A CONSTRUCTION OF THREE-DIMENSIONAL VIEWS FROM THE SILHOUETTE DATA OF POTTERY.

Ian O. Angell
Royal Holloway College
University of London

Peter L. Main
Research Laboratory
The British Museum

In a paper given at last year's conference at the Institute of Archaeology in London, one of us (PLM) described a graphics program implemented on a mini-computer which allowed two dimensional outlines of archaeological artefacts to be stored in a retrieval system, and to be reproduced on a graph plotter in a variety of formats (Main, 1981). The original data recorded consisted of two-dimensional coordinates taken in sequence around the outline. As reproduced on the plotter, the outlines are composed of smooth curves which interpolate these points, giving a high-quality outline of publication standard. An important feature of the program was the facility for defining a 'layout scheme' for a particular type of artefact, allowing a degree of standardisation of presentation within each artefact class.

With the increasing availability of relatively cheap computer equipment, we can look forward to the time when computerisation of much of the more laborious work for publication of excavation reports is the normal procedure. Given adequate on-site computerisation of information during excavation, software is already in existence to perform the following tasks of publication preparation (to varying degrees of perfection):

word-processing of the text of the report
production of finds catalogues
drawing and shading of trench sections (either from sketches or by photogrammetry)
production of site plans
production of artefact distribution plots

production of artefact outline drawings.

At present the main areas where the computer cannot compete are writing the report itself, and introducing decoration on to artefact outline drawings (this task must still be left to a professional illustrator), and photography. Photography is expensive and is therefore relatively scarce in excavation publications. A way of presenting a three-dimensional impression of an artefact on paper, particularly if it could place the observer in any position relative to the artefact, would be of interest. If it took up no more room on the paper than the original drawing it would be doubly attractive.

Discussion between the authors after last year's conference prompted us to collaborate in trying to extend the idea of computer-drawn two dimensional outlines to three dimensions. We choose the easiest possible case for initial trials, namely wheel-thrown pottery, which has rotational symmetry and thus requires no more data than has already been recorded for producing two dimensional outlines. One author (IOA) had software available which could be adapted to rotate a two-dimensional pot-section through 360 degrees to produce a solid pot, and to present it as a perspective pseudo-three-dimensional image, viewed from any angle. The other author had digitised data from medieval cooking-pot sections available. The experiments were carried out with the following objectives in mind :

1) In general terms to work towards producing a reasonably standard representation which would occupy little or no more space than the traditional two-dimensional pot-drawings which appear in excavation reports, but which would give a three-dimensional impression, including three dimensional blow-ups of the pot's rim, if desired.

2) In order to get the benefit of the three-dimensional effect, the pot would need to be viewed from slightly above.

3) We wanted to assess the effect of rotating the two-dimensional section through <u>less</u> than 360 degrees, in other words presenting the pot as if a wedge-shaped slice had been removed. Although this would incorporate a view of a section through the pot, this would be slightly distorted since the pot is

being viewed from above. Thus any standard presentation would also have to include a true section at right angles to the pot, as appears on the left hand side of traditional illustrations.

4) The area left blank for an artists impression of decoration, fabric etc. should be on the right hand section of the three-dimensional view. This would make the artist's task of producing a realistic effect less difficult, since he would be working on a pseudo three-dimensional surface.

5) Where an impression of fabric appears on a normal two-dimensional pot drawing, it has to be incorporated in some way into the illustration of the decoration, and this is rather unsatisfactory. On a three-dimensional view, it would be best if the section which appears on the right hand side were not blacked in, but left blank for an artists impression of the pot fabric.

The method for generating such designs is called 'body of revolution' or in the more general case 'body of rotation' (Angell, 1981). Basically, the section outline is defined as a sequence of n points in the x/y plane of 3-D space, $\{ (x_i,y_i,0) \mid 1 \leq i \leq n \}$. These points may be joined in order to form n-1 lines. This sequence may be rotated in turn about the vertical y-axis by m angles in the form $\{ \alpha_j = 2\pi j/m \mid 1 \leq j \leq m \}$, to form the vertices :-

$$\{ (x_i\cos\alpha_j, y_i, x_i\sin\alpha_j) \mid 1 \leq i \leq n \ , \ 1 \leq j \leq m \} .$$

Vertices are joined to their neighbours in the vertical and horizontal, to form a set of lines. These lines combine to form the boundaries of surface 'facets', which are necessarily quadrilateral or triangular.

The data concerning vertices, lines and facets may then be processed by a hidden line algorithm, in order to draw a perspective view of those lines defining the surface of the pot which are not obscured by opaque facets lying between the observer and lines. The values of n and m will naturally depend on the computer storage available.

Obviously, once the data has been generated then the observer can move to any position in space (specified by the (x,y,z) coordinates of the eye, which always looks toward the coordinate origin.

Figure 1 shows a reconstruction viewed from 'straight on', i.e. in the y=0

figure 1

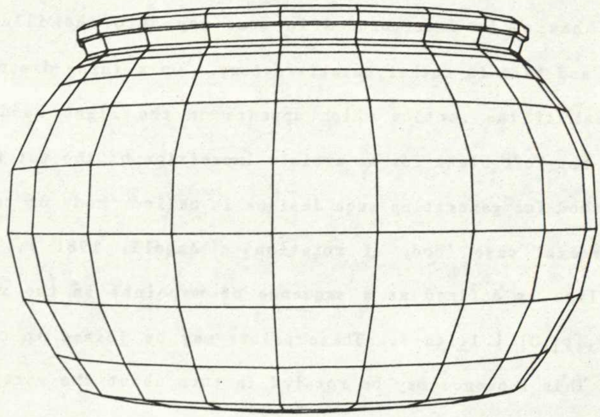


figure 2

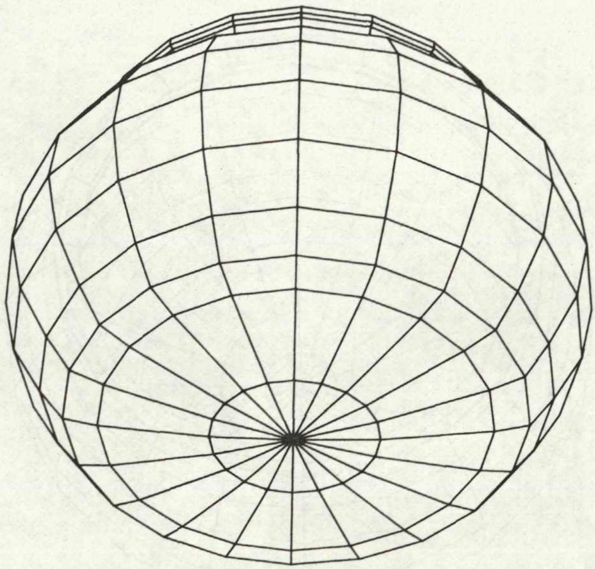
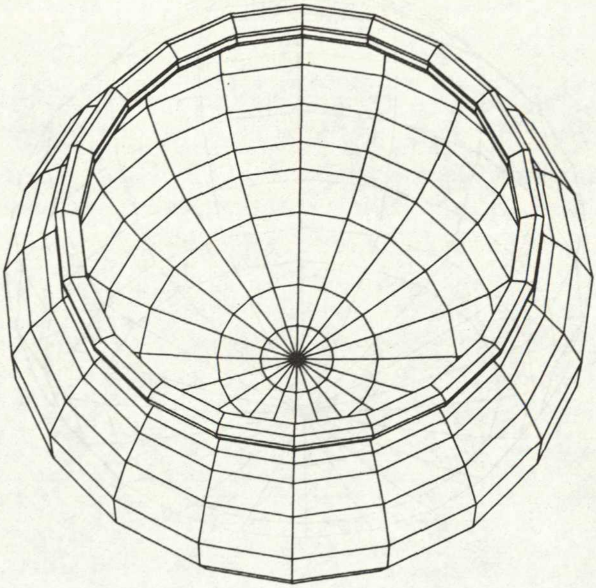


figure 3



plane. We can view from below to get Figure 2, or from high above as in Figure 3 (note the triangular facets which occur when one of the defining points lie on the axis of rotation). Figure 4 shows a view from slightly above.

We can also distinguish the rim of a pot if it has interesting features, and draw it separately as we do with another pot shown in Figure 5.

When viewing a complete pot, the 'inside' will naturally obscured, so we extend the concept of a 'body of rotation' by slicing out a wedge of about 90 degrees, as shown in Figure 6. The sections of the pot laid bare by such a slice may be shaded by hatching in the polygonal area with closely packed horizontal lines.

When required we can also blank out the lines which form the facets on the right of the figure so that an artist may add a surface design. If necessary we may also add a smoothed version of the pot section alongside the sliced 3-D view, Figure 7.

The obvious next step is to smooth out the polygonal surface, which is where colour graphics is useful. Unfortunately the necessary sophisticated colour devices are expensive, which is why we concentrate here on line drawings.

One of us (IOA) has produced such a hidden surface algorithm which also rounds and smooths the surface of the pot: suprisingly this program is simpler than the line drawing program. However we only have access to a display with 8 colours, so that it is impossible to implement the shading necessary for the smoothing. It is hoped that a suitable device will be available in the near future, and this latter program can be the topic of a future paper.

Angell, I.O., 1981 — 'A Practical Introduction to Computer Graphics'. Macmillan, London and Basingstoke.

Main, P.L., 1981 — 'SHU - an Interactive Graphics Program for the Storage, Retrieval and Analysis of Artefact Shapes'. Proc. 'Quantative Methods in Archaeology' Conference, CAA81.

figure 4

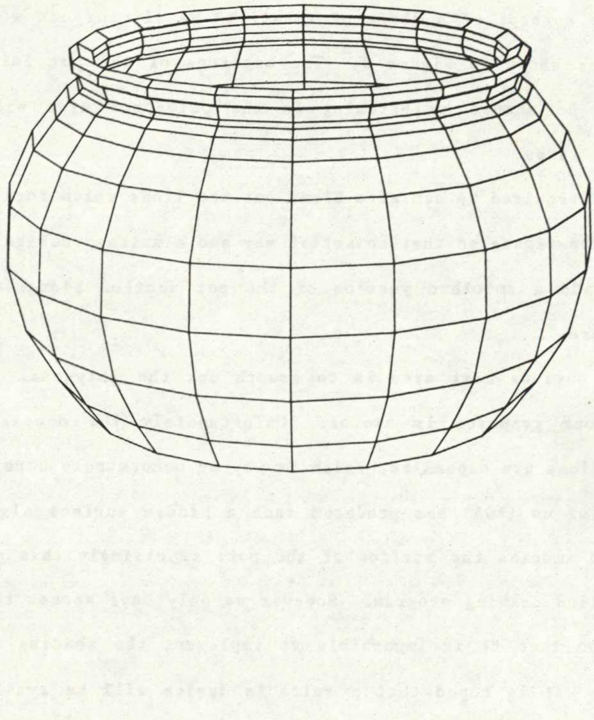


figure 5

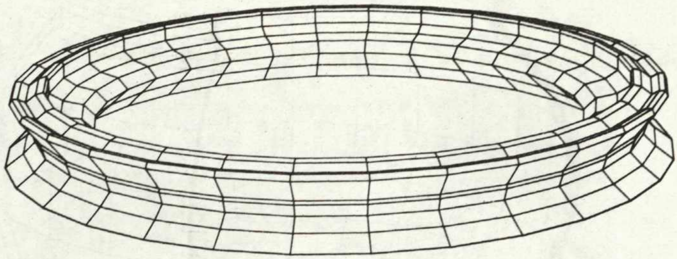
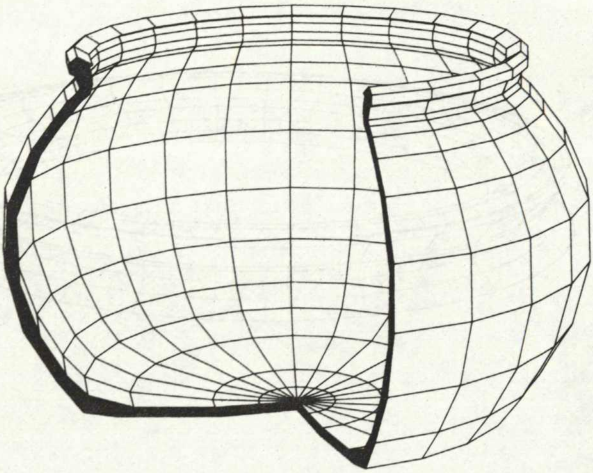


figure 6



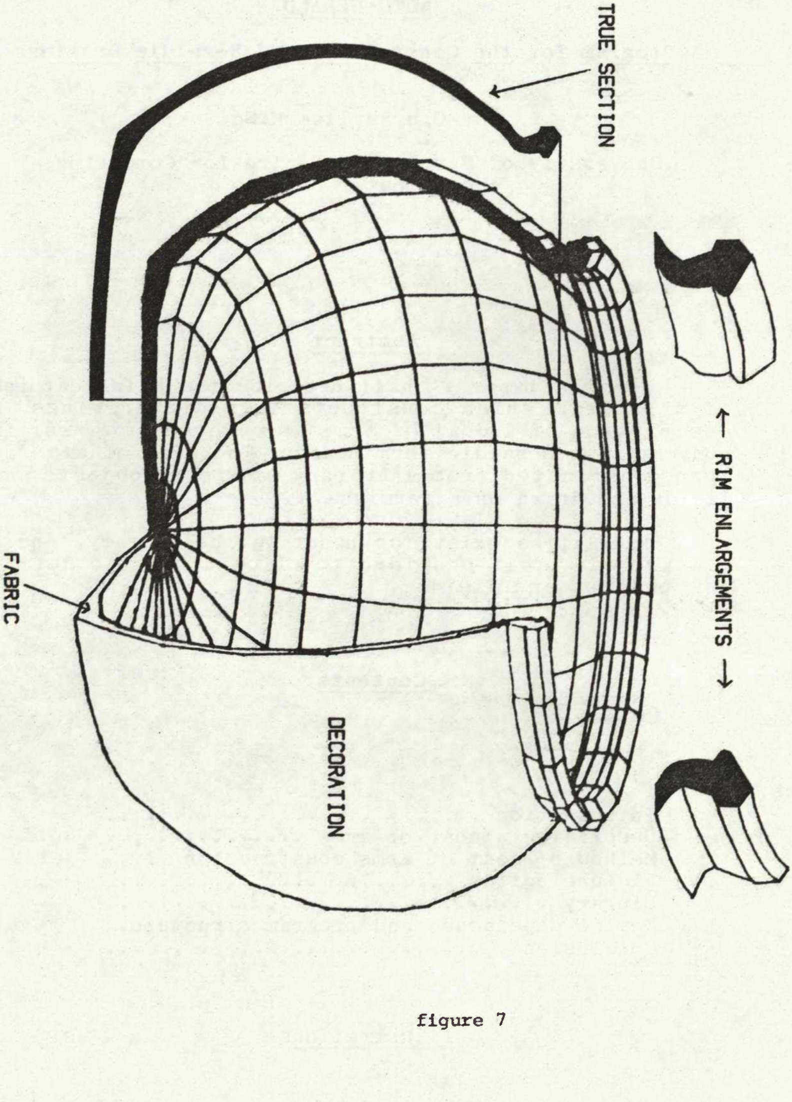


figure 7