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Foreword

CAD and the Arts

When I was invited to do a special issue for Computer-Aided Design, I picked the topic "CAD and the Arts", since that topic was foremost on my mind. For several years I had been interacting with artists who created abstract geometrical sculptures, and I had used the computer to visualize and understand their geometric constellations.

Since 1995, I have worked closely with Brent Collins, a wood sculptor who creates fascinating composite patterns of saddle surfaces [1]. Our discussions and collaborations took off from his "Hyperbolic Hexagon" (Fig. 1), a sequence of six saddle elements of alternating orientation, closed into a toroidal ring, forming six holes between them as well as an additional central opening. We wondered what would happen, if the original saddle-chain was given a longitudinal twist before its ends were joined into a ring. In our collaboration, we found that the computer not only allows quicker and easier prototyping of new, potentially interesting shapes, it is also a productive and enjoyable exploration tool. First I wrote a very narrowly focussed utility program [2] to capture this particular family of shapes. With this tool, new ideas that emerged in our frequent phone discussions could be quickly visualized, and the resulting shapes could be carefully inspected from all sides. By fine-tuning several built-in geometric parameters, such as the thickness and extent of the flanges, or the exact dimensions of the holes formed by the surrounding saddles, the local aesthetic optimum could be determined with high confidence. This eliminates the feeling of uneasiness known to many a sculptor: "Perhaps — if I had made this flange a little wider, the sculpture would look even better…"

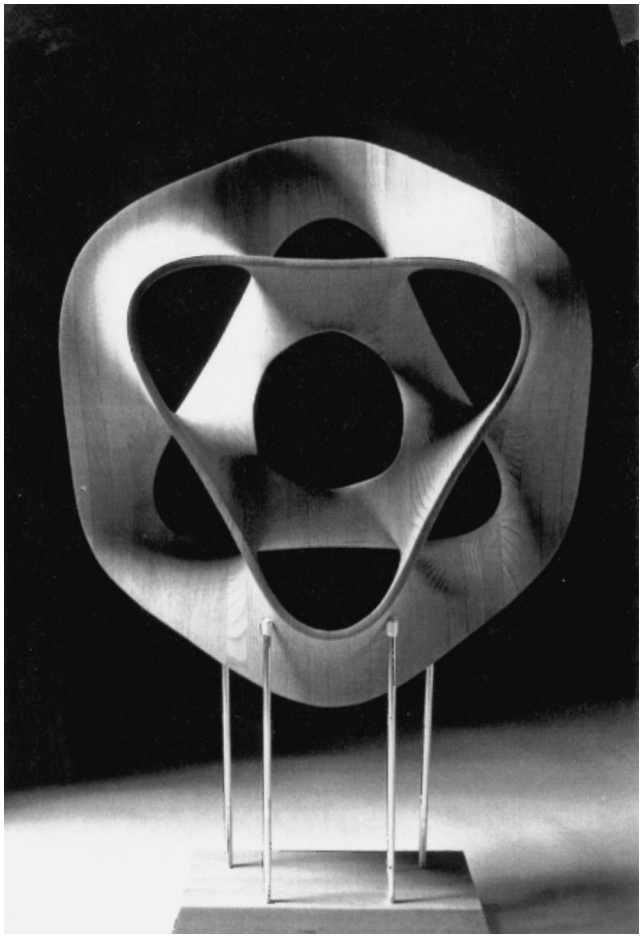

Fig. 1. "Hyperbolic Hexagon" by Brent Collins.

Moreover, the computer also allowed us to tackle structures of a level of complexity that clearly exceeded what an unassisted human could hope to achieve — in the conceptual design phase, as well as in the actual implementation of the final shape. Once a pleasing looking form had been found in the virtual reality of the CAD tool, the computer program could then slice that shape at regular intervals corresponding to the thickness of the boards from which the final shape was to be laminated — typically 7/8th of an inch. Full size plots of these cross-sections were sent to Collins who could then transfer them onto wooden boards, cut them out individually, and then assemble the often rather odd-looking pieces into a "stair-cased" approximation of the desired form. This approach guaranteed that the overall symmetry and dimensions were properly observed, while Collins' skills as an artist and craftsman would hone the detailed shape of the surface until it was pleasing to the eye as well as to the touch (Fig. 2).

After about a year of use and periodic enhancements, my utility program had become reasonably robust and flexible, and a new role of the computer started to emerge. Most of the sculptures that I had designed with this program, and which had a tendency to grow progressively more complex, also inspired new ideas during the inspection, analysis, and optimization of these fascinating shapes. Often small enhancements had to be made to my computer program to

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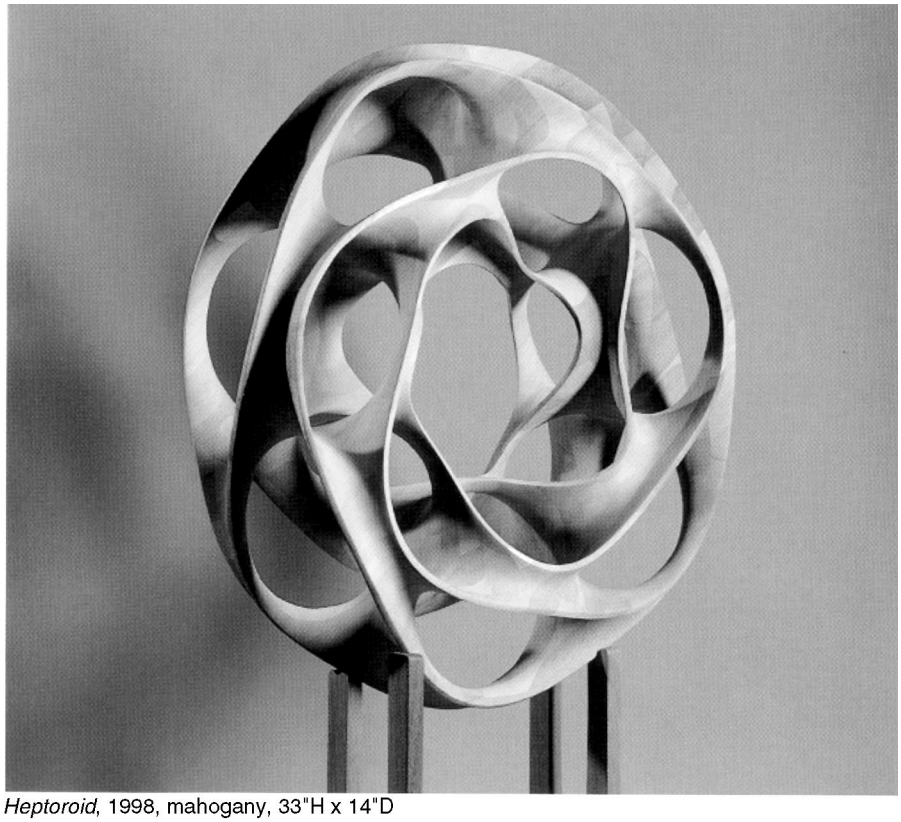

Heptoroid, 1998, mahogany, 33"H x 14"D

Fig. 2. "Heptoroid" by Brent Collins, designed with Séquin's program.

allow me to follow up on some of these novel ideas and to make it possible to visualize the resulting structures. For example, one such extension was triggered by the question whether it was possible to intertwine more than one of these toroidal saddle rings without interference of the flanges that connect subsequent saddles. Soon this led to another question — whether a single saddle-chain could intertwine itself by making more than one pass around the toroidal loop. A small change to the program allowed the sculpture generator to test this idea — and answer it in the affirmative (Fig. 3).

In this way, a computer program can also become an amplifier for one's creativity. Since it is so easy to explore a whole domain of possibilities by just moving a few sliders, users of this generator can quickly become conscious of the boundaries of that domain; it then is natural to ask: "What lies beyond?" or "What happens when I break a particular assumption?" One can easily ponder questions — and obtain answers to them — that one might never have considered asking, if each experiment had to be done by building a physical model.

The role of the computer in creating new artistic shapes had intrigued me for a long time. I was quite familiar with the work of Bruce Beasley [3] who has been using the computer as a design tool since the early 1980s. He uses custom-enhanced modeling software by Hewlett Packard to design, visualize, and prototype his many mutually intersecting polyhedral shapes and to compose them into daring yet carefully balanced compositions. A special example is Helaman Ferguson [4], who has been a mathematician and a sculptor most of his life and who is able to combine his creativity and his analytical skills in a very productive manner. He often uses computer-controlled tools to realize his mathematical visions and to sculpt his calculated, abstract surfaces as precisely as possible.

I was curious — what else was going on out there in this realm? What other artists or creative designers were using a computer in some form? A call for a special issue seemed like the right way to find out. Unfortunately, the few people whom I already knew and who were doing the kinds of things described above did not have time or were not interested in writing papers; so I had to rely on the papers that would be submitted. I really did not know what to expect. Would any artists write about their use of the computer? Would any CAD tool developers catering to the special problems of artists send in papers?

The actual submissions showed an interesting trend. Most contributions were concerned with the creative/generative aspects of new artistic forms, with a good mix of papers that employ procedural shape generation and others describing novel user interfaces to deal with the interactive creation of 3D geometry. Correspondingly, the papers appearing in this special issue start with a design system for 2D patterns and end up with an interactive haptics user interface for 3D shapes.

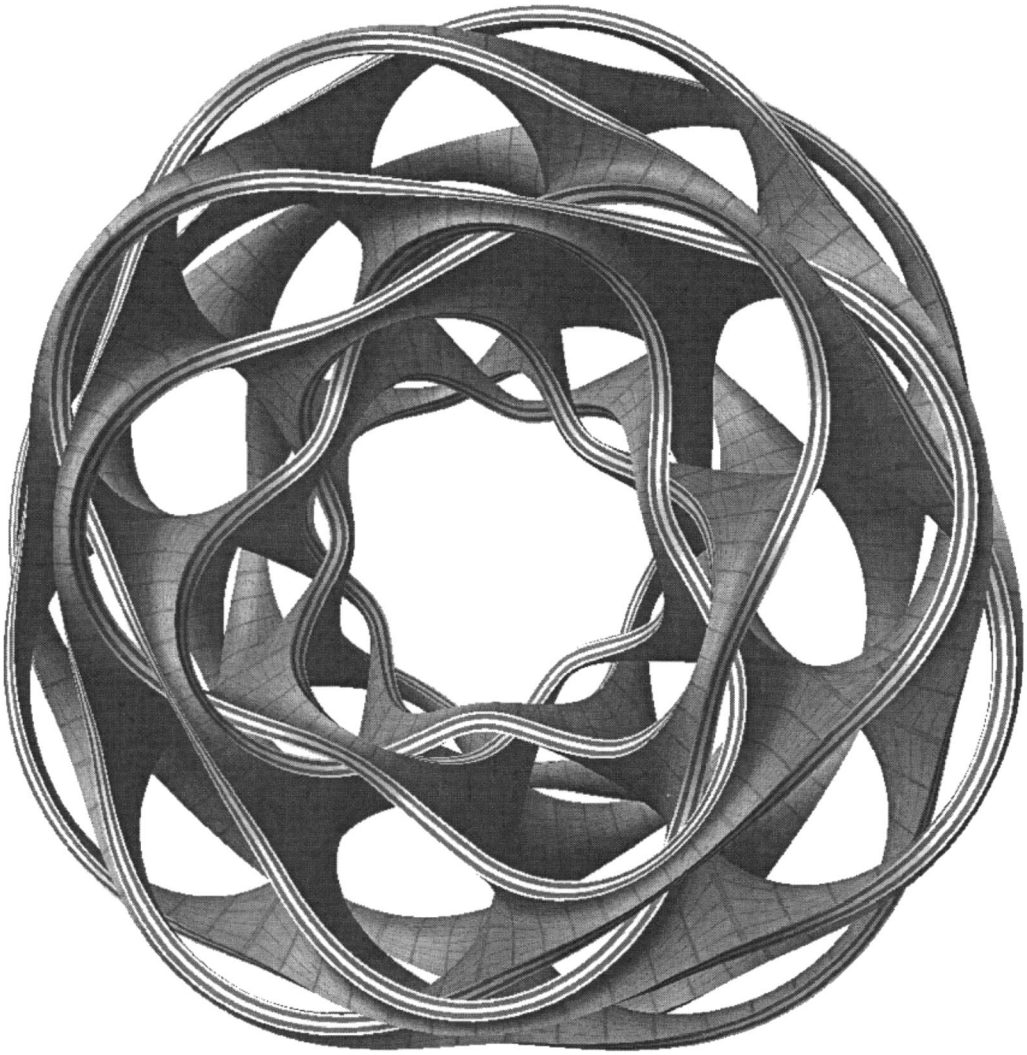

Fig. 3. A doubly-wound toroid generated with Séquin's program.

Mike Field's "prism" software allows the exploration of symmetry groups in 2D for educational or recreational purposes, as well as the production of artistic patterns for use in, say, the textile industry. The underlying algorithms are based on chaotic dynamics and are generated point by point in an iterative manner. Sato and Hagiwara have prototyped a shape creation system for "useful" hand tools by employing genetic search algorithms that evolve general shapes according to high-level selections made by the user, until a kinematic shape has emerged that might serve a previously specified function or some novel purpose. The paper by Pasko et al. reviews ways in which the computer can assist an artist in the traditional crafts of carving, embossing, and chasing. Individual shapes and patterns are converted into geometry that can be mapped procedurally onto flat or curved substrates. Alternatively, the artist can use the computer interactively through a pressure sensitive tablet to do virtual free-form carving with chisels of adjustable geometry. Dorman and Rockwood introduce a true three-dimensional user interface with the help of a DataGlove. Their system permits the interactive manipulation of polygon-based surfaces over domains of adjustable size. A built-in smoothing procedure prevents the surface from becoming too jagged. Dachille et al. go a step further in providing a "realistic" sculpting interface. Through the use of a haptic device they give the artist a 3D interface through which one can feel the surface and its resistance to modifications. In addition, they allow the designer to specify explicit constraints such as tangent directions or curvature.

These papers exemplify a general trend to make these computer-based design environments not simply a (still quite imperfect) emulation of real physical artist's tools, but to exploit some unique and novel services that only a computer can offer. But in general, CAD support for artists is still lagging behind that found in other domains. The problem may be that needs and goals of artists are far less structured and less well understood than those of engineers. Hopefully, this special issue will encourage the development of some better tools

for the artistic domain — there are many people who would welcome them.

References

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