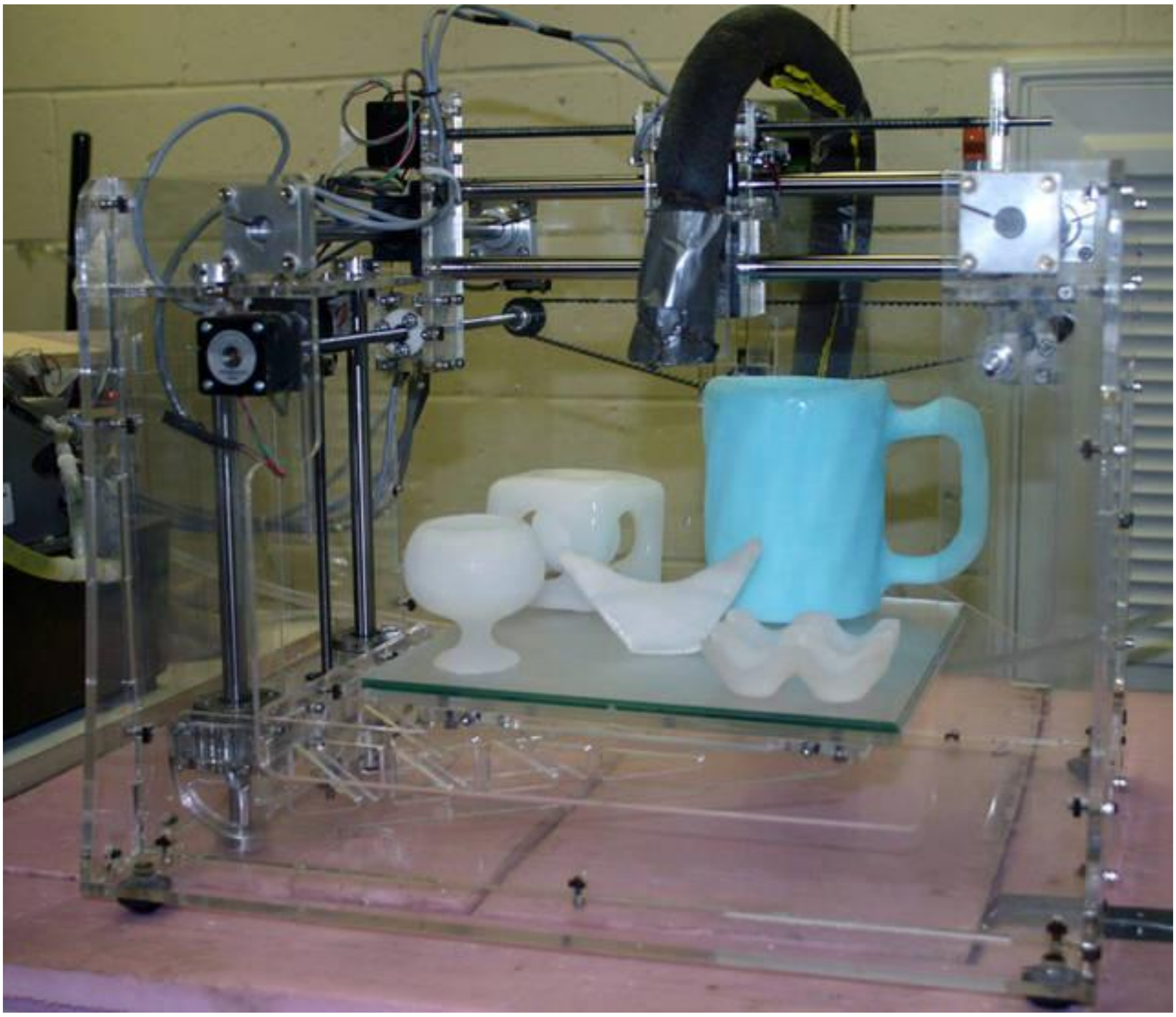
Fractal 3D printing with ice

5 June 2012

3D printer-hackers at McGill University in Montreal have modded their 3D rig to print solids made from ice. Scaled up, they believe they'll be able to create large-scale ice buildings, but for now, they're using it for very temporary, very cold, very intricate rapid prototyping:

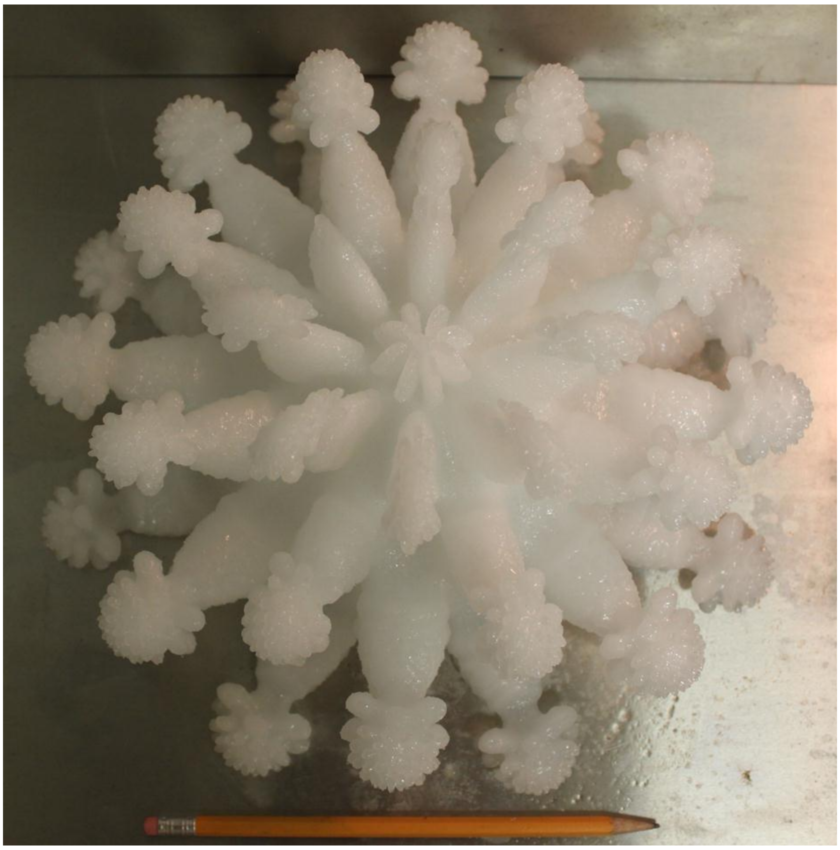
Currently, the practical applications of this project include commercial and industrial part modeling, and construction for the ice-tourism industry. For instance, small-scale ice models represent economical alternatives to intricate 3D models of architectural objects, be they scale models of buildings, site models, or building details. Presently, casting techniques are being investigated in order to produce high-quality metal copies from ice originals. In the long term, inhabitable, environmentally-friendly structures will be built at the architectural scale using computer-assisted techniques, thus increasing the level of automation in an industry that is currently very labour intensive.



How a Robot Becomes the Best Icemaker Ever

Water may freeze at 32 degrees Fahrenheit, but it prints at about minus 8. This is just one of the insights that **Pieter Sijpkes**, a professor emeritus at McGill University, has discovered since cobbling together a machine that prints objects by building up ultrathin layers of ice. He and his team have printed a statue, an egg carton, a martini glass, and molds that melt conveniently away. And now also 3d fractals.

3D printing with Ice of the 3D fractal for z(n+1) = z(n)^6 + c



3D printing with Ice of the 3D fractal for z(n+1) = z(n)^-6 + c

How a Robot Becomes the Best Icemaker Ever

Water may freeze at 32 degrees Fahrenheit, but it prints at about minus 8. This is just one of the insights that **Pieter Sijpkes**, a professor emeritus at McGill University, has discovered since cobbling together a machine that prints objects by building up ultrathin layers of ice. He and his team have printed a statue, an egg carton, a martini glass, and molds that melt conveniently away. And now also 3d fractals.

Why ice? Well, it's cheap and readily available, and low-cost ice models could help inventors design products more quickly. The challenge of printing with ice, besides the very cold temps necessary for the process, was building a machine that's up to the task. Here's how Sijpkes did it.

- **Hardware**
  The researchers used a robot arm, because it had the right structure and workspace for the system they wanted to build. A tool at the end of the arm houses the valves, nozzles, and wiring.
- **Software**
  The team uses modeling software to design the object they want to build. Then they translate that geometry information into the necessary control data for the robot to print the object.
- **Fluid Delivery**
  Water and methyl ester are deposited in 0.25-mm layers via nozzles on the tip of the arm. The methyl ester acts as scaffolding—it softens at a lower temp than ice, so it can be scraped away, leaving the structure intact.
- **Temp Control**
  The object is formed inside a minus-8-degree chamber, but a heating coil keeps the tip of the arm at about 68 degrees so liquid flow isn't interrupted during application.
- **Laser Correction**
  After every five layers have been deposited, a laser-displacement system measures the geometry of the top layer and adjusts the valve-control data to correct for any errors.
- **Time**
  It takes anywhere from a few hours to days to create an object. Next up: an outdoor robot that would take up snow or slush and spray it into freezing layers to build objects.