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Sculptures in the void

You can look, but you can't touch. Computers and art meet to produce three-dimensional representations of sculptures that do not actually exist

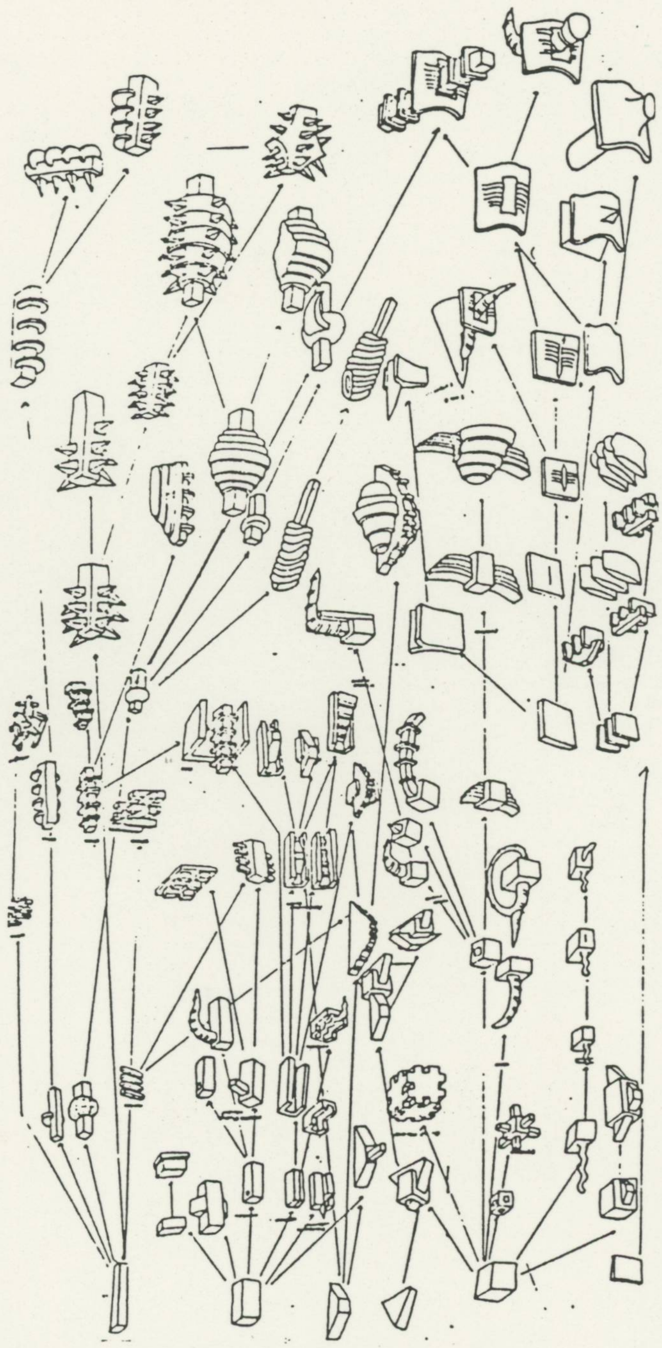
William Latham

THE SCULPTURES I have been making are ghosts: they exist only as computer data, and not in physical form. Artists have made sculptures from many different materials—marble, steel, bricks and wood—in the workshop or studio. In contrast, I create my sculptures, or forms, in a "virtual" space viewed through the porthole of a computer screen. Using the computer, I can rotate and view the forms from any point, and can simulate visual attributes such as texture, lighting and surface qualities using techniques that give photographic realism.

The result is a highly realistic representation of a sculpture that does not exist. The three-dimensional realism is enhanced by using stereo projection and animation. The fact that you cannot touch the sculpture, and that it exists only in virtual space, adds to the mystery of the work of art. The true significance is not the irony of being unable to touch my sculpture, but that by working in computer space I can create highly complex forms that would be impossible in traditional sculpture. This is because there is no gravity or material resistance. This allows me to explore and invent forms which had previously been outside my imagination. These forms I call "computer sculptures".

There is another aspect of the work that is perhaps more interesting. That is the systematic approach and rules devised with my colleague Stephen Todd at IBM to generate the forms. These rules are called "form evolution". Using these rules, there appears to be no limit to the number of different forms you can produce, from shells to eggs, antlers, slugs and sea urchins. Although we are creating forms that appear imaginary, poetic or even "romantic", we are actually using a structured and systematic approach.

I experimented with a system for creating complex sculptures before using computer graphics. At the Royal College of Art, I developed a way of designing sculptures called the evolutionary tree. This approach takes a series of simple operations and carries them out on basic shapes to create complex forms. Using this method, I drew by hand a chart of evolutions, measuring 10 metres long by 2 metres high. It became obvious that my aim of exploring complex forms could well be helped by computer.



Graphics by William H. Latham

Part of the hand-drawn evolutionary tree

Meanwhile, people at the IBM UK Scientific Centre in Winchester were looking at ways of visualising scientific data, and had developed a variety of systems. These included a database graphics system for data exploration, and a modeller called the Winchester Solid Modeller (WINSOM)—developed by Peter Quarendon and others at IBM for data visualisation. WINSOM works with a programming tool called the Extensible Solid Model Editor (ESME), which was written by Stephen Todd for experimenting with different picture styles.

In 1987, the Scientific Centre commissioned me to produce a series of computer sculptures using the WINSOM and ESME computer programs. The results encouraged longer collaboration, aimed at using the computer for faster form exploration and generation, to widen a sculptor's creative scope. It became apparent that this work was also interesting to designers and architects who are similarly involved with problems of modelling complex forms.

The collaboration has two aspects. Using simple programmed operations (written in the ESME language) helps me explore complex forms. The photo-realistic techniques of WINSOM allows me to realise and communicate these forms.

The WINSOM and ESME models are based on the concept of "set-theoretic" modelling. This can generate solid objects from basic building blocks such as spheres, which are combined by set-theory operations such as union and difference. Engineers often use this type of modelling for a variety of applications.

ESME is a conventional programming language with additional functions that handle geometry and solid model-

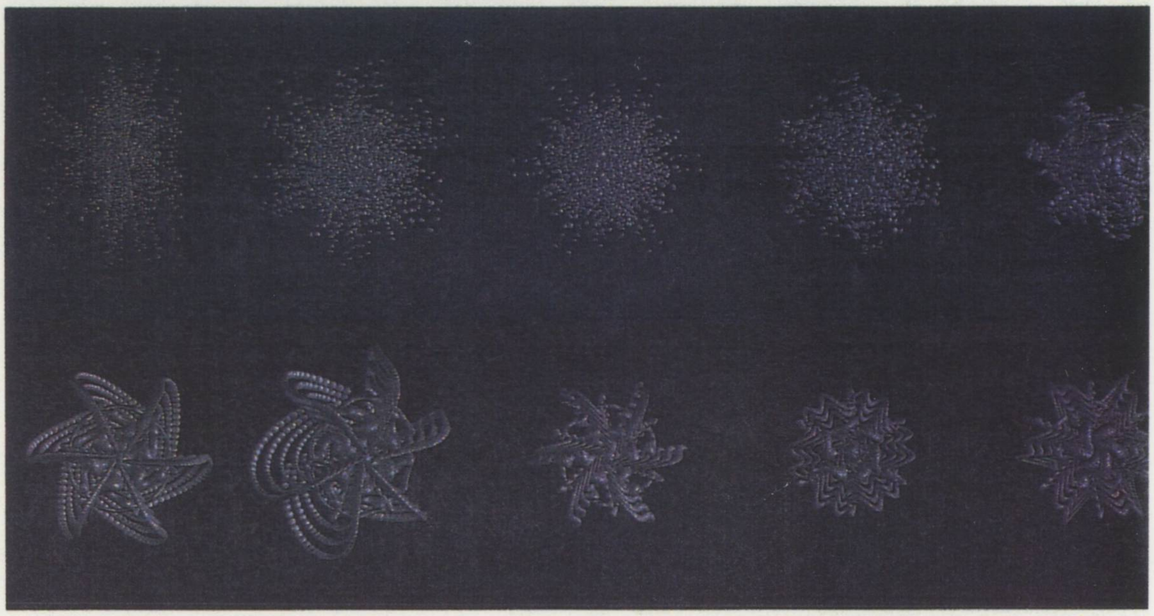
One of William Latham's latest works of art

ling. Two ESME functions provide the operations used to generate most of my complex forms.

The first of these is the "horn" function, which takes a form and transforms it many times, creating many different shapes. The variety depends on the original form, and on the instructions defining a horn, such as bend, scale, twist, grow and stack. These terms are words that any sculptor would use when talking to a technician in a traditional studio. The second function is "branch". This takes a form and produces many copies of it, radiating from a central point.

Combining these simple functions with the power of set-theoretic modelling allows me to construct a huge range of forms. There are an infinite number of sculptures that I could create, but at any given moment the functions and parameters of the program constrain me to a limited number of choices. This has proved a very good mixture to encourage creative output, and has focused my ideas.

None of the forms I have generated at the IBM Scientific Centre has ever existed as a "real" object. They appear as high-resolution screen images or photographs, or as animations on videotape. As a form develops, I use a variety of "realisations". The simplest realisation is a sketch, or ▶



A sequence of stills from an animated film called The Evolution of Form Animation

▶ wireframe which I can generate very quickly, and can rotate on the screen at will. I use this to check the basic form and to choose interesting views. Many forms never progress beyond this stage. Next, using WINSOM, I fill in and colour the form in three dimensions, in a low-resolution version, to check that there are no features hidden in a way that was not obvious from the wire frame. Finally, WINSOM generates a full high-resolution photo-realistic image.

To obtain the image, I can use a whole battery of special effects. These include three-dimensional texturing, shadows, colour and surface qualities. To use these effects, I set various parameters: these determine the lighting, or define a style of texturing using fractal techniques, or describe a special colour or particular "bumpy" surface qualities.

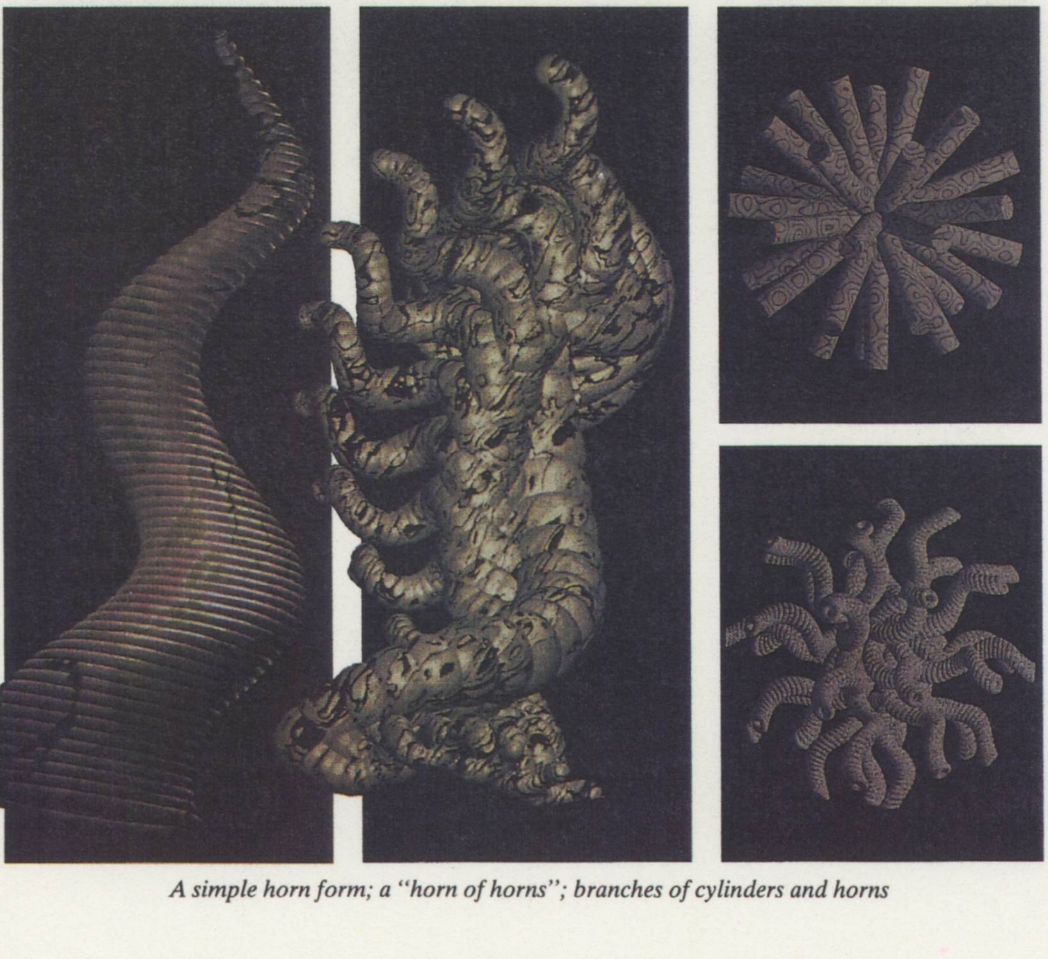
When using these photo-realistic techniques, my intention is to give the forms a dream-like quality. My forms float in a kind of twilight world halfway between the real and the imaginary. And as in a dream, they are lit with a strange eerie glow and have a curious clarity.

We can make the sculptures appear even more three-dimensional using stereoscopic projection. It is possible to use stereo pairs, with two projectors and polarising filters. This requires a special screen. Alternatively, a red and a green image are combined on a single slide. This requires only one projector, but loses the colour of the image. In either case, the viewer must wear the appropriate spectacles. Texture is particularly important for stereo viewing, because it allows greater perception of depth, and enhances the three-dimensional quality.

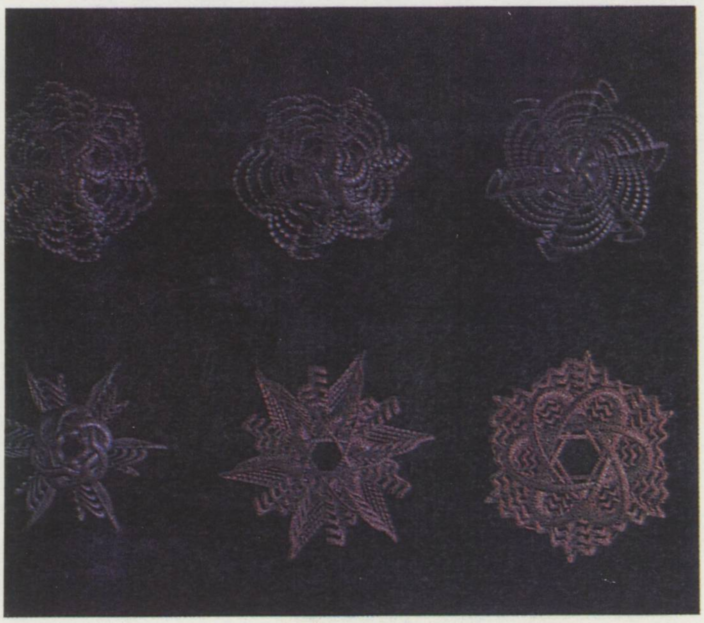
Animations are much better at giving a viewer a full appreciation of the form of an object. The simplest type of animation rotates the form in front of the viewer so that you can see all round it. More complex animations lead the viewer round, or even through, a form. The same ESME program that generates the form creates the viewing path. Finally, the power of animation allows the form itself to grow and distort.

The combination of photo-realism and computer graphics is popular with the general public and lends itself to mass reproduction and television broadcasts. As soon as sculptures become "data" then the artwork need not reside in the art gallery, because the artist can transmit it into the viewer's living-room.

In future, we expect to allow users to be more directly involved in designing



A simple horn form; a "horn of horns"; branches of cylinders and horns



Techniques to create the nonexistent

COMPUTER sculpture brings together three techniques: constructive solid geometry modelling, graphical rendering, and the programming of forms. Significantly, it provides an environment where these can be applied without the need for detailed technical knowledge. The techniques were originally combined for scientific "visualisations", such as molecular graphics in biochemistry, but also provide a good environment for computer sculpting. Constructive solid geometry (CSG)—the generation of complex objects from simple operations on simple objects—was first developed for computer-aided design applications at the University of Rochester, in the US, in the late 1970s. Research at the University of Bath in England led to the development of the WINSOM set-theoretic modeller at IBM in 1983, and so to the application of CSG to visualisation. WINSOM provides a wide range of graphics techniques, texture being the most important for William Latham's sculptures. WINSOM gives an easy-to-use set of facilities for generating, merging and manipulating textures. Making complex forms relies on programming rather than building the forms up piece by piece. The ESME programming tool provides an interactive programming environment that understands the forms as objects, and is especially convenient for animation. Researchers at Bath University are now exploring the use of algebraic programming for geometry. IBM is working with the University of Glasgow to look into the use of functional programming both for shape definition and as a tool for easy control of graphical algorithms. **Stephen Todd**

the forms. The mathematics of form-generation functions will, however, still constrain the interaction with the user. There will not be the freedom associated with "paintbox" systems, such as those used by television companies to create graphics for maps, diagrams and title sequences. But we will marry form-generation techniques with my original concept of the evolutionary tree, to give users a new type of interface. In this way, users will have a quick and easy way to generate complex forms.

The "form evolution" approach has allowed me to create shapes that had previously been beyond my imagination, and to present the results to the viewer. As holography improves, it will be possible to project a full-size sculpture into the viewer's living room: the ghosts of sculptures will truly appear. Perhaps we will no longer need to have sculptures in physical form at all. □

The exhibition *The Conquest of Form*, computer art by William Latham, produced at the IBM UK Scientific Centre, is currently touring Britain. It can be seen at the Natural History Museum in London from June 1990 for 3 months.