29. Do-it-yourself reconstruction modelling

Gill Chapman
Division of Design, Sheffield City Polytechnic, Sheffield, U.K.

29.1 Introduction

A survey of the field of 3D computer visualisation for archaeology in the UK shows that most of it has taken place in specialist centres using very expensive mainframe computers and solid modelling software packages which required a substantial level of computing expertise on the part of the user (see Chapman 1990, Section A.4; also Reilly 1988). This is particularly true of the reconstruction modelling of vanished or partially destroyed buildings, and has meant that this kind of visualisation has so far been available only to archaeologists with contacts in such a centre. For example, the pioneering work done by Woodwark and Bowyer in Bath used a solid modelling package originally written for engineering (Woodwark & Bowyer 1986), and, more recently, a model of Furness Abbey has been built for Lancaster University Archaeological Unit using software normally used for plant design (Delooze & Wood 1991).

Until recently the cost of computer power and memory has made this kind of graphical work beyond the reach of ordinary archaeological units in any case — but recently costs have been coming down rapidly and are still falling. It is my belief that the time has now arrived when such work should be possible for units dealing with big projects, and software is now sufficiently 'user friendly' for archaeologists to use without too much difficulty. An investigation of the possibilities in this area was undertaken for the Lancaster University Archaeological Unit (LUAU), together with a specific reconstruction project (Chapman 1990).

For the purposes of this paper the results of the project, the modelling of a Hoffman Limekiln at Langcliffe near Settle (North Yorkshire, UK), are examined first. This illustrates the kind of results which can be achieved using software and hardware comparable to what might be available to archaeological units of fairly modest means (For more detail of the Langcliffe model and comparative material see Wood & Chapman forthcoming). Strategy is then considered for archaeological units wishing to embark upon do-it-yourself 3D modelling, particularly the criteria to be born in mind when choosing software (see also Chapman 1991).

29.2 The model of a Hoffman Kiln

In 1873, the Craven Lime Company built one of the largest examples of a Hoffman Limekiln at Langcliffe near Settle. The surviving base of this structure was the subject of a detailed survey by LUAU (Trueman *et al.* 1989) and a computer model was generated from this data in the form of plans and sections. The opportunity to generate such a model held several potential uses to the archaeologists. The project brief was to record and interpret the Langcliffe site with particular emphasis on the history and mode of operation of the Hoffman kiln.

It was envisaged that a computer model would be a considerable aid to visualising both the form and function of the kiln and would also provide a means of testing the validity of interpretations made regarding these.

The software used for the model of the limekiln, built by Gill Chapman, was a 3D surface modeller called CGAL, written at Teesside Polytechnic by Peter Comninos, and running on Apollo workstations. Although comparable in results to software now widely available it is by no means ideal. The construction process and its problems are described in some detail, some of the difficulties being due to the particular software, others being common to all surface modellers or to computer modelling in general. The description 'surface modeller' means that CGAL holds the information about the model in the computer in terms of its surfaces and not in terms of the volumes which they enclose. In general, this is a cheaper way of holding the information than that used by solid modellers.

The starting point for an object in a surface model is one or more 2D shapes, or polygons. These can be put into the computer in a variety of ways; in this example *x* and *y* coordinates were taken from plans and sections and fed in via the keyboard. Once the 2D shapes are complete, the software can manipulate them in a variety of ways to form 3D objects. For example, a simplified kiln base was formed from two polygons, one the cross-section of the base and the other the path taken by the outside edge of the kiln viewed in plan (see Fig. 29.1). CGAL 'swept' the cross-section around the path to form the basic 3D shape. The simplified model was completed by the addition of other objects — for example the chimney, formed by 'lofting' a large square polygon and a smaller one together; roof posts made by 'extruding' single polygons; and the roof itself, another sweep (Fig. 29.2).

This simplified model was quick and easy to produce, and would have been quite useful as it stood. The creation of a fully detailed model was much more problematic, mainly because a surface modeller is unable to 'cut holes' in an object after it is made. The kiln base is tunnelled into frequently, both by entrances and by flues, so it had to be built up from several different segments, like building blocks. For example, Fig. 29.3 shows a tunnel entrance (a loft) and the segment which was created to fit over the tunnel. This was made using a 'skinning' process which created a surface over several different polygons representing sections through the block. In all, eight different blocks were created, then each one had to be copied many times and positioned accurately. The detailed model of the kiln base would have been much easier using a solid modeller even though creating the initial kiln shape would have been more difficult.

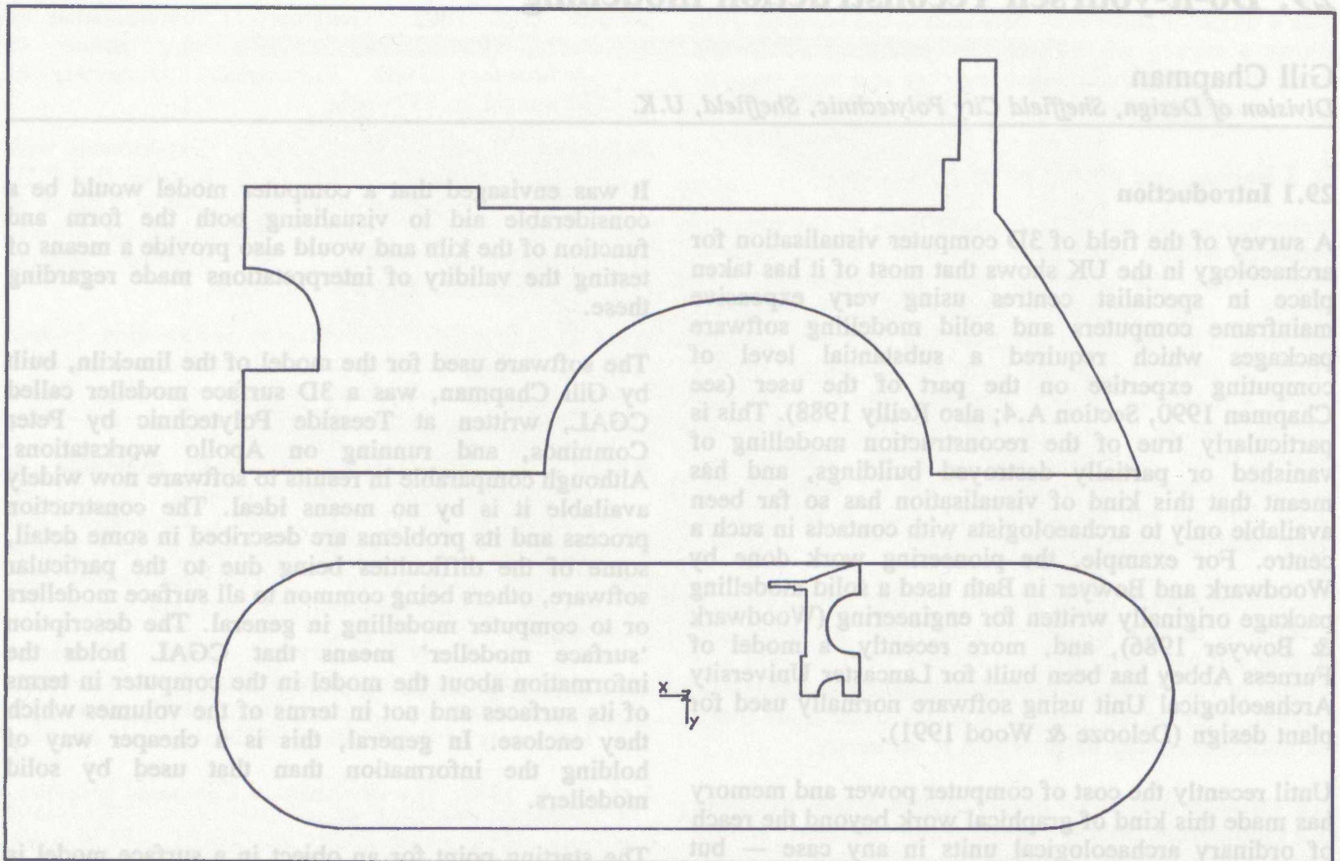


Figure 29.1: Cross-section and path for kiln base.

Once built the model can be coloured and lit quite effectively. This is usually one of the strengths of a surface modeller, and CGAL is no exception, although now surpassed by newer software. This is particularly true in the area of ease of use — CGAL is not very interactive and the desired results take a lot of trial and error. Features such as transparency and a variety of 3D textures are available. Presentation views can be enhanced by hand or with a computer painting package, making them both more attractive and more realistic (Fig. 29.4). This is not 'cheating', but a sensible use of different techniques for different purposes. Animations can be produced to 'walk-through' the building or, perhaps most useful of all, to illustrate working practices. Animations to illustrate air-flow through the kiln (Fig. 29.5) and the movement of materials around it are still being worked on.

29.3 Criteria for do-it-yourself modelling

Archaeologists such as those at LUAU who wish to embark on computer modelling themselves are faced with a bewildering choice. This choice is restricted by various factors, one of which is, of course, the available budget. This primarily determines the kind of hardware which can be considered, which in turn restricts the choice of software. A sensible starting point for many units would be a top-level PC or an entry-level workstation and since this also suited LUAU's finances, it was decided to examine software which would run on this hardware platform. The next essential step was to analyse the desired results carefully. For example, if the priority is for attractive views of the reconstructed building for general public display, a surface modeller with similar capabilities to CGAL is ideal. If the aim is more scientific, requiring finite element analysis for example, or various kinds of simulation, then a solid modeller is required — but these need more powerful hardware and are in general more difficult to use. The ideal is a software package which combines the advantages of both and these are now becoming available.

There are other important criteria as well, and these will of course vary with the particular needs of individual units. For example, very few archaeologists are computer specialists, so any software chosen should be reasonably 'user-friendly'. There is some dispute between 'professional' computer users who tend to prefer to type their commands in at the keyboard and those who find a system of menu choices picked with a mouse easier to comprehend. These systems are known as WIMPS, because they use windows, icons, mice and pull-down menus. On the whole, a WIMPS system is easier initially for new users, but this is not a hard and fast rule. Either way, it is important that there should be a clear system of prompts, a logical way to put commands together, a good 'help' system and clear documentation.

Another important consideration is the ease and variety of data input and output. Many archaeologists would like to use data which has been collected electronically — by an EDM or via photogrammetry, or fed into a database on site — directly for modelling. Research suggests that the current state of software combined with present practices in data collection makes this generally impractical at present (e.g. Billington 1989), and data will normally be input from plans and sections or via the keyboard. However, 3D computer

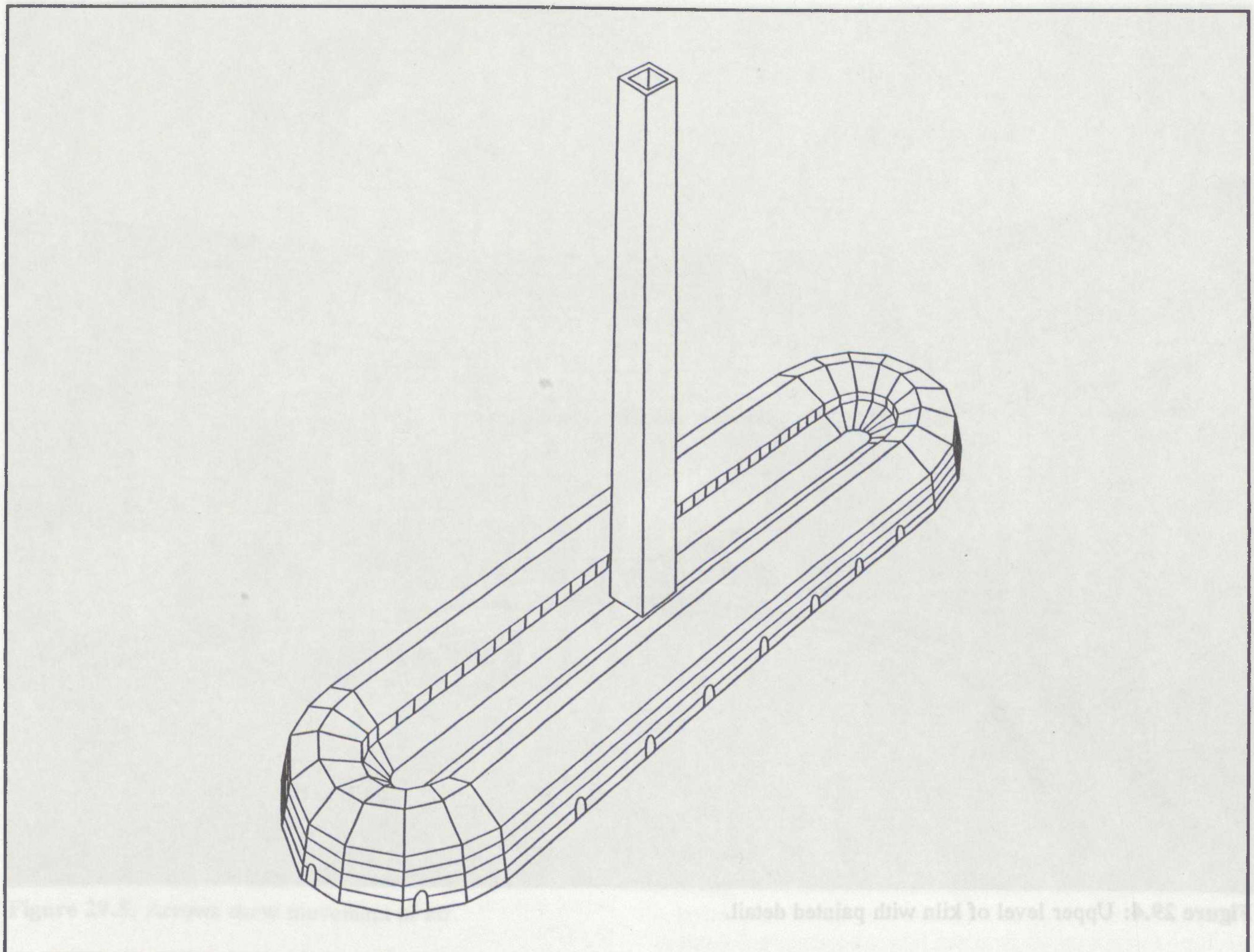
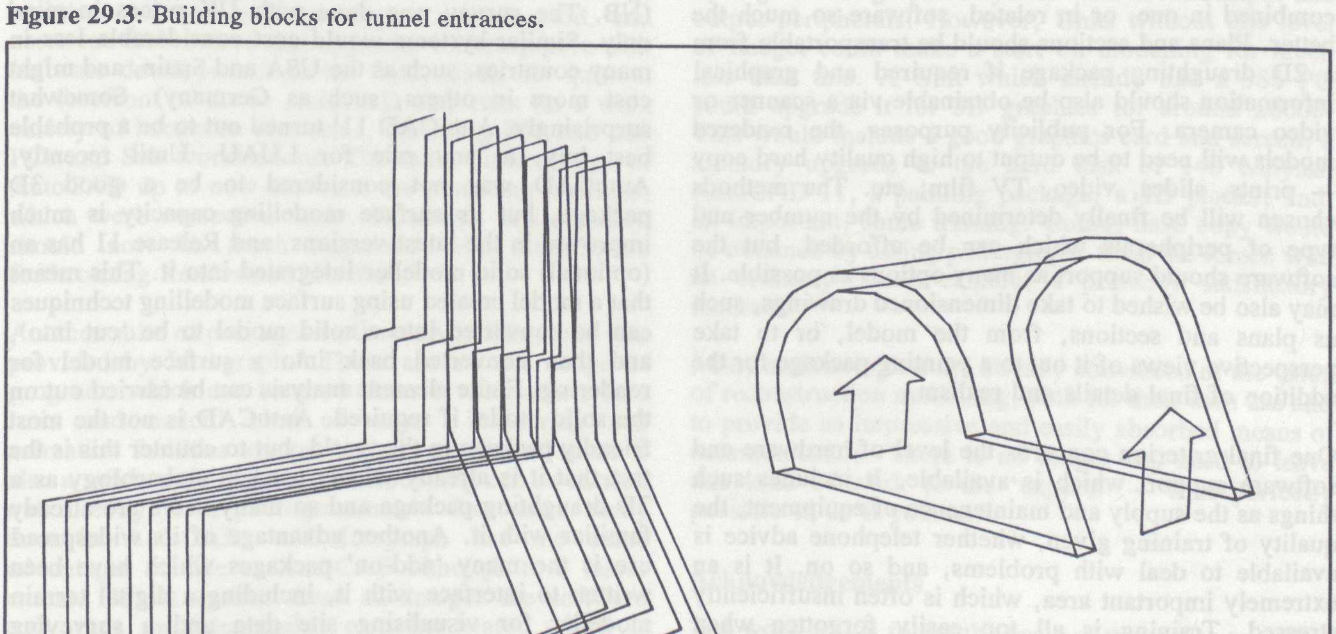


Figure 29.2: Completed simple kiln model.

Figure 29.3: Building blocks for tunnel entrances.



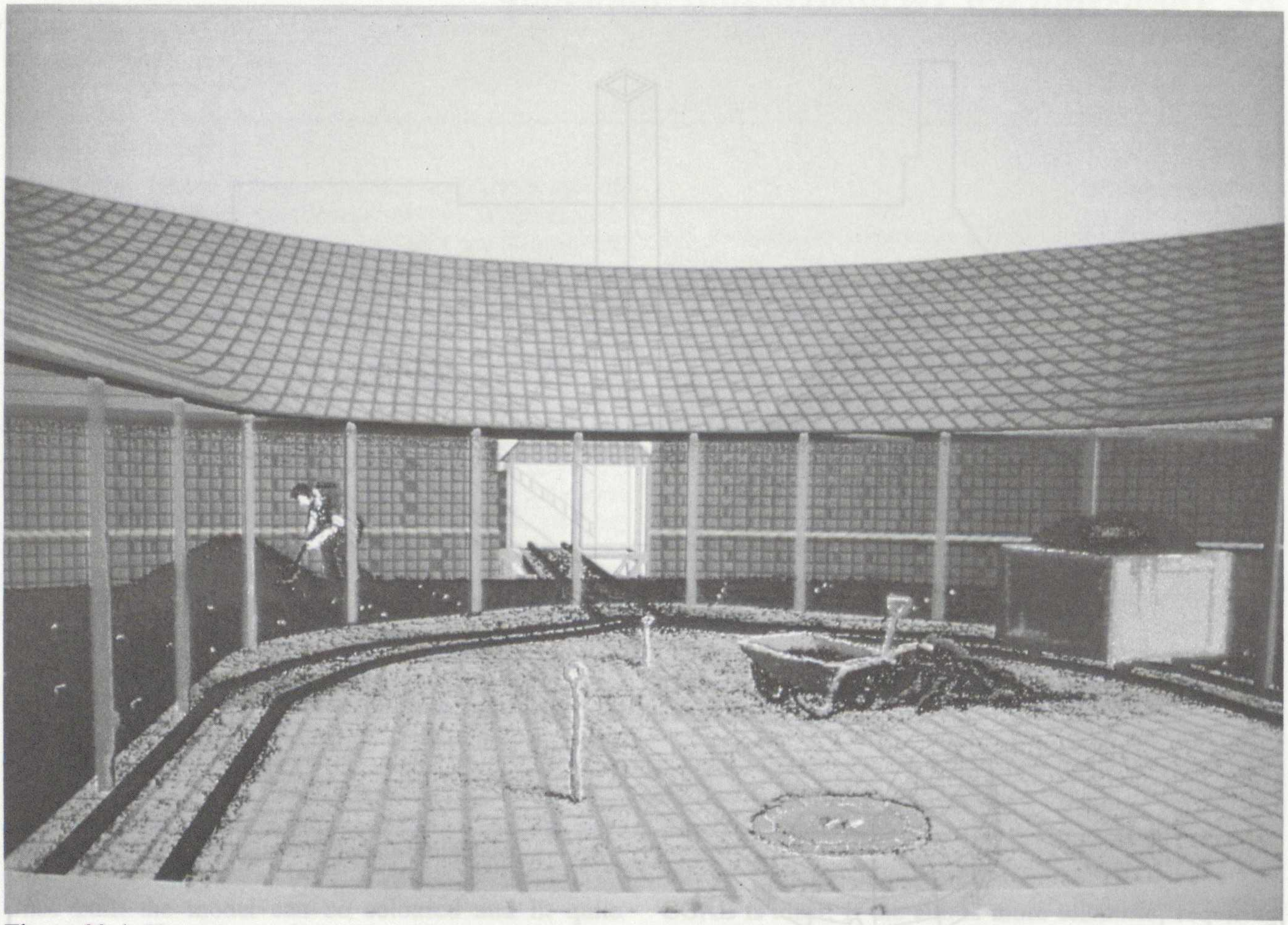


Figure 29.4: Upper level of kiln with painted detail.

visualisation of site data is another growth area in archaeology, and if these two activities can be combined in one, or in related, software so much the better. Plans and sections should be transportable from a 2D draughting package if required and graphical information should also be obtainable via a scanner or video camera. For publicity purposes, the rendered models will need to be output to high quality hard copy — prints, slides, video, TV film, etc. The methods chosen will be finally determined by the number and type of peripherals which can be afforded, but the software should support as many options as possible. It may also be wished to take dimensioned drawings, such as plans and sections, from the model, or to take perspective views of it out to a painting package for the addition of final details and realism.

One final criterion concerns the level of hardware and software support which is available. It includes such things as the supply and maintenance of equipment, the quality of training given, whether telephone advice is available to deal with problems, and so on. It is an extremely important area, which is often insufficiently stressed. Training is all too easily forgotten when budgeting — it can easily cost more than the software itself.

A survey of available software was done bearing these criteria in mind and with an initial budget of £30,000. (NB. The survey was done with UK prices in mind only. Similar systems would cost considerable less in many countries, such as the USA and Spain, and might cost more in others, such as Germany). Somewhat surprisingly, AutoCAD 11[1] turned out to be a probable best buy, at any rate for LUAU. Until recently, AutoCAD was not considered to be a good 3D package, but its surface modelling capacity is much improved in the latest versions, and Release 11 has an (optional) solid modeller integrated into it. This means that a model created using surface modelling techniques can be converted into a solid model to be 'cut into', and then converted back into a surface model for rendering. Finite element analysis can be carried out on the solid model if required. AutoCAD is not the most friendly package in the world, but to counter this is the fact that it is already widely used in archaeology as a 2D draughting package and so many users are already familiar with it. Another advantage of its widespread use is the many 'add-on' packages which have been written to interface with it, including a digital terrain modeller for visualising site data and a surveying package.[2] AutoCAD's file format, DXF, has become an industry standard, so that data transfer to and from other packages is as problem-free as it ever is (although

1. AutoCAD 11 from Autodesk Ltd, Cross Lanes, Guildford, Surrey.
2. Supplied by DCA Engineering. Many other add-on packages for AutoCAD are featured in CAD User, the AutoCAD user's journal.

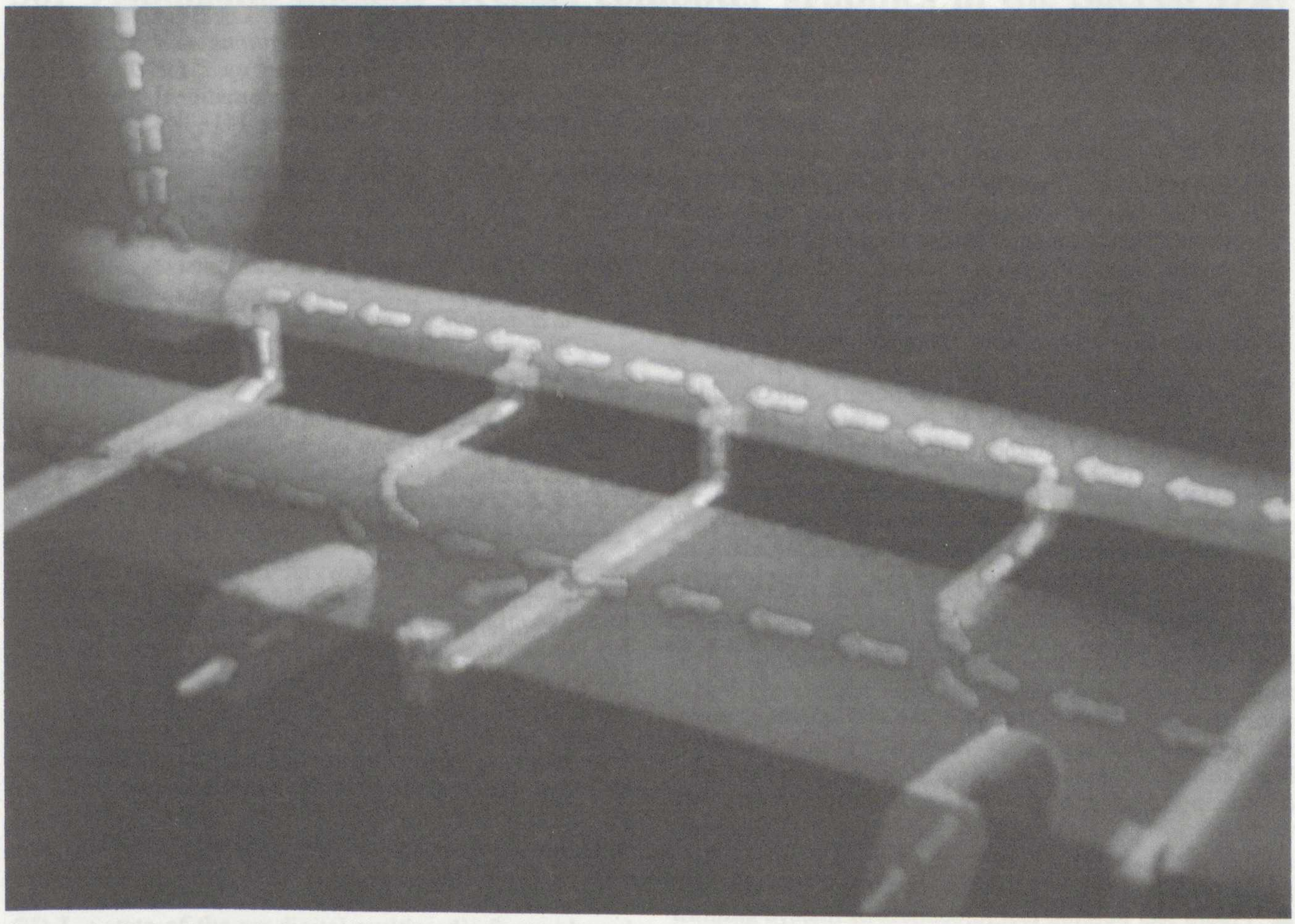


Figure 29.5: Arrows show movement of air.

still not perfect). Exchange of information with other users will also be widely available. Training, maintenance, and back-up support are all good, and users can feel assured that upgrades will keep pace with software developments in the field, albeit not quite at the forefront of them. AutoCAD also runs on a wide variety of hardware platforms, including 386 and 486 PCs and Sun workstations. The main disadvantage of AutoCAD up to now has been the rendering facilities, which were somewhat basic. However, this situation should now be much improved with AutoDesk's forthcoming Renderman interface.[3]

Another suite of packages well worth looking at is that provided by Intergraph.[4] There are a wide range of programs which can be used alone or with others in a 'mix and match' kind of way. Rendering and animation facilities are particularly good, and there is also a solid modelling option. Modelling can be carried out directly from photogrammetric data more easily than in AutoCAD, and Integraph has the same advantages of size as AutoCAD although to a lesser extent. To set against these advantages the software only runs on Intergraph's own hardware, which is considered to be overpriced by some, and maintenance and support has come in for some criticism.

For £30,000 an archaeological unit in the UK can set up a good 3D graphics system with several input and output peripherals. However, Units without this level of budget could make a start on modelling for much less than this. A Unit which already had a 386 PC could upgrade it for 3D graphics for around £6000. This would include a good graphics card and screen, a memory upgrade to the hard disk of 140 Mbytes, AutoCAD 11, a painting package, a 3D plotter, and, all-important, some training. Colour hard copy would be obtained by taking photographs from the screen with an ordinary 35mm camera, a perfectly satisfactory method.

Many archaeologists are already convinced of the value of reconstruction modelling, both for their own use and to provide an impressive and easily absorbed means of communication. There is no longer any need to leave this kind of work to the 'experts' — it is perfectly possible to do it yourself!

Acknowledgements

The work which forms the basis of this paper could not have been done without the help and encouragement of many people. I am particularly grateful for the collaboration of LUAU in the persons of Jason Wood

3. Since this paper was delivered this has become a reality with Autodesk's 3D Studio, a modelling, rendering and animation package which can be used alone or take AutoCAD files.

4. Intergraph UK Ltd, Delta Business Park, Great Western Way, Swindon, Wiltshire.

and Michael Trueman, and to my MSc supervisors at Teesside Polytechnic, Janice Webster and Sophie Forgan.

References

BILLINGTON, A. 1989. *The representation of archaeological data by 3D modelling techniques*, unpublished Computer Aided Graphical Technology Applications MSc thesis, School of Computing and Mathematics, Teeside Polytechnic.

CHAPMAN, G. 1990. *3D computer visualisation of archaeological data, with particular reference to reconstruction modelling*, Computer Aided Graphical Technology Applications MSc thesis, School of Computing and Mathematics, Teesside Polytechnic.

CHAPMAN, G. 1991. "Surface modelling and proprietary software for building reconstruction", *Archaeological Computing Newsletter*, **27**: 3–11.

DELOOZE, K. & J. WOOD 1991. "Furness Abbey survey project — the application of computer graphics and data visualisation to reconstruction modelling of an historic monument", in K. Lockyear & S. Rahtz (eds.), *Computer Applications and Quantitative Methods in Archaeology 1990*, British Archaeological Reports (International Series) **565**, Oxford, Tempus Reparatum: 141–148.

REILLY, P. 1988. "Recent advances in the applications of graphics systems to archaeology", *IBM UKSC Report*, **185**.

TRUEMAN, M., S. ISAAC & J. QUATERMAINE 1989. *The Langcliffe Quarry Limeworks, Settle: an archaeological survey of the site and Hoffman Limekiln*, Lancaster: Lancaster University Archaeological Unit.

WOOD, J. & G. CHAPMAN forthcoming. "3D computer visualisation of historic buildings — with particular reference to reconstruction modelling", in P. Reilly & S. Rahtz (eds.), *Archaeology in the Information Age*, London, Unwin Hyman.

WOODWARK, J. & A. BOWYER 1986. "Better and faster pictures from solid models", *Computer Aided Engineering Journal*, Feb 1986.