

A Three Dimensional Modeller for Art and Design Education

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Introduction

The original brief for this project was to explore the use of the micro computer for the teaching and promotion of three dimensional understanding in education. Initially it had been intended to adapt existing software, but it soon became apparent that there were no suitable packages for this work. Not only were there very few three dimensional modellers in existence which could meet the resources of education, but these were based on an ancestry of draughting and engineering, presenting often complex and unsympathetic environments for art and design users.

Consequently it became necessary to create a new environment for this purpose to which would be added a scheme of work for introducing and teaching three dimensional concepts. The name adopted for this environment was Timaeus, borrowed from the Platonic dialogue which describes the construction of the universe.

References and Precedents

Three dimensional form and spatial understanding are areas of vital importance to almost all design and production and yet areas which our education provides no real strategy for teaching. The urgent need of such a strategy is argued by Professor Bruce Archer,¹ but this task is made difficult by the lack of academic literature directly applicable to these studies. Consequently precedents were sought principally from the field of art and design and its main practitioners.

Perhaps because of the individualist and practical nature of art and design education, less has been written about these practices than might be expected. One notable exception is Keith Critchlow's *Order in Space*.² His clear and precise introduction of solid geometry and non rectilinear structure provided both an inspiration and challenge to designing Timaeus. Similarly Edvard Lanteri's *Modelling and Sculpture*³ provided a lucid account of the stages and procedures traditionally used in sculpture.

The work of many artists and designers was examined, particularly their drawings. Most influential was the printmaker Piranesi, whose Carseri⁴ etchings first suggested the dual

hierarchies of form and structure used in Timaeus.

The Hardware, Operation and Interface

The RM Nimbus was chosen as the host machine because at the time it was the only common educational computer with sufficiently powerful features for three dimensional modelling. Because of the lack of educational resources only standard equipment, a colour monitor and mouse, were assumed to be available.

To keep the operation of the program simple and easy to learn a WIMPS (windows, icons, mice and pointers) environment was designed which reflected the program structure. The use of menus means that the program can be self prompting, and by rendering the keyboard redundant except for the input of names, complicated keystrokes are avoided. The addition of context sensitive help and an on screen tutorial provides support for everyday operation.

The problems and solutions of three dimensional computer graphics are well researched and documented by Newman and Sproull⁵ besides others. This left two important issues to be resolved in the interface. First the definition of form which determines the data structures of the program. Second the structure of space which determines how forms are built, edited and manoeuvred in space.

The nature of form

A major characteristic of any three dimensional modeller is its definition of form. This determines not only how the form is stored, but the operations that can be performed on it and the ways it can be drawn.

From the beginning solid modelling was rejected. Apart from technical considerations of speed and memory, there are strong artistic precedents for using a system based on line. Sculptors and designers have relied on the use of line in drawing and continuing this tradition provides a greater emphasis on form and structure than solid modelling could achieve. An extension of line to faceted drawing preserves the linear and structured character of the image while allowing extra features of planes and surfaces to be incorporated and drawn with hidden line removal.

A form itself is taken to be, at its most abstract, a thought of three dimensional complexity. In practice this means the consideration of a group of locations in space. This might be the relationship of a single point to a coordinate system, the pairing of two single points as a straight line, a sequence of points defining a curve and so on. A simple grouping of points is called a line. Lines are grouped as forms and a collection of forms is a scene.

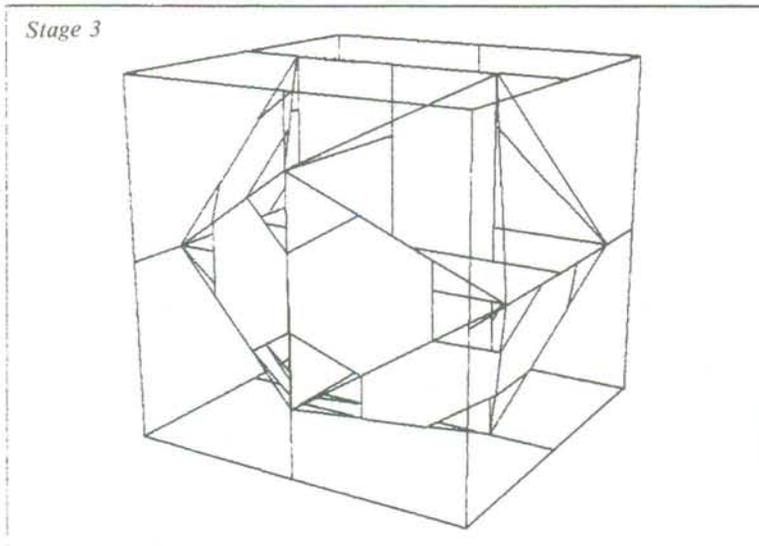
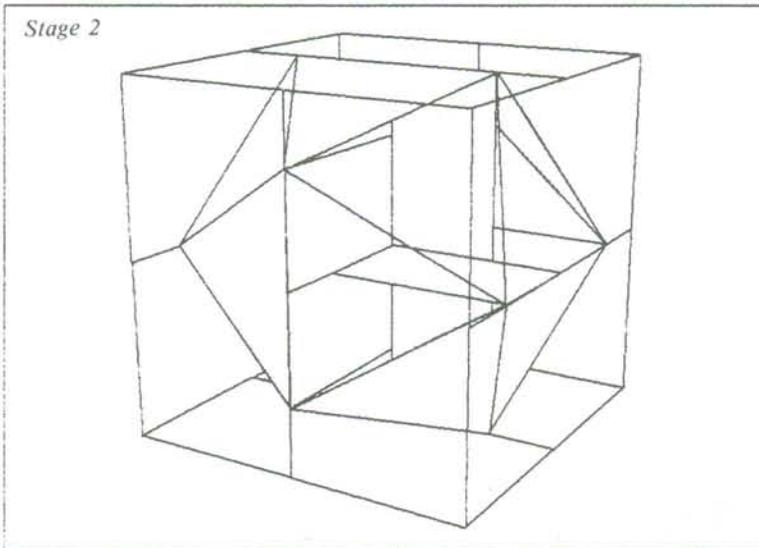
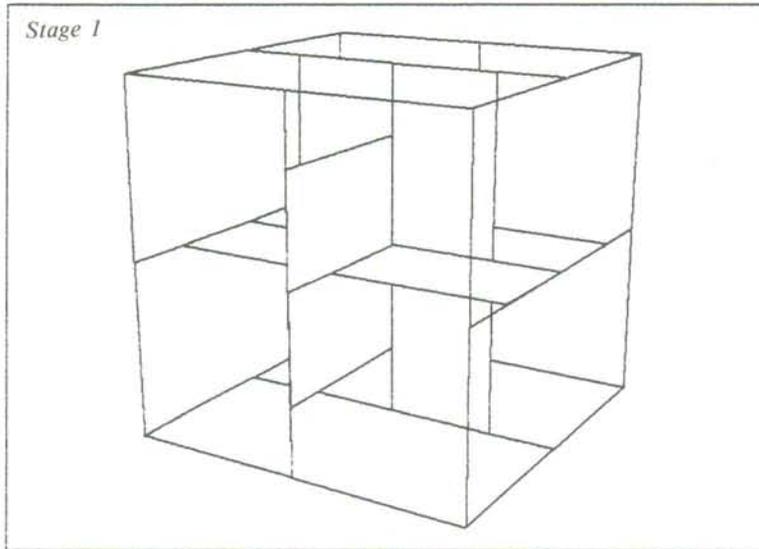
This defines a simple hierarchy of forms from single locations, through lines and forms to a whole scene. It is important to realize that an object at every level of this hierarchy constitutes a form. Access to each level of this hierarchy provides flexibility in the building, editing and manipulation of forms.

Because the output of the program is essentially linear, each form is drawn as a series of lines indicating simple relationships of locations. Two other variables, the use and colour of line increase the quality of line expression. The colour variable is self evident. The use variable further defines the relationship of locations being described and in particular determines how the line is drawn. For instance uses of lines included a string — a simple linking of points, a plane — which fills the defined area as a facet, and a surface — a continuum of facets.

Finally all forms can be treated as components of more complex forms. After manoeuvring a number of forms as separate objects in the scene these can then be united as one new form. This process can be used recursively with each newly created form being used as a component of a future form.

The structure of space

All systems of creating forms in space, not only on computers but in drawing and direct construction are biased. That is they have a tendency to encourage particular formal configurations. For instance draughting has a bias towards treating the third dimension as perpendicular to the drawing plane. Lego, as a constructional system, also provides a rectilinear bias, where as a plastic medium such as clay encourages organic rather than geometrical forms. Similarly if a three dimensional modeller on a computer uses an x, y, z



coordinate system for the input of data then more rectilinear thinking will be encouraged, whereas polar coordinates will encourage more spherical thinking. We may tend to think of space as neutral but in fact it is structured, either by the medium or the conventions we organise our three dimensional thought in.

As one of the main purposes of Timaeus was to introduce different types and classes of form (e.g. employing spherical and non rectilinear geometries), a coordinate system was avoided for the main input of data. Instead a system of crating was adopted, where points in space are located relative to their position on another crate or structure. Therefore the use of different crates structures the space differently, encouraging original solutions to formal problems. Structures are provided in libraries of forms but as all structures can be made as forms, it is easy to define new structures to suit the task in hand.

This system of crating is used not only in the creation of new lines but in manoeuvring forms in a scene. Thus in both stipulating the position of points in a line and locating a form in a scene it is simply a matter of pointing to its location on a previously defined structure. Local variations and orientations can then be achieved by altering coordinates.

One advantage of the crating method for locating objects in space is that it encourages a structured approach to three dimensional work. A complicated form can be structured by a hierarchy of structures, starting with a simple form such as a cube or sphere and either modifying it or building on it to create the required structure.

A further advantage of using crating for accessing locations in space is that it

1. *The building of a truncated icosahedron*

Stage 1

Three x,y,z planes established within a cubic structure

Stage 2

Icosahedron built on the x, y, planes.

Stage 3

Hexagons components of the truncated icosahedron hung on the icosahedron structure.

Stage 4

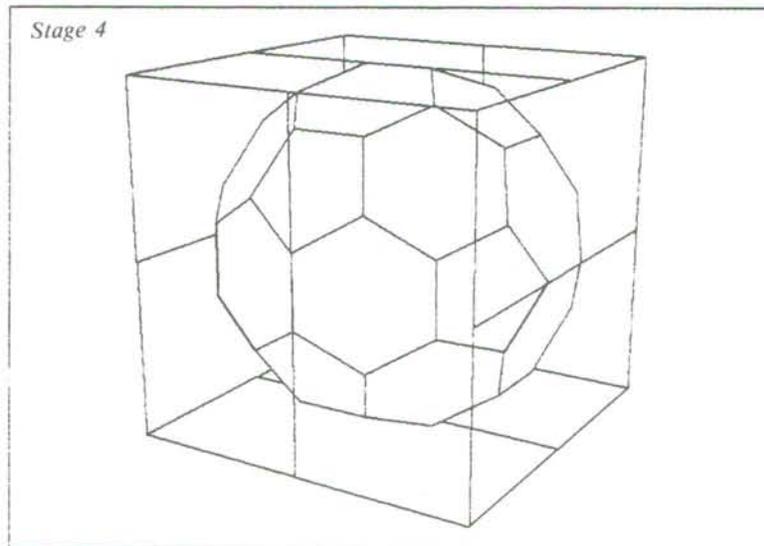
The completed truncated icosahedron within the original cubic structure.

allows more natural projections, such as perspective to be employed at all stages of operation. This allows the creative process to be viewed and considered from the most convenient angle just as in drawing or three dimensional construction.

Dual Structure

Three dimensionally Timaeus offers a dual structure. The nature of form employed encourages forms to be built in components and joined together as increasingly complex forms. However the use of crates for building and manoeuvring provides spatial structures of almost infinite variety.

This notion of dual structure is only one interpretation of the programs three dimensional interface. In fact the component forms, the structures used and the final product are all one and the same — that is a form. They are made in exactly the same way and are all interchangeable. The main difference

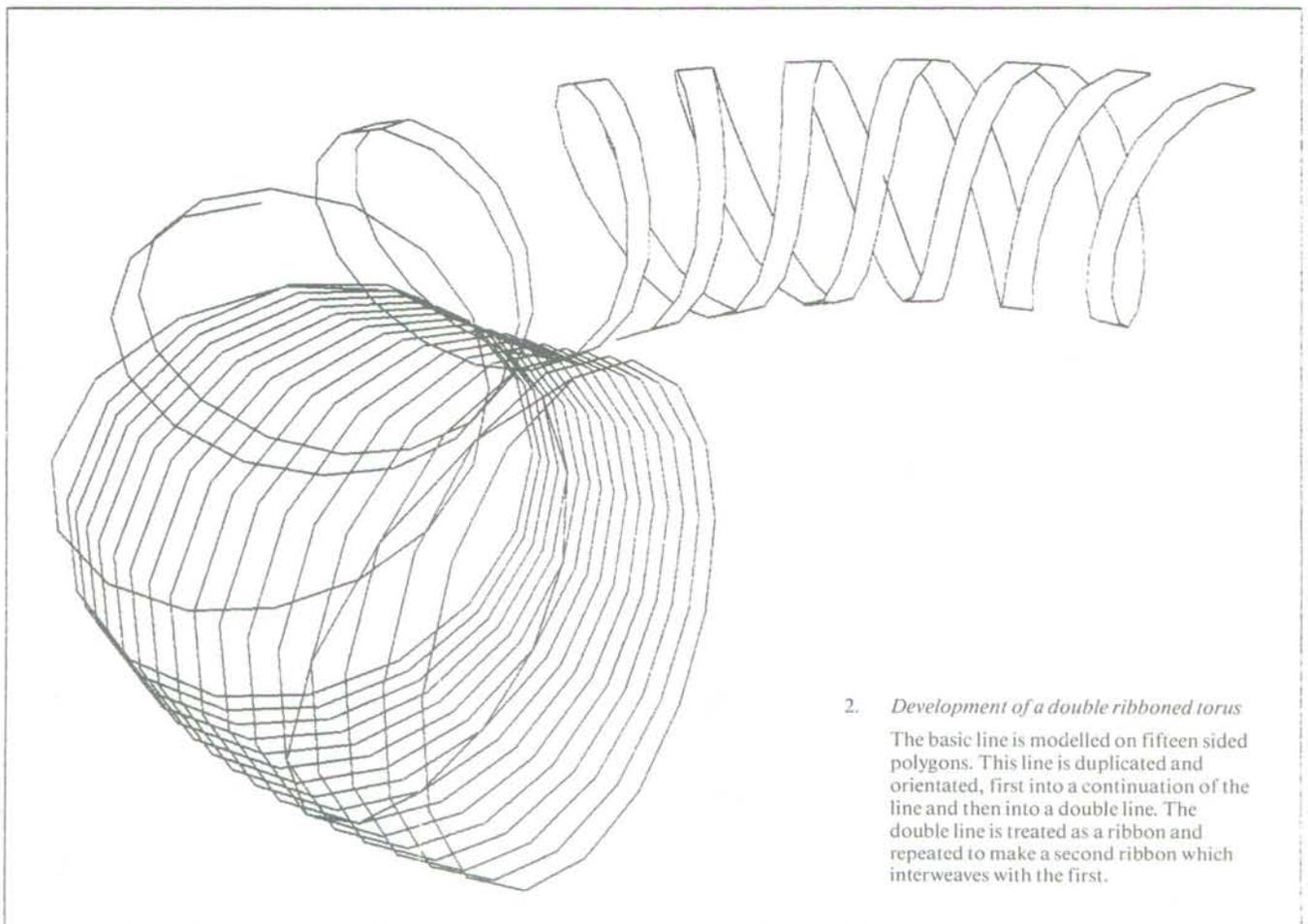


between a component and a structure is its application in the building process.

But by admitting the dual structure of form within the program students are encouraged to think both of the

hierarchy of components that build a form and the forms overall structure. To consider not only the parts but the whole, simultaneously.

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2. *Development of a double ribboned torus*

The basic line is modelled on fifteen sided polygons. This line is duplicated and orientated, first into a continuation of the line and then into a double line. The double line is treated as a ribbon and repeated to make a second ribbon which interweaves with the first.