World's First 3D Fax Machine

1st test was from Scientific Measurements Systems Inc. to

The University of Texas Mechanical Engineering Department using a modem

---

Author: Reuben Reyes
The University of Texas at Austin
hitechmex@mail.utexas.edu

I was part of the engineering team that tested and produced the world's first 3D fax machine. This test was done through a partnership between The University of Texas (UT) Mechanical Engineering Department and Scientific Measurements Systems (SMS) Inc. where I worked as a software engineer. At the time SMS had the world's best industrial X-ray Computed Tomography (CT) scanning system capable of the highest X-ray scanning resolution at about 80 microns. UT Mechanical Engineering had a research laser sintering machine capable of producing (printing) 3D objects from CAD/CAM files. At SMS we produced 3D computer models from X-ray CT scans, in either CAM/CAM files or as 2D slices or 3D volumes. While working at SMS the engineering team produced many digital 3D objects from X-ray CT volume scans. As far back as 1989 SMS sent digital 3D objects from X-ray scans in STL format to Austin, Texas startup company DTM via modem for 3D printouts, but these were always sent after the X-ray CT scanning was finished. In addition to sending data files of 3D scans via a phone modem some data were also driven by car and delivered to SMS on digital media because of large size of files and time needed to send over phone lines.

What was unique about the project with UT Mechanical Engineering Dept. and SMS was:

1. The X-ray CT machine produced a series of 2D slices that when completed was the full 3D volume scan of object.
2. As each slice was completed the digital information of the slice was sent to laser sintering machine via phone modem.

3. The Laser sintering machine produced one slice at a time of the overall object as it was received via phone modem.
4. Information of each slice was sent as vectored outlined polygons.
5. Pixel information was also sent as a 2D images for each slice.
6. Information about the object edges were sent as both exterior and interior surfaces.
7. The laser sintering machine did both exterior surfaces and interior surfaces.
8. The X-ray CT scanning, laser sintering, and communication via phone modem were all automatic. Once started it did not require human intervention.

The target object that was scanned and reproduced at UT Mechanical Engineering Dept. was a Ford engine piston. It was reproduced in a polycarbonate material, and it took 2 hours to X-ray CT scan the object, send data via phone modem, and to reproduce as a 3D object in polycarbonate material. Since all were done at the same time it took only 2 hours. If the piston had 1st been scanned and then sent via modem and then laser sintered it would have taken six hours or more. At the start of the 1st full test of the "World's 1st 3D Fax Machine" a group of scientists came to SMS to view the process. The scientists were at UT for the "Solid Freeform Symposium"(1). What was witnessed was a Ford piston placed inside the X-ray CT scanning chamber. Lead doors were lock and the X-ray CT scanning process was started. The view of the X-ray CT scanning was viewed via 2 video cameras inside the X-ray chamber. When the scanning was about half done the scientists drove from SMS Inc. to University of Texas Mechanical Engineering Dept. about 9 miles distance. When the scientists arrived at the laser sintering lab at UT they witnessed half of a polycarbonate piston being reproduced in 3D. At the end of the test, the completed reproduced piston was taken out of the laser sintering chamber and cleaned. The next day both the reproduced polycarbonate piston and the actual Ford piston were shown together in the same room.

Unlike most other 3D fax machines this one test simultaneously 3D scanned, sent data via modem, and produced interior and exterior surfaces of a complex 3D object from one continuous 3D X-ray CT scan. The first successful test was done in August 1991, Austin Texas.

Article showing laser sintering machine at UT Mechanical Engineering Dept. (2)

UT Austin engineers to attempt first manufacture of solid object by long-distance laser sintering

By Robert Tindol

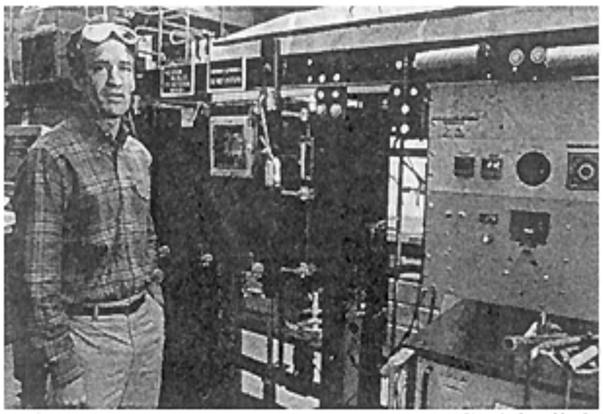


Photo by Larry Murphy

According to mechanical engineering professor Dr. Joe Beaman, "Laser sintering might be feasible for limited production of hundreds of the same object."

Researchers at UT Austin will join with Scientific Measurement Systems Inc. this week in trying to create a solid, three-dimensional object by transmitting digital information by telephone to a laser device.

If successful, the experiment will mark the first time that the process — known as laser sintering, a form of desktop manufacturing — will have been employed in such a manner.

In laser sintering, a design is converted by a computer into digital information, which in turn is used to guide a laser in fusing, or sintering, a powdered material to make a solid object. The process was invented by Dr. Carl R. Deckard, a former UT Austin mechanical engineering student, and is being commercialized by the Austin-based DTM Corp.

Dr. Joe Beaman, who was Deckard's graduate adviser at UT Austin and who now conducts research on laser sintering, says the process is an important breakthrough in manufacturing because of the expense and time involved in machining a custom-designed part.

Whereas a small metal part can take as much as six months and cost as much as $60,000 to make if it is a one-of-a-kind item, laser sintering can accomplish the same task in a fraction of the time and cost.

"Most processes are associated with subtracting material, so the reason you have a lot of parts made is so you can put them together," Beaman says. "We're adding material one layer at a time, regardless of how complex the interior of the part is, and this means that you don't have to worry about how to get the milling tool inside to do intricate work. A part is often structured not only for a function, but also to address the limitations of current machining technology, so laser sintering will allow a way around this.

"The real impetus these days is how fast you can get a product to market," Beaman says. "One reason for the Japanese success in automobiles is that they've reduced the time from market information concept to prototype to three years. It still takes American auto manufacturers five years to accomplish the same thing, but laser sintering could help us by allowing for faster prototypes."

Laser sintering works by depositing a thin layer of powder on a flat plate level with the floor of an oven chamber and then rapidly passing a tiny but intense laser beam over selected areas of the powder. In effect, the powder on the plate becomes a thin slice of the final object, with the laser fusing the powder in any area where solid material is called for by the design.

If there is to be a hollow space in an area of that slice, the laser does not fire when passing over that area, leaving a layer of loose powder on the same plane as the fused material.

Once a layer has been completed, the plate in the oven chamber drops slightly, another deposit of powder is spread evenly, and the laser is again passed over the entire area of the plate. The process is continued until the object is finished, and any pockets of loose powder are then blown away.

The process is so delicate and precise that researchers have made what they describe as the first seamless toy whistle. In the traditional manufacturing process, two halves of a whistle are molded so that they can be glued together around a ball that rattles in the central chamber.

In the laser sintering process, the ball is formed on top of a layer of powder as the entire whistle is built up, and when the object is finished, the solid ball is totally enclosed by powder inside the whistle's hollow chamber. The powder is then removed, leaving the ball to rattle free in the chamber.

The original powder materials used for the laser sintering process have been polymers and investment casting wax. When the latter is used, the wax impression of the object is dipped in a ceramic slurry, which is then allowed to harden. Afterward, the wax is melted away and hot metal is poured into the ceramic shell to make the final product.

In recent months, Beaman and his coworkers have experimented with sintering ceramic and metal materials. Sintering wax impressions requires only one tenth the time of the traditional lost-wax process, while making the object directly from metal with the sintering process requires only one hundredth the time of the traditional method.

"We first thought that maybe two or three identical objects would be the limit," says Beaman. "Now we're thinking that laser sintering might even be feasible for limited production of hundreds of the same object."

Beaman says that the only limit to the materials that can be used in laser sintering is the ability of the material to soften during the sintering process. Nevertheless, the researchers have already found a wide variety of materials that work in the process.

During the demonstration, to be conducted Aug. 13, Scientific Measurement Systems Inc. will transmit information by telephone on the dimensions of a jet turbine blade from the company's headquarters at 2209 Donley in North Austin to a lab in UT Austin's Engineering Teaching Center, where the mechanical engineering department and various research facilities are housed.

Jerry Martin of Scientific Measurement Systems says the data to be transmitted will be obtained by an X-ray inspection process known as computed tomography, in which X-rays are used to measure both the external and internal dimensions of an object, regardless of the object's complexity. Data obtained as the turbine blade is being scanned with X-rays will be transmitted by telephone to a laser sintering device on the UT Austin campus.

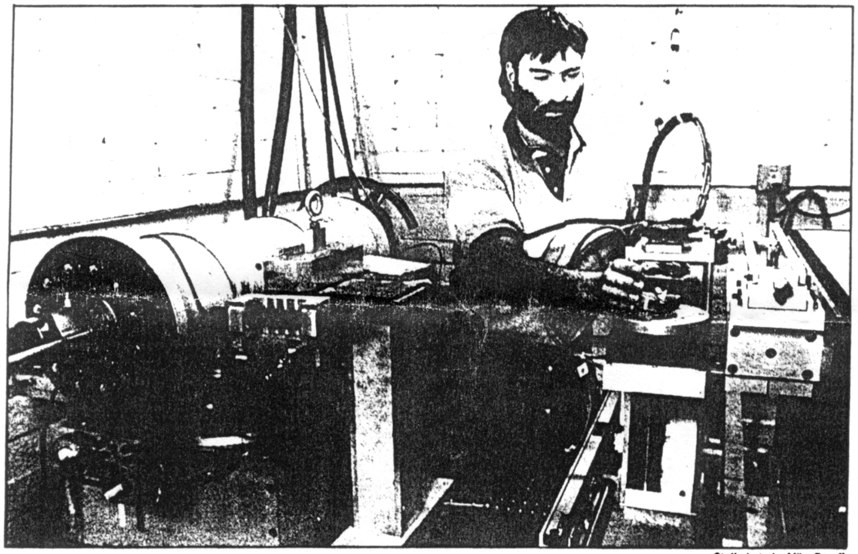
If all goes well, a polymer reproduction of the turbine blade will be completed about an hour after Scientific Measurement Systems technicians begin transmitting the information across town.

Scientific Measurement Systems Inc. is a leading supplier of computerized X-ray inspection systems for the aerospace, aircraft, automotive and defense industries.

Link to higher resolution image of UT news article:
http://hitechmex.org/self/3d_fax1536.gif

Article showing X-ray CAT scanner at Scientific Measurement Systems Inc. (3)

Thursday, August 15, 1991 Austin American-Statesman



Staff photo by Mike Boroff

Brett Simon, senior tomographic technician at Scientific Measurement Systems Inc., scans an automobile piston in a 420,000-volt scanner in the company's North Austin plant. The image was computerized and then transmitted by phone to a laser device in UT's mechanical engineering building, where researchers there called their advanced 3-D prototyping technology a success.

WORLD'S FIRST '3-D FAX'

UT researchers take rapid prototyping a step further

By Kirk Ladendorf
American-Statesman Staff

University of Texas researchers, only partly joking, called it the world's first 3-D fax.

By linking two high-tech systems — an X-ray scanning device and a computer-driven laser — the researchers this week transmitted a 3-D copy of an automobile piston over the telephone line.

They joined with Austin-based Scientific Measurement Systems, which makes high-tech industrial scanning devices, to put on the demonstration.

The automobile piston was scanned in Scientific Measurement's 420,000-volt scanner; the image was computerized and then transmitted by phone to a computer-driven laser device in the basement of UT's mechanical engineering building.

The result of the first trial was imperfect, but it was rated a success.

"It worked," said UT mechanical engineering Professor Joe Beaman. "I wouldn't call it a pretty part, but it was definitely it" — the auto piston reformed in polycarbonate material and scaled down to about one-third its original size.

The copied part did not include all of the detail of the actual piston, Beaman said, because only 60 scanned cross sections were made to save demonstration time.

The demonstration was conducted in conjunction with a UT-sponsored international symposium on advanced methods for solid free-form fabrication, or as it is more commonly called, rapid prototyping.

UT is considered a leader in the field. Out of its mechanical engineering laboratory came the process called laser sintering — using a computer-driven laser to fuse together fine powder of material into precise 3-D prototypes made of polycarbonate.

DTM Corp., an Austin-based start-up owned by the B.F. Goodrich Co., has developed commercial versions of laser sintering devices targeted at industrial users.

For Scientific Measurement SystemsInc. the "3-D fax" could create important new marketing opportunities for its sophisticated scanning equipment, which performs the industrial version of a hospital CAT scan

See UT, G2

UT researchers make gains in 3-D prototyping technology

Continued from G1

on the human body.

"I see it as being a significant impetus to cause our products to start to take on more interest," said Jerry Martin, the company's vice president of marketing.

Potential users, he said, could be aerospace companies, automobile makers and even utility companies that need to replace worn parts in nuclear power plants where drawings no longer exist.

Considerable interest in the process has come from Japanese manufacturers, Martin said.

For Beaman, the graduate adviser to Carl Deckard, who discovered laser sintering, the demonstration was just one more step toward expanding the power of the new technology. Beaman is currently exploring techniques to produce aluminum 3-D copies using the sintering process.

Rapid prototyping is attracting interest from manufacturers as a way to short-cut the time-consuming and expensive method of turning out one-of-a-kind prototypes in machine shops. A small industrial part can take six months and cost as much as $60,000 to make, according to some experts.

Laser sintering can accomplish the same task in a fraction of the time and cost.

The demonstration was supported by the Texas Advanced Technology program, a state-backed effort to show potential commercial uses of technology.

Link to higher resolution image of SMS news article:
http://hitechmex.org/self/3d_faxSMS1536.gif

Reverse reference: This article was previously published at;

http://www.tacc.utexas.edu/~reyes/tacc_personal/self/3D_fax.html
and was referenced by:
"Visualization Handbook" by Charles D. Hansen, Chris R. Johnson
Chapter 6 Isosurfaces and Level-Sets by Ross T. Whitaker

Also previously published at;
http://www.ices.utexas. edu/~reyes/self/3D fax.html
and was referenced by:
"Sensing and reproducing the shapes of 3D objects using claytronics"
by Padmanabhan Pillai, Jason Campbell
and
"A 3D Fax Machine based on Claytronics"
by Padmanabhan Pillai, Jason Campbell, Gautam Kedia, Shishir Moudgal, Kaushik Sheth

Also previously published at;
https://webspace.utexas.edu/reyesr/self/3D_fax.html
and was referenced by:
"Scotty: Relocating Physical Objects Across Distances Using Destructive Scanning, Encryption, and 3D Printing"
by Stefanie Mueller, Martin Fritzsche, Jan Kossmann, Maximilian Schneider, Jonathan Striebel, Patrick Baudisch

References:

1. Solid Freeform Symposium, Austin Texas; August 12-15, 1991
2. The University of Texas, On Campus; Week of August 12, 1991
3. Austin American Statesmen (Austin Texas); August 15, 1991