How I learned about 3D printing from CyArk
A Guest Blog from a Middle School Science Fair
By: Zachary McDonald

Earlier in 2012, as a part of my Science Fair Project at St. Catherine School, I wanted to learn about 3D printing. I started by researching what exactly 3D printing is and how it's already used by many different industries today. Compared to 2D printing (think of your school report being printed on a flat piece of paper), 3D printing starts with the same first step: the computer sending the information to the printer. Next, instead of putting layers of ink toner on paper, the 3D printer lays down layers of plastic, metal, or other material on top of each other over a base, building up a 3D object thin-layer by thin-layer.

According to my research, the first 3D printer was invented by Charles Hull in 1984. This was 14 years before I was born. The company that Charles Hull created is now located in Valencia, California and is called 3D Systems. Now, 3D printing is used in many different ways:

- NASA is testing the use of 3D printing to print spacecraft parts that might be needed on long space missions. NASA would also like to build satellites up in space instead of building them on earth and then launching them up, like they do now. Even more exciting is that 3D printing could be used to build places for living and working on the moon. Scott Summit of Bespoke Innovations said "If you're going to create a lunar station, you're not going to do it by hauling your cranes and your gantries and cement bags and everything else up onto the moon. You are really going to want to do it by three-dimensionally printing a structure right on the moon."
- Bioprinting is the term used when scientists talk about replacing organs in the human body. Researchers in Germany have already used 3D printers to make artificial molecules that can be shaped into human veins. Scientists are looking forward to being able to 3D print larger organs like kidneys or hearts, but this is in the future.
- Using 3D printing, chefs have made soft foods like cheese, cooked carrots, and chocolate into new shapes. Instead of using plastic or other polymers, soft foods can be put into a 3D print head and pumped out, layer by layer, forming whatever design a digital blueprint specifies. Kids might eat more vegetables if they came in fun shapes.
- 3D printing is also being studied for household uses. In the future, we will probably have to recycle a lot more than we do now. It'll become more clear how our wastefulness is bad for the environment because there will be more people and less space for junkyards. Instead of throwing away something that is broken like a coffeemaker, everyone might have a 3D printer at home and they could print the broken part and replace it instead of just throwing out the whole machine.

I learned that CyArk is also using 3D printing. Recently, they worked with a professor at UC Berkeley, Ronald Rael, to 3D print Mount Rushmore! I've seen reproductions of Mount Rushmore before, but CyArk's 3D print is by the far the most accurate. Take a look at the fun model of Mount Rushmore that you can find at the Trafalga Fun Center in Lehi, Utah and compare it to the real Mount Rushmore.

Because CyArk is working directly with the Mount Rushmore Park, they were able to create a perfectly exact replica. I wanted to learn how they were able to do it. How did they get the whole mountain sculpture on a computer so it can tell the 3D printer the exact shapes that it should print?

I learned that CyArk had to first create a very precise 3D model of the whole mountain and that's where the 3D printer would get its information to create this exact replica. Creating an accurate model involves measuring the object in real-life and inputting these measurements into a digital modeling program. The more measurements you take of the real-life object, the more accurate your 3D model will be. In May of 2010, CyArk took 2.3 billion measurements of Mount Rushmore in just two weeks! They didn't use traditional methods like measuring tape, because that would have taken 4.6 million days to do (a surveyor using traditional methods can collect about 500 measurement point a day)! What CyArk used to collect those 2.3 billion measurements is a laser scanner.

A laser scanner is a machine that was created by CyArk's founder, Mr. Ben Kacyra. It works by sending out a laser beam that hits an object then bounces back to the machine. The way that laser beam bounces back allows the machine to then calculate and record the precise coordinates of that point on

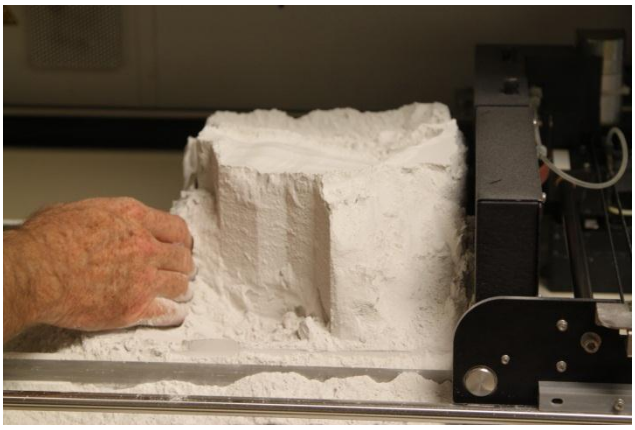
the object. So each time the laser scanner does this, it is recording one measurement. Luckily, the machine can do this very quickly – it can send out and record hundreds of thousands of points in just one second! Once you bring all these points together, you have a complete and very precise 3D model, called a point cloud.

It wasn't easy capturing all those points at Mount Rushmore. CyArk had to work with the ropes team at Mount Rushmore Park to make sure that the laser scanner reached all around the sculpture so they wouldn't miss any part of it in the model. Here is the ropes team hanging high in the air with the laser scanner, off the face of President Theodore Roosevelt. Pretty scary if you're afraid of heights!

Here is what the final point cloud model looked like once CyArk put all those 2.3 billion points together.

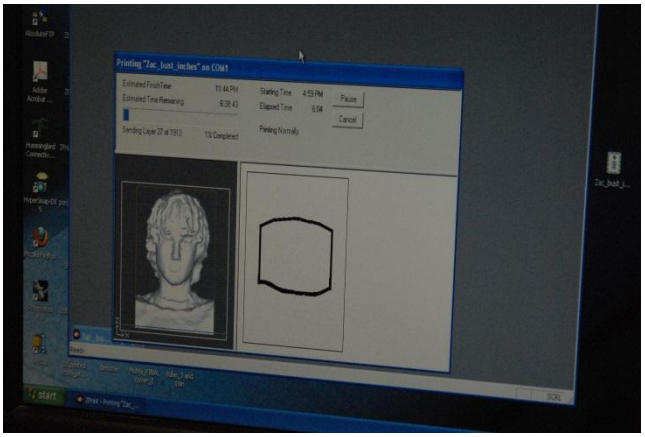
Unfortunately, 3D printers cannot read point cloud models yet, so CyArk used all the points to create a surface model (called a mesh model). This is the model that was then sent to the 3D printer.

The 3D printer machine that was used for Mount Rushmore was especially made by Professor Ronald Rael to use concrete as the printing material. The final 3D print is about ten inches wide and five inches tall. It took about seven hours for the machine to finish printing it. When it was finished printing, Professor Rael had to remove all the loose material that was still around the model. Then, a thin protective layer of epoxy resin was painted over the print and left to dry for six hours.



I got to spend a whole day at CyArk's office and learn firsthand about laser scanning and 3D modeling. They showed me how the laser scanner works and we did a test by scanning my head. You can even see the laser beam hitting my back.

The hardest part was sitting still during the laser scanning and photos. I could not smile or move at all. The exciting part was that I got to have the model of my head printed using the same machine that printed Mount Rushmore!



I even got to help dig out the model from the 3D printer, but I had to be very careful because it was still very delicate. The print of my head is not full size because it had to fit within the printer. Larger objects take longer to print and are more costly.

Although 3D printing is still a special process that not many people have access to, it was a lot of fun researching it and getting to see how it worked. I think 3D printing will be a part of everyone's future before too long, so I wanted to show other kids how it works.

Laser scanners, too, are hard to come by, so CyArk showed me a different way that you or I can create a 3D model of our heads or any simple objects at home. Want to try it? Take a look at this step-by-step lesson plan that CyArk put together. The best part is that all you need is a regular digital camera, a ruler, a pencil, some paper, and a computer with internet connection and a printer. You can use free software online that will even let you order a 3D print, made out of cardboard. Try it out and write back at the bottom of this blog to let me know how it went.