



Quantum Leap in Rapid Prototyping Unveiled



Dr. Behrokh Khoshnevis, developer of Contour Crafting technology, with equipment used for his prototyping system.

A newly patented rapid prototyping technique, called "Contour Crafting," allows quick fabrication of large, highly finished, computer-designed objects. The trowel - the simple flat blade used by artists and builders for millennia to shape fluid materials like clay or plaster - is the key element in the new rapid-prototyping technology, which was recently patented by University of Southern California researcher Dr. Behrokh Khoshnevis.(left)

"Rapid prototyping" is the general name for a group of novel manufacturing processes that have come into commercial use in the last decade. In all of them, a computer controls a continuous feed of raw material to build up complex three-dimensional objects. Such objects are typically then used as prototypes to create molds or jigs for traditional mass-production techniques.

Three-Dimensional Prototypes

Like other rapid-prototyping processes, Contour Crafting is a way to realize a three-dimensional object designed with a Computer Aided Design (CAD) system. Most existing prototyping processes work by first having computers analyze a CAD representation into a stack of flat, thin sections. A cone, for example, is visualized as a stack of disks of constantly increasing size; a hollow cylinder as a stack of identically sized rings.

Then, various techniques are used to create these visualized layers, one by one. Some rapid-prototype systems use ultraviolet light or lasers to harden soft plastic or plastic powder layer by layer onto rising platforms; some use a computer-controlled laser to cut glued-together layers of special fiber paper, one layer at a time. One technique, called "three-dimensional printing," uses an ink-jet-printer-like nozzle to spray layers of glue on plastic powder, one layer at a time. All of these layering techniques share a common problem - rough edges. If the layers are thick, the side edges of the resulting shape show laddering effects on what should be smooth surfaces, so that what should be a cone looks instead like a stack of discrete, differently-sized disks. The effect can be minimized by making the layers thinner; but doing so makes the rapid prototyping much slower, because it takes many more layers to create a finished product. Making even a relatively small part can take hours or even days with existing machines. Since such machines cost \$100,000 or more, the time factor sharply increases the cost of parts.

Even when cost is not a factor, all existing systems have physical limits on the size of the objects that can be created. The maximum size is about one cubic meter - a box 39 inches on a side.

Breaking the Boundaries

Khoshnevis' Contour Crafting system breaks those boundaries. It improves on an existing technique in which a computer-controlled extrusion nozzle squirts out plastic to build up layers, somewhat like the way a cake decorator squeezes out patterns.

Khoshnevis has added to this setup a pair of movable, flat control surfaces that he calls "trowels" - just above and to the side of the nozzle. The trowel movements, shaping the material coming out of the nozzle before it sets, are controlled by the computer. In the Khoshnevis system, the nozzle and trowel arrangement creates the object's outside walls as a thin but strong shell. A separate pouring mechanism fills in solid objects by adding material in bulk, layer by layer. The researcher said he got the idea when smoothing plaster on his house.

The inventor acknowledges that programming the Contour Crafting system is more complex than with existing rapid-prototyping systems. Such systems need only describe the fabrication of the object using three control parameters - the three dimensions of space, represented as the x, y, and z axes of a CAD representation.

Contour Crafting programming needs to specify not just the three spatial coordinates, but three more control parameters - the desired orientation of the two trowels, plus a flow-rate for the extrusion nozzle. "These are not trivial problems," Khoshnevis said, "but they are solvable, and the solutions are becoming easier as we gain experience."

Against these difficulties, the inventor cites the new system's advantages:

A wide variety of materials can be used. The extrusion nozzles can dispense polyethylene, ABS, nylon or other strong, common synthetics or specialized plastics that harden when exposed to ultraviolet light. The fact that the nozzle can be large allows the use of ultra-strong new fiber-composites, as well as such traditional materials as plaster or concrete. Khoshnevis is experimenting with metal powder carried in a plastic binder. Subsequent heat treatment "sinters" the work - burning off the binder and fusing the metal.

The process is much more rapid than any existing rapid-prototyping system, building parts in less than one-tenth the time. In addition, extremely large parts are possible. "If you install the extrusion nozzles on a gantry assembly," Khoshnevis said, "it is completely feasible to build items as big as boats, all in one piece." Large auto or airplane parts could be created in a single process.

High-value items like boats are candidates for production by the new method, the researcher believes. "As we gain expertise in this method," Khoshnevis said, "machines improve and cost falls. I believe this method will be competitive with some manufacturing processes."

The National Science Foundation and private industry have supported the inventor's work. His collaborators include professor Steven Nutt of the School of Engineering department of materials science; two Ph.D. candidates, Rick Russell and Zheng-Ha Yeh; and three master's degree candidates Majid Aghababazadeh, Dmitri Landos and Steve Farentino. Farentino currently works in the Southern California-rapid prototyping industry. Khoshnevis received patent #5,529,471 in June 1996 for Contour Crafting technology and has another patent pending.

For more information, contact:

Dr. Behrokh Khoshnevis.

E-mail: khoshnev@usc.edu or Eric Mankin

Tel: 213-740-9344.

E-mail: mankin@usc.edu

©1997 U.S. Tech.

The information you receive on-line from U.S. Tech is protected by the copyright laws of the United States.
U.S. Tech, PO Box 957, Valley Forge, PA 19482, Tel: 610.783.6100 Fax: 610.783.0317

E-Mail: ustech@gim.net