

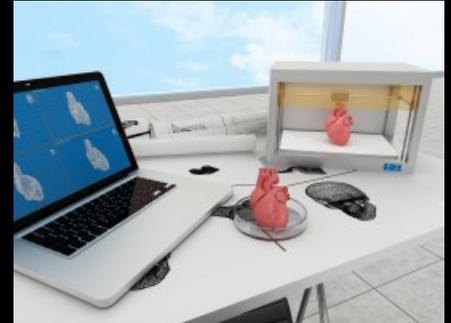
3D PRINTING

This issue's articles ▼

3D Printing for Your Health

May 2015

Imagine you live in an area of the world where doctors don't have access to modern medical equipment. Imagine you needed a prosthesis or implant to improve your life and your ability to work. With access to a 3D printer and free, open source designs, the quality of available healthcare in your area could change vastly.



Meet Dr. Scott Hollister!

May 2015

Dr. Hollister is a Professor of Biomedical Engineering and Mechanical Engineering at the University of Michigan, where he directs the Scaffold Tissue Engineering Group (STEG). Dr. Hollister and his collaborators have designed and developed a variety of medical devices utilizing 3D printing, an area in which he has worked for 17 years, publishing his first paper in 1997.



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May 2015

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3D PRINTING

This issue's articles

3D Printing for Your Health

May 2015

by Robin Hegg

Imagine you live in an area of the world where doctors don't have access to modern medical equipment. Imagine you needed a prosthesis or implant to improve your life and your ability to work. With access to a 3D printer and free, open source designs, the quality of available healthcare in your area could change vastly. The increased accessibility and affordability of 3D printers could revolutionize how objects are manufactured, challenge copyright laws, and give even the most isolated people access to the things they need. In September of 2014, a 3D printer was delivered to the International Space Station. A few months later, NASA emailed the astronauts CAD (computer aided design) drawings for a socket wrench, which they were able to print onboard the space station.



3D printers are able to create a three-dimensional object by applying layers of material following a computer's instruction. The process of 3D printing is also called additive manufacturing, because the printed object is created by adding layer upon layer of material. The printing material can be anything from plastics to human cells to sugar.

To create a 3D object, a 3D model must be created first. This can be done using CAD software, a 3D scanner, or a digital camera and special software. The 3D model then needs to be converted into a .STL or .OBJ file for the printing software to read it. The converted file then needs to be processed by a "slicer," a piece of software that converts the 3D model into a series of layers and provides the 3D printer with a G-code file of printing instructions.

IN THIS ISSUE:

Discover the possibilities of 3D printing in the latest issue of IEEE Spark! Learn how 3D printing is changing healthcare, meet a doctor who is using 3D printing to save lives, 3D print a map, and see how libraries are connecting students to 3D printing technology.

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3D printers have become much more affordable in recent years and it's expected that desktop 3D printers will be available in the near future. Machines that once cost \$20,000 now cost less than \$1,000. The Peachy Printer, a Kickstarter-funded project, is designed to cost \$100. 3D printing is becoming such an exciting and wide-spread new technology that a recent report looking at engineering job listings over the course of one month found that 35 percent of engineering jobs required familiarity with 3D printing.

Having the ability to manufacture an object so easily and locally means that creating prototypes or customized products could be much simpler and cheaper than ever before. One of the greatest benefits of using a 3D printer is the ability to create small numbers of customized objects. In traditional manufacturing, the higher number of items produced, the cheaper they are to make. Manufacturing small batches of items or single, customized items, can be very expensive. 3D printers could change all that.

One area in which 3D printing could revolutionize cost, access, and innovation is the medical field. Researchers are even working to print with live cells, which would allow scientists to print tissue and organs, a process sometimes called bioprinting. It's expected that 3D printing will become widely used to create hearing aid and dental implants. 3D printing not only makes custom-fitted implants and prosthetics more possible and affordable, it also means medical equipment could be cheaper and more readily accessible.

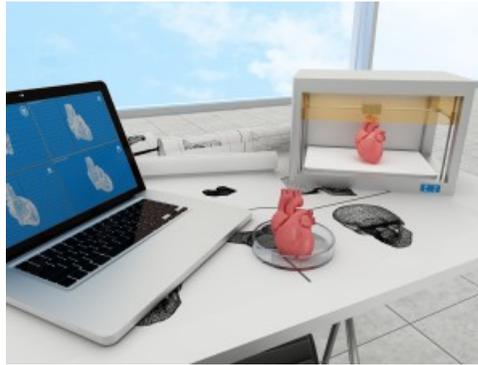


3D printing has already been used to create a titanium pelvis, a titanium lower jaw, and a plastic tracheal splint, all of which were successfully implanted in patients. In March of 2014, surgeons were able to use 3D printed parts to help rebuild the face of an injured motorcyclist.

e-Nable is an all volunteer organization working to design and print prosthetic hands, primarily for children. Volunteers include high school students and Scout troops, who work to print or assemble the prosthetics for people who need them. The organization works to match people in need of a prosthetic with someone who can make it for them. They also work on new prosthetic designs and make their designs available for free so others can use them where they are needed.

3D printed prosthetics have also been used to help animals. In December of 2014 a **video of a dog named Derby** running for the first time on his 3D printed legs, became popular online. 3D printed prosthetics have also been used to give a duckling a new foot, a bald eagle a new beak, and hermit crabs new and interesting shells.

3D printers can also be used to make special tools for doctors. In January of 2015, doctors at St. Thomas' Hospital in London were able to use images from a Magnetic Resonance Imaging (MRI) scan to create a 3D printed replica of a two-year-old's heart. The heart had a very complex hole in it. Using the 3D model of the child's heart, doctors were then able to create a custom-fitted Gore-Tex patch to fix the hole. Having the 3D printed model of the heart also allowed surgeons to have a much better idea of what they would find before surgery began.



Researchers are also working to 3D print tissue in a process sometimes called bioprinting. Bioprinting involves using cells as the printing material and could have many exciting medical applications. Replacement tissue could be printed to replace skin, other tissues, and possibly even entire organs. Bioprinting is a complex process involving researchers in a number of different fields, including medicine, cell biology, materials science, and many kinds of engineering.

Researchers have had early success generating a variety of different tissues, including bone, skin, cartilage, and heart tissue and are working toward being able to manufacture fully functional tissue and replacement organs. Researchers in Cornell University College of Engineering's Jonathan Butcher Laboratory have been working to develop methods of bioprinting living aortic heart valves. Cornell's Lawrence Bonassar Laboratory is working to create replacement intervertebral disks. Researchers were able to bioprint these tissue engineered intervertebral disks with cell-seeded hydrogel constructs and implant them into male rats.



Researchers have also been studying how inkjet printing techniques could be used to build organs and body parts. Layers of living cells would be deposited onto a gel medium or sugar matrix. Layer upon layer would be added until three-dimensional structures were formed. The first system for 3D printing tissue was created in 2009. Printerinks and Organovo, two private companies, have worked together to use 3D printing to develop human tissue. They have adapted printer cartridges to use stem cells, resulting in a substance called Bioink.

China has begun investing heavily in 3D printing development, committing almost \$500 million to establish ten national 3D printing development institutes. Chinese scientists began printing kidneys, livers, and ears with living tissue in 2013. Researchers at Hangzhou Dianzi University created a 3D printer specifically for bioprinting with living cells, called the Regenovo. The printer is

able to produce a four to five inch ear cartilage sample or a mini liver sample in under an hour. Regenovo's creator predicts that printing fully functional organs may be possible in the next ten to twenty years.

Teens have also been taking advantage of the ability to produce objects with a 3D printer, leading to some impressive outcomes in many fields, including medicine.

As part of a school project, Mohammad Sayed and his classmates worked to improve his wheelchair. Using a 3D printer, the students added a laptop tray and a canopy, and changed the wheelchair's wheel mechanism so that it could be moved with a rowing action instead of the traditional push. The printed parts cost only about \$2 or \$3 dollars, and the students are making their plans open source so anyone who wants can 3D print these wheelchair add-ons themselves.

Seventeen-year-old Easton LaChapelle developed a 3D printed robotic prosthetic arm. Using modeling software and a 3D printer, he printed parts and constructed a functional prosthetic arm that can interface with the human brain, all in his bedroom.

3D printing is changing how we make things, who can make things, and how much time and money it takes. In the field of healthcare, it's improving patient access, making implants, prosthetics, and other tools more available, affordable, and customizable. Doctors and designers now have the ability to collaborate quickly across the world, sparking and speeding innovation.

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DR. HOLLISTER
UNIVERSITY OF MICHIGAN HEALTH SYSTEM

1. You have an interesting background! How does the work you do involve your aerospace/mechanical and biomedical engineering backgrounds?

At a fundamental level, all engineering disciplines share a common root, basically mathematics, the sciences (physics, chemistry and biology), and now especially a knowledge of some type of computer programming. Skills I learned in aerospace/mechanical engineering like solid mechanics, numerical methods, and computer programming I use in biomedical engineering. Although we don't often think of them this way, biological tissues like bone, skin, and cartilage have mechanical properties and behavior just like engineered structures including concrete, synthetic rubber, steel, etc. Therefore, I use this type of background from aerospace/mechanical engineering in biomedical engineering. This is why it is important to learn the fundamental sciences and mathematics, as well as some level of computer programming.

2. How did you first get involved with 3-D printing? Do you create 3-D printed items for fun? And, how is this integrated into the work you do?

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NPR
CNN

EDUCATIONAL BACKGROUND:

**B.S., University of
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Aerospace Engineering**
**M.S.E., University of
Michigan, Ann Arbor,
Applied Mechanics**
**M.S., University of
Michigan, Ann Arbor,
Bioengineering**
**Ph.D., University of
Michigan, Ann Arbor,
Bioengineering**

ADVICE TO STUDENTS:

First of all, I would suggest that students study the fundamentals, math, the sciences and computer programming and modeling. All of this background is important for fully utilizing 3D printing. You have to be able to make the designs that go into the machine (requires math, physics, and computer modeling/programming), but you also had to understand material science and chemistry so

I first became involved in 3-D printing in the early to mid 1990's when a mentor of mine, Professor Noboru Kikuchi, developed a method to design optimized material layouts that produced very complex structures. He mentioned that he was looking at 3D printing, because it was the only method capable of manufacturing these complicated material layouts. I had started working in tissue engineering and regenerative medicine (the study of regenerating or helping to make new tissues) at the time in the area of designing and making materials called "scaffolds" which are 3-D structures used in tissue engineering to deliver and support cells. These scaffolds can have very complex geometry including a porous structure. I thought to myself that 3D printing could be used to manufacture scaffolds as well. My research laboratory and I started working on the use of 3D printing to make scaffolds, and we published our first paper on this idea in 1997.

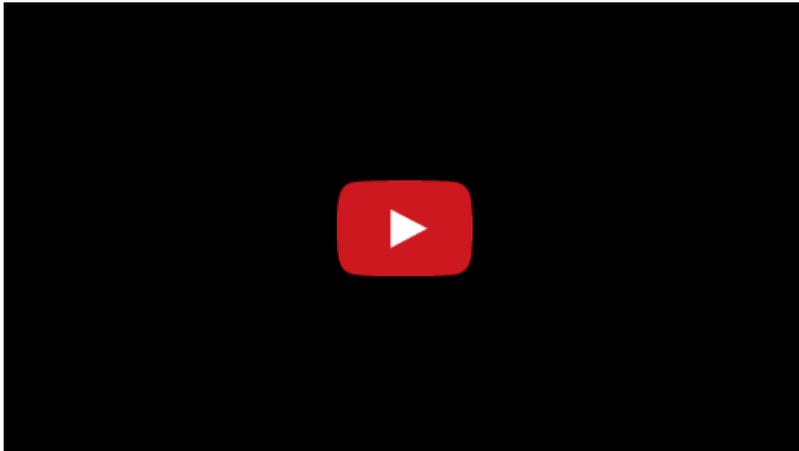
3. You and a cohort developed a 3-D printed device that helped saved a baby's life – tell us how this came about and why 3-D printing made the difference.

Dr. Glenn Green (the pediatric Otolaryngologist with whom I developed the airway splint) and I were brought together by a colleague at the University of Michigan. Dr. Green is a specialist who has developed surgical techniques for complex airway reconstruction in children. He had an interest in applying tissue engineering technology



HOLLISTER AND GREEN
UNIVERSITY OF MICHIGAN HEALTH SYSTEM

to airway reconstruction. My laboratory and I had developed image-based techniques (for designing structures such as scaffolds) and 3D printing of polycaprolactone (a type of resorbable, biocompatible plastic) for a variety of applications, especially in tissue engineering.



Video credit: University of Michigan Health System

We were initially interested in tissue engineering an entire trachea, a very challenging endeavor. The trachea is sometimes called the "windpipe" and it is a tube that connects the throat to the lungs, allowing air to pass for breathing. I mentioned that I thought it would be best to do this in a step by step manner, much the way that NASA developed the Apollo program to go to the moon by first developing the Mercury program to work out how to launch vehicles and humans into space, then the Gemini program to work out how to locate and

that you can make/adapt the materials to the 3D printing systems. Finally, 3D printers require control and mechanical/electrical devices. All of these issues are important for 3D printing, as well as enjoying the "cool" aspect of it.

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dock space vehicles and finally the Apollo program (my aerospace background coming into play). So we thought we would develop the scaffold first for the airway, then work on how to add cells to regenerate the tissue. Dr. Green then said he felt that even the scaffold alone could address a very challenging problem he faced with kids, and that was tracheobronchomalacia (a long term meaning softening and collapse of the trachea and bronchi – that is the airway). That is how we started work on the tracheal splint.

The geometry of the splint was itself complicated. It had multiple suture holes (holes thru which a surgical needle and 'thread' could be passed to secure the splint with 'stitches') and we designed the splint based on digital models we made from CT or MRI scans of each individual patient. This meant that the design could change with each patient. Therefore, due to the complex 3D geometry and the patient specific nature of the splint, we needed to use 3D printing.



3D PRINTED SPLINT WITH SUTURE HOLES
UNIVERSITY OF MICHIGAN HEALTH SYSTEM

4. What do you love about blending technology and medicine?

At one level, the human body (and any animal body) can be thought of as very complex machines, perhaps the most complex machines that exist. Bodies have mechanical structures, chemical structures, electricity, nanotechnology, Multiscale structures, etc. Medical doctors have a very complex job to treat this very complex machinery. I believe that technology and engineering can make and has already made great advances for medicine. To design and develop devices and technology to diagnose and treat disease and trauma requires a great deal of engineering. You see this in many of the great advances in medicine from CT and MRI scanners to joint replacements to minimally invasive surgery to name just a few. It is always exciting to come to work and think about how we can develop new devices to help patients. 3D printing will greatly expand the types of devices we can make, from external devices to internal implants, and even 3D printed cells and tissues. It is exciting to have these 3D printing technologies available that allow us to make our designs and ideas into a physical structure in a matter of hours and days as opposed to weeks and months.

5. What do you think are some of the future applications for 3-D printing in general, and for medicine in particular?

Definitely you will see more 3D printed patient specific medical devices and implants. In fact, in five years, I believe that most academic and high level medical centers will have their own 3D printing centers and engineering staff to design and 3D print devices and implants for those difficult and uncommon cases for which an "off the shelf" implant or device won't work. Complex surgeries will routinely be planned and practiced on 3D printed models before they are



3D PRINTED TRACHEA MODEL AND SPLINTS
JULIET FULLER/UNIVERSITY OF MICHIGAN HEALTH SYSTEM

done on the patient. In fact, patients will be drawn to these centers to have this personalized medicine and surgery over centers that do not have these services. Finally, you will also have the capability to print cells (that is being done now) to create live tissues in the lab on which to test drugs and procedures, in addition to being able to implant into patients.

I think in general for 3D printing, you will see more "at home" printing. Just as now we have computers and the internet in our homes, something that would have been unheard of in the 60's and 70's when only large companies, academic centers and the government had large mainframe computers, a 3D printer will be just like a laptop computer in the home. You will see more personalized items and devices for the home, just as we have the advent of personalized medicine. Furthermore, whereas computer literacy and programming was the domain of educated specialists in the 60s and 70s, but now is taught in elementary schools, the same will happen for 3D printing and Computer Aided Design techniques needed to create the design for items we will 3D print at home.

6. Is there anything you don't like about blending medical and technology applications? Challenges?

I wouldn't say there is anything I don't like about blending medicine and technology, but there are significant challenges. First and foremost is that as a professor you always need to be writing proposals and trying to raise money to support research. We constantly worry about having money to support and train our graduate students and post-doctoral fellows, as well as to purchase equipment to do work. This can be especially challenging in 3D printing, where sophisticated machines can easily cost over \$100,000. I think another big challenge is that even though you can blend technology and medicine initially in research, getting the technology to the patient can be a long and expensive road. It is therefore a challenge to not think narrowly about just the science/engineering/technology, but also about what the end problem is that you are trying to solve, the regulatory issues for the device you trying to make, and the business aspects of getting the device/technology into clinical use. Finally, just the breadth of knowledge to work on interdisciplinary endeavors like medical 3D printing becomes more challenging every day. I often find myself regretting that I don't have a better understanding of fundamental issues like chemistry and materials science that are important to advancing this field. That is why I would really like to emphasize these issues to students. Also, I think often times we as educators don't give students enough of an insight and motivation as to why they (the students) should learn fundamental STEM topics. For example, how often do we tell students that the video games that they are playing are really enabled by the mathematics that goes into computer graphics, the quantum mechanics fundamentals that went into the development of microchips, and even ideas of heat transfer that go into designing the cooling systems that enable the powerful computers that can run the sophisticated video games?



Video credit: University of Michigan Health System

7. How have the development of computers and software impacted the engineering and medicine work you have done over the years?

Computers and software advances have had a tremendous impact on the work I have done over the years. The increased computing power available (ala Moore's law) and memory capability have allowed us to work with and create patient specific models from huge image databases. We can also perform much more sophisticated design simulation in a much shorter time. These types of advances play directly into 3D printing, as the designs we generate for patient specific devices begin with patient image data, which can be a tremendous amount of data.

8. Are there any new initiatives you are focusing on that apply 3-D printing to support surgery, medicine, or healthcare?

We are working on ideas of how to make 3D printed models more mechanically realistic to mimic tissue properties to enable more realistic training and simulation for physicians. We are also always working on designs for new implants, and try to expand the range of biomaterials that we can utilize with 3D printing systems. This is a critical need for 3D printing, to expand the material repertoire that we can use on these systems.

9. Whom do you admire and why?

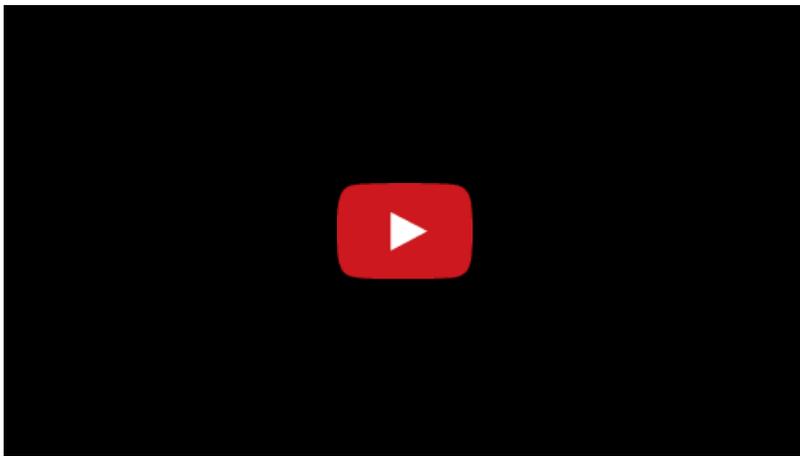
I would have to start with my late father Ernest Hollister. Although he never went to college, he had a tremendous interest in technology and science. I took many trips as a kid to NASA, national parks, etc. He instilled in me the wonder and fascination with learning new things and learning about science and technology. I also admire in general people that challenge to push ideas forward, and are will to suffer a great deal to push ideas forward. That have a vision for what can be. I have often heard it said that scientists look at the world and say "Why?" while engineers look at the world and say "Why Not?". I think that spirit, trying to advance ideas in the face of long odds and sticking to it is very admirable, especially as I feel it difficult to do myself many times. People like Tesla, Edison, the Wright Brothers, Lister, Vannevar Bush, Wozniak, Jobs, and many others who had great visions and went through a lot to see them fulfilled, and in many cases never saw their visions fulfilled in their lifetimes. Finally, I would like to say that I admire today's middle and high school students like my sons. Their world that they are growing up in is expanding so rapidly and they are faced with learning so much new knowledge, that it is a great challenge. They face much greater pressures and competition

growing up, and I admire how they deal with these challenges.

10. Is there a particular application or industry that you think could benefit the most from 3-D printing advances in the next few years?

I am obviously biased, but medicine and the healthcare industry, and patients as a result, will benefit tremendously from 3D printing. As I mentioned in an earlier question, patients in the future will routinely be able to get devices, implants, and even material/cell composites designed especially for their anatomy and conditions. I think 3D printing will also expand the range of healthcare into underserved regions, as 3D printers become cheaper and the range of materials becomes greater for 3D printing, you will be able to send devices for a few patients to every corner of the world.

The other area will be at home applications and businesses, as individuals can make their own gadgets and devices at home, or through third parties like Shapeways (<http://www.shapeways.com/>), an online service that works with individuals who design 3-d products on their own computers, and upload to build and sell.



Video credit: Shapeways

11. What's the most gratifying aspect of your work?

I would say that there are two aspects of my work that are most gratifying. First and foremost, is to see that work we have done help people and literally save lives. No matter what you achieve in your career, how much money you make, or how many awards you win, nothing is better than contributing to an improvement in someone's life. Second, the ability to interact with so many intellectual colleagues and to learn new ideas every day makes the work very stimulating and exciting.

12. What advice would you give to students interested in learning more about 3-D printing applications?

First of all, I would suggest that students study the fundamentals, math, the sciences and computer programming and modeling. All of this background is important for fully utilizing 3D printing. You have to be able to make the designs that go into the machine (requires math, physics, and computer modeling/programming), but you also had to understand material science and chemistry so that you can make/adapt the materials to the 3D printing systems. Finally, 3D printers require control and mechanical/electrical devices. All of these issues are important for 3D printing, as well as enjoying the "cool" aspect of it.

13. If you weren't working in medicine, what would you be doing?

I would say that if I weren't in biomedical engineering, I would be doing some other type of engineering, likely in the aerospace and automotive industry. In many ways, what I would be doing then would be much different, but in some ways the design, modeling and 3D printing work would be very similar. This goes back to my original comment that all branches of engineering share some common roots like mathematics, the sciences and computer programming. However, I would also like to make a plug for the humanities. As I believe that understanding the humanities and the arts, in addition to science and technology, is important for being a creative person.

3D PRINTING

This issue's articles

Print a 3D Map

May 2015

by Robin Hegg

The process of 3D printing starts with taking a model of a three dimensional object and breaking it down into layers. These layers are what the 3D printer will use as a guide when laying down the material to build the object. Topography, or the study of surface shape, works much the same way. Surveyors or satellites and sonar will measure an area's size and shape at different vertical points. To record the topography of an area on a map, these layers are recorded with lines called "contour lines" marking the height of the landscape's features at different set points. For example, a map of a mountain might show the area of land at 100 meters, the area of land at 200 meters, at 300 meters, and so on, thus giving the reader a more detailed sense of the three-dimensional space represented on the two-dimensional map.



TOPOGRAPHIC MAP WITH CONTOUR LINES

In this activity, you will use the same method used by slicing software in 3D printing to break an object of your choosing into layers. With the data you collect about each layer, you will "print" a topographical map-style model of the object, laying down layer by layer of material, just like a 3D printer. You will be "printing" a three-dimensional topographical map.

DID YOU KNOW?

NASA funded a prototype 3D printer designed to print pizzas for astronauts on long space missions.

3D printers were used to create Peter Quill's spacecraft, the Milano, in the movie Guardians of the Galaxy.

3D printing booths now make it possible to print a 3D model of yourself!

FIND OUT MORE:

You can also visit **TryEngineering.org** to explore other engineering activities and resources. Additional activities and lessons can be found **here**.

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MATERIALS

foam board, corrugated cardboard or balsa wood, ruler, pipe cleaners, pen or pencil, craft knife (with adult supervision) or scissors

STEPS

1. Select an object in your house. It can be a relatively simple shape, like a bowl or a cup, or something more complex.

2. Use your ruler to measure the thickness of the layering material you are using (foam board, corrugated cardboard, or balsa wood). This will be the increment of height you are working with.



3D TOPOGRAPHIC MAP

3. At the height of the first layer, use your pipe cleaners to wrap around the object, giving you the horizontal size and shape of that layer.

4. Next, place the pipe cleaner shape on your layering material and use your knife or scissors to cut out the shape.

5. Continue to do this for each layer, calculating the height of the layer, forming the size and shape of the layer with pipe cleaners, and cutting out your layer.

6. Once you've created all your layers, "print" your object by gluing the layers together one-by-one in the correct order. You now have a "3D printed" model and a topographical map of your original object.

QUESTIONS

1. Does your "map" look like your object? Why do you think it does or does not?
2. What does this let you know about the level of detail given on a topographical map?

3. In what ways is a .STL file for a 3D printer similar to a topographical representation of a three-dimensional area?

4. How do you think thickness of the layers you created here compare to the layers created for a 3D printer?

5. If you chose an object with a more complicated shape, what challenges did you run into? What other tools might have helped you make your measurements and construct your layers? What tools do you think topographical surveyors use?

3D PRINTING

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May 2015



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3D PRINTING

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3D Print at Your Library!

May 2015

by Robin Hegg

3D printing can put the power of production into the hands of individuals. But until the arrival of affordable home printers, there are programs through libraries, schools, and camps, that can help you access and learn about 3D printers.



Libraries are leading the way in educating the public about 3D printing technology and making it accessible. Many libraries now have 3D printers available for public use and many hold 3D printing programs in which teens and adults can learn how to use the 3D printers. Librarians are working to define their role in the wider use of 3D printing and trying to anticipate the questions and issues that increased 3D printing raises, such as possible copyright infringement, or the legal ramifications of a 3D-printed gun. They are working to develop a set of best practices to help guide library patrons in their 3D printing. Ask about the availability of 3D printers and 3D printing programs in your local library system.

There are also opportunities to learn about 3D printing through after school programs, like those at New York City-based **Pixel Academy** and through summer camps like **Digital Media Academy's 3D Printing and Industrial Design** summer tech camp for teens.

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2015 ISSUE 2

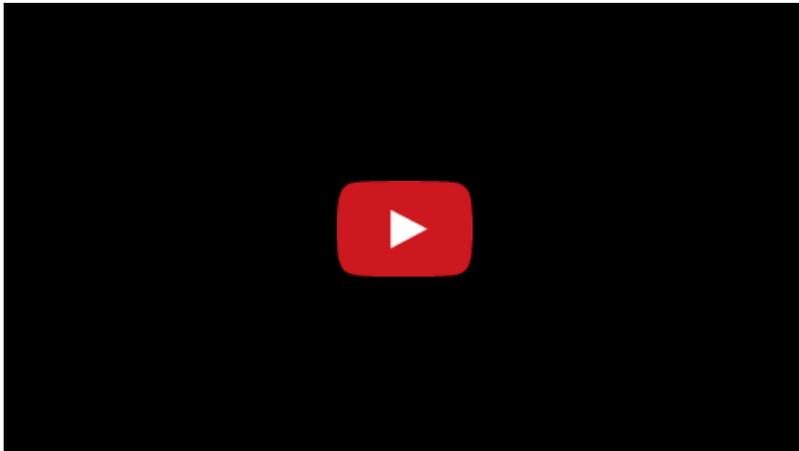
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Rock Stars of 3D Printing

May 2015

by Robin Hegg

The IEEE Computer Society hosts a series of "Rock Star" events, highlighting new technology and presenting a panel of some of the major figures in the featured field. This past March, the IEEE Computer Society presented Rock Stars of 3D Printing, an event aimed at business and technology leaders, helping them to understand how the growth of 3D printing will be changing the ways they do business and to learn how they can put it to good use in their field.



One of IEEE's own rock stars of 3D printing is IEEE member Charles Hull. In 1984, Hull developed a prototype system called stereolithography, in which ultraviolet light lasers are used to cure photopolymers. Photopolymers are polymers that change their properties when exposed to light. In this process, the ultraviolet light causes cross-links to form, bonding one polymer chain to another, making the material harden. These photopolymers are then added in layers to create a 3D object. Hull called it a "system for generating three-dimensional objects by creating a cross-sectional pattern of the object to be formed." Hull's other major contribution to the field of 3D printing is the design of the .STL file format and the digital slicing and infill method many 3D printers use today. These processes convert the 3D model into layers, using triangles to approximate the curves of a 3D object. The file that's created gives the 3D printer a guide for how material should be laid out in order to build the final three-dimensional object.

IN THIS ISSUE:

Discover the possibilities of 3D printing in the latest issue of IEEE Spark! Learn how 3D printing is changing healthcare, meet a doctor who is using 3D printing to save lives, 3D print a map, and see how libraries are connecting students to 3D printing technology.

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In 1983, Hull printed a small cup in his lab using ultraviolet light and liquid plastic. Many industrial 3D printers still use this process today. Hull went on to found 3D Systems Corporation in 1986. Their first 3D printer hit the market in 1988, costing about \$100,000.

IEEE Spark Challenge: 3D Printing

Think you know IEEE Spark? Test your knowledge of engineering, computing and technology with the IEEE Spark Challenge!

- 1) Who is considered to be the inventor of the 3D printer?
 - a. S. Scott Crump
 - b. Hideo Kodama
 - c. Dr. Carl Deckard
 - d. Chuck Hull

- 2) A 3D printer is an industrial robot.
 - a. True
 - b. False

- 3) Which tool did NASA astronauts print on the International Space Station in 2014?
 - a. Hammer
 - b. Screwdriver
 - c. Socket wrench
 - d. Tape measurer

- 4) The use of 3D printers to print tissues or organs is known as:
 - a. Bioprinting
 - b. Nanoscale printing
 - c. Body printing
 - d. Photosculpture

- 5) Which of the following bodily materials have been printed using a 3D printer?
 - a. Heart tissue
 - b. Cartilage
 - c. Bone
 - d. Skin
 - e. All of the above

- 6) Another term for 3D printing is:
- Mass customization
 - Additive manufacturing
 - Rapid prototyping
 - Finishing
- 7) A 3D printer constructs an object using which of the following structures?
- cubes
 - spheres
 - layers
 - triangles
- 8) CAD, which is often used to model objects so they can be 3D printed, stands for:
- Collaborative Automatic Design
 - Chip Assisted Design
 - Coordinated Artistic Design
 - Computer-Aided Design
- 9) Which of the following objects have been printed using a 3D printer?
- apartment building
 - bicycle frame
 - guitar
 - couch
 - All of the above
- 10) What size are the smallest 3D printed structures?
- 500 nanometers
 - 10 nanometers
 - 15 micrometers
 - 100 micrometers



IEEE Spark Challenge: 3D Printing Answer Key

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