d-printer.html)

This article talks about the implications that the 3-D printer has in the real world. As well as, the way 3-D printers work. This article has relevance in my paper because it talks about the reduction of human error in manufacturing .

Thompson, C. (2012, 06). New tech V. old laws. *Wired*, 20, 56-n/a. Retrieved from

<http://search.proquest.com/docview/1027591693?accountid=14541>

Thomas Valenty bought a MakerBot last winter. He printed WarHammer figurines and posted them on www.thingibot.com However, WarHammer ordered the takedown of the CAD file citing the Digital Millennium Copyright Act. they said that when 3-D printers become more advanced they could pose more legal battles.

Ulanoff, L. (2014). World's First 3D Printed Car Took Years to Design, But Only 44 Hours To Print. *Mashable*. Retrieved on September 22, 2014, from

<http://mashable.com/2014/09/16/first-3d-printed-car/>

The article is seen as a important source under benefits because it talks about how engineers created a car in a CAD and made a 3-D printed car out of it. The top speed is 40 mph and runs on a electric battery. This proves one of the many possible benefits 3-D printing can have on our society.

Wehrspann, J. (2013). 3-D printing technology: Impact on agriculture. *Farm Industry News*,

Retrieved from <http://search.proquest.com/docview/1439273482?accountid=14541>

People would not think that 3-D printing can provide great benefits to farmers, but it can. Through the use of these 3-D printers we examine how farmers can use this device in order to print equipment, then if that equipment is no longer needed by the farmer, they can simply recycle the material and create more equipment pieces.

Weinberg, M. (2010). It Would Be Awesome If They Don't Screw It Up: 3D Printing, Intellectual Property, and the Fight Over the Next Great Disruptive Technology.

PublicKnowledge. Retrieved on September 22, 2014, from

<https://www.publicknowledge.org/files/docs/3DPrintingPaperPublicKnowledge.pdf>

This article cites all the copyright, trademark, and patent laws of the United States, that a 3-D printer needs to know. The author talks about how patents can be used to an extent as long as they are not officially patented by the U.S patent office.

Williams, R., (2014, January 29). 3D printing human tissue and organs to 'spark ethics debate'.

The Telegraph. Retrieved from

<http://www.telegraph.co.uk/technology/news/10604035/3D-printing-human-tissue-and-organs-to-spark-ethics-debate.html>

This newspaper article cites examples of successful 3-D printed organs that were given to patients during test runs. This included a fully functioning liver that worked for 4 months.

This connects to the ethics portion of the paper because it provides an argument on whether the technological goods outweigh the negatives.