47 Experiments with user–friendly volume visualisation and iconographic display methods to explore core data

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47.1 INTRODUCTION

Massive, and still larger, multidimensional data sets are now a fact of modern archaeology. Whether the data are derived from numerical simulations or, more likely, from measurements made during fieldwork, the problem of extracting knowledge from the data is frequently a greater challenge than its generation or acquisition. Like workers in many other disciplines, some archaeologists have turned to visualisation as a means of extracting meaning hidden within the masses of data they have gathered. Visualisation is the exploration of data through the use of displayable geometric objects; comprehending and gaining insights into that which is ordinarily incomprehensible through the use of interactive graphics and imaging. The crucial stage between data and rendering for visualisation is *realisation*: describing how the data should be represented in terms of boundaries, surfaces and their properties (e.g. colour, opacity, specularity, etc.), and other graphical, image and geometric characteristics. In short it is the means to visualisation.

The notion of visualisation is hardly new, and many examples of its application are documented in the annals of history (see Collins 1992). The appeal of presenting information visually is hardly surprising since over half the neurones in the human brain are given over to the cognitive power of the vision system.

For a number of years a few archaeologists have eagerly adopted computerised methods which in some sense allow them to *look at* phenomena which are *unseeable* in the earthy reality from which the data was derived. Unfortunately, for many archaeologists access to the many techniques that have been developed has been restricted for a variety of reasons. Typically the set of functions needed to deal with an archaeological problem could not be found in a single integrated environment. Instead, several packages would have to be acquired and special data filters and translators built in order to export and import data between systems. More frustratingly, some methods were implemented on specialist and comparatively rare (at least in archaeological circles) graphics hardware. In addition, the software was often what might be termed, euphemistically, esoteric. So even if systems were available, there could still be an understandable reluctance to gamble time and resources on unsupported and perhaps unstable software. Idiosyncrasies in terms of both function and the human–computer interface often feature in the most advanced technological methods, since they will frequently be developed with very specific research problems in mind. The researchers developing these systems are not too interested in spending a lot of time on the interface and concentrate on the function needed to satisfy their problem. Such systems are far removed from supported commercial products which are shaped by the requirements (and refining capacity) of a large user base. It is hardly surprising therefore, that with restricted access and non–standard systems and interfaces visualisation has tended to be perceived as a black art.

In this archaeology is not unique. Many other disciplines readily appreciated the potential of vision–based exploration of large high–dimensional data sets, and numerous techniques which reveal new facets of data, or enable new lines of enquiry, through the visual stimuli of graphically presented information, have been discovered. The net result was that many techniques have been developed in isolation in a variety of disparate disciplines, using different software, hardware and human–computer interaction standards. So, while many useful methods have been abroad in the scientific world for some time, it has been difficult for the archaeological community at large to evaluate their utility, because they were not implemented in a common or easy–to–understand environment. This community of *data explorers* remained, if not unnoticed, largely uncatered for by the commercial computer graphics industry until a few years ago.

Computerised archaeological illustration and reconstruction has not been so poorly serviced, although even here the available systems have not been widely used until recently. During the past 15 years or so, many computer vendors focused graphics research and development efforts on supporting the CAD (Computer–Aided Design) industry. Thus, the markedly improved speeds with which vectors and polygons can be displayed on a monitor was brought about, in no small part, by the requirements for the fast display of complex two–dimensional drawings and three–dimensional wire–frames. Archaeologists have benefited from this trend and there is now a well–established body of accomplished archaeological users of CAD systems (e.g. Wood *et al.* 1992, Duriat *et al.* 1990), with their own special interest groups (e.g. *CAD User Group of the Institute of Field Archaeologists*) and publications (e.g. *CSA — Newsletter of the Centre for the Study of Architecture*) indicating the level of professionalism in the field. Only within the last five or six years have an appreciable number of vendors elected to integrate specialised graphic functions into their hardware, particularly in the workstations arena, to support applications with new requirements. Obviously, the large CAD community is not being abandoned. Their needs are now being augmented by those of other important markets. For example, rendering systems have been driven by the broadcasting and entertainment industry as well as by industrial designers. This has resulted in a whole host of products: *Alias Animator*™, *Alias Designer*™, *Alias PowerAnimator*™ and *Alias Upfront*™ from Alias Research Inc., the *Advanced Visualizer*™ from Wavefront Technologies Inc. and *TDImage*™ from Thompson Digital Image Inc. are some of the best known. Many of these products are used with commercial CAD packages such as Autodesk Inc.'s *AUTOCAD*™, Dassault Systèmes' *CATIA*™. and *CADAM*™ from CADAM Inc., to name but three examples.

Perhaps the most notable development in the industry over the last few years as far as the archaeological community is concerned is the appearance of software vendors producing and marketing packages which attempt to convert data, from a host of disparate sources, into pictures on a monitor. Pure, natural, earth and life sciences have all exerted considerable influence on the genesis of these data visualisation offerings. The most sophisticated systems attempt to enable free interaction and dynamic modification of large, complex (i.e. multidimensional, multi-parameter, time–sequenced) data sets. This has been made possible through new, and more powerful, processors and new computing paradigms such as parallel processing. The appearance of powerful workstations has brought such systems within the budgets of many more organisations. The number of products competing in the advanced visualisation market is not small and is growing rapidly. Amongst the best known systems currently available are: Ohio State University's *apE*™, AVS Inc.'s *AVS*™, IBM Corp.'s *Data Explorer*™ (DX), Wavefront Technologies Inc.'s *Data Visualizer*™. Silicon Graphics Inc.'s *IRIS Explorer*™, Precision Visuals Inc.'s *PV–WAVE*™. and Vital Images Inc.'s *VoxelView*™. Each provide rafts of data visualisation functions for the researcher adrift in a sea of high–dimensional data.

Enlightened vendors realised that most of their users are not computer hackers but scientists interested in data and problems related to their own disciplines and fields of research. Researchers often care little about the niceties of computer scientists, but they do care about the power and transparency of the solutions provided. Now, not only is considerable effort put into providing user–friendly mechanisms for exploring the meaning of data graphically (i.e. to enable visualisation), finding ways of simplifying the process of turning data into displayable objects (i.e. realisation) happily is a topic receiving growing attention.

47.1.1 Improving user interfaces: visual programming environments

The development of integrated computer tools, specifically designed to convert primary data into visual objects to enable exploration and stimulate insight, is only a partial solution as far as archaeological researchers are concerned. A key aspect of user acceptance in the archaeological community is that the *skill level* — in terms of programming ability — required to realise complex data transformations for visualisation purposes, is being reduced rapidly by means of visual programming interfaces (e.g. Shu 1989). The so–called visual programming paradigm offers considerable power over the flow of control and functionality within

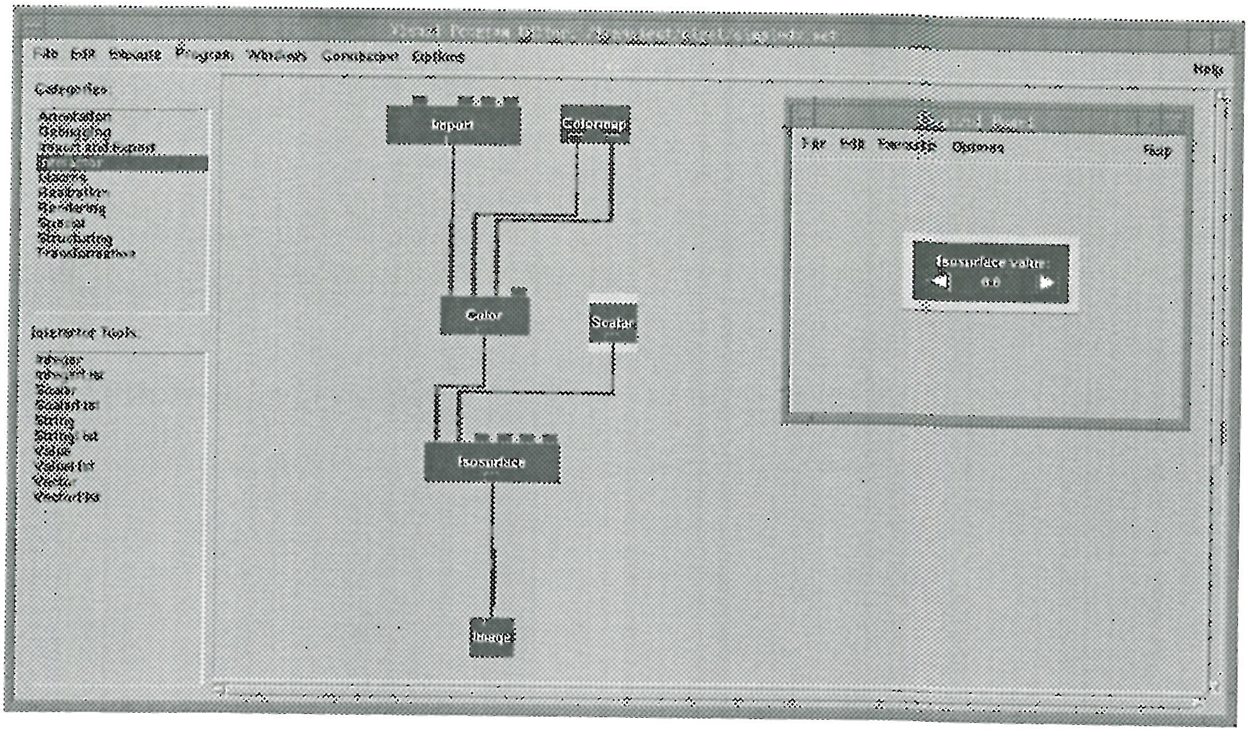


Figure 47.1: A simple visual program.

an application, especially in data exploration projects. Today, a small number of very powerful, but easy–to–use, functions enable the serious data explorer to import and export, annotate, realise, render, interact with, transform and probe his or her data. The archaeological investigator is thereby freed to spend more of the available time investigating or refining the data, rather than handling the intricacies of graphics programming.

47.2 THE RESEARCH VEHICLE (DX)

The research vehicle used by the writers is IBM *Data Explorer*™., also known as "DX". DX, requiring no special graphics hardware other than an 8–bit adaptor, runs on the IBM Risc System/6000™, and several other manufacturer workstations, including Hewlett–Packard, Silicon Graphics and Sun, as well as the IBM POWER *Visualisation System*™. The developers of this product — a team from IBM's Research Division — designed this system specifically to encourage innovative exploration of large data sets by using non–traditional types of visualisation functions. It embodies a very powerful and flexible data model (Haber, Lucas & Collins 1991). Specifically, DX enables the human data explorer to accomplish five fundamental tasks: put data into suitable forms for viewing; sequence (or animate) data to explore changes in both spatial and temporal dimensions; view the data from any position as a whole or partitioned (slices etc.); compare or correlate multiple data sets and explore them in a wide variety of ways *simultaneously*; and manipulate or transform the data mathematically to aid analysis.

DX provides three levels of interaction with the system: a user–interface, a scripting language and an application programming interface (API). DX puts a wide range of realisation functions at the user's disposal to use in an enormous variety of meaningful combinations. These can be selected and incorporated into a programming using the script language or by building networks or visual programs (e.g. Figure 47.1, Figure 47.2 and Figure 47.4.). Macros created by the user or provided with the system are also available. The so–called "power" user can also use the API to create new add–on functional modules (or tools) in C or FORTRAN.

Undoubtedly, it is the visual programming mode of interaction which is probably the most significant feature for the would–be archaeological data explorer. The tools (i.e. subroutine or co–routine) are grouped into functionally related categories (e.g. annotation, debugging, import/export, interactors, macros, realisation, rendering, transformation, structuring, etc.). The user first selects the category then the required tool by click-

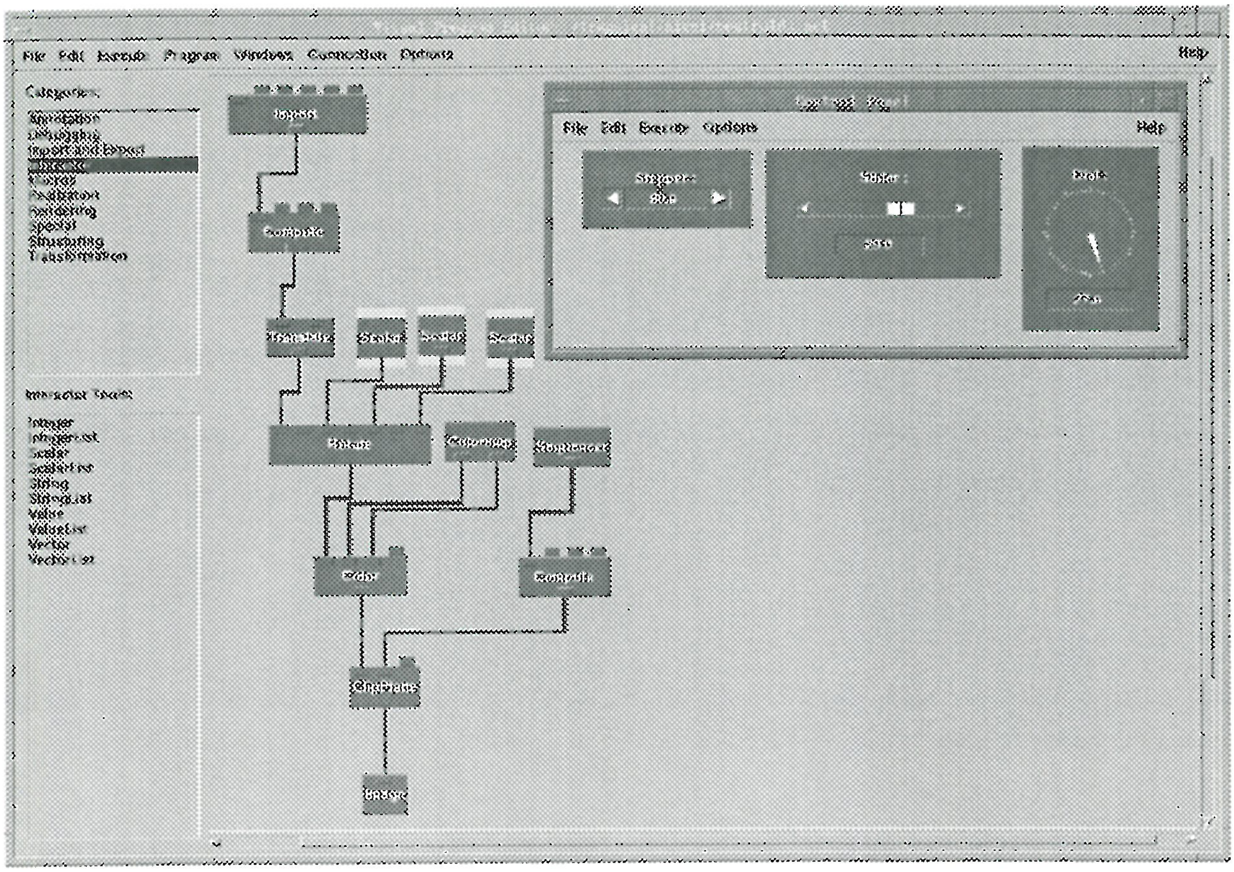


Figure 47.2: Refining the user's control through a scalar tool (stepper, slider and dial).

ing on the appropriate entries in the tools menus; the chosen module is placed in the visual program window ("canvas"). Each tool is represented on the canvas by an oblong icon with a number of square tabs running along its top and bottom edges (Figure 47.1). The tabs on the top edge represent possible inputs, the tabs on the bottom indicate outputs from the module. By clicking on an output tab a line indicating the flow of data can be dragged and connected to the inputs of another module. The system contains some intelligence: legal input tabs will light–up when the output connection is dragged nearby; once connected the tabs are folded into the main icon; the system now controls the flow of data automatically.

A simple program might consist of the following: read a data set, define 3D isosurface(s) through the data, apply a colour code, and display the picture. The casual programmer selects the modules needed to perform the task from the menu list (i.e. the "import" module from the "import/export" menu, the "colourmap" module from the "special" menu, the "colour" module from the "transformation" menu, the "isosurface" module from the "realisation" menu, and "display" from the "render" menu) and places them on the canvas, connecting the output and input tabs as shown in Figure 47.1. Double clicking on the import tool will open up an input panel. The user needs only to enter the name of the data file in the appropriate field and close the panel. Now, clicking on "execute" will cause the program to run. Without an explicit input (which can be entered by opening the panels for each module) the system will allocate default values to the display window size, the camera attributes, the viewing angle, the type of rendering required, the contour range to be contoured, etc.). The user can override the default values by typing into the relevant module panels, or by activating "interactors" which allow the user to dynamically interact with the data. Two forms of interactors are supported: direct and indirect. Direct interaction is controlled from the display window. Zooming, panning, rotations are enabled through pull–down menus and using the mouse to turn a 3D cursor or move the centre of viewing to a new location for instance. Indirect interaction is possible through control panels made up of dials, sliders and steppers. These are easy to create and use. In the above example, if the researcher wanted to dynamically change the value of the isosurface to be

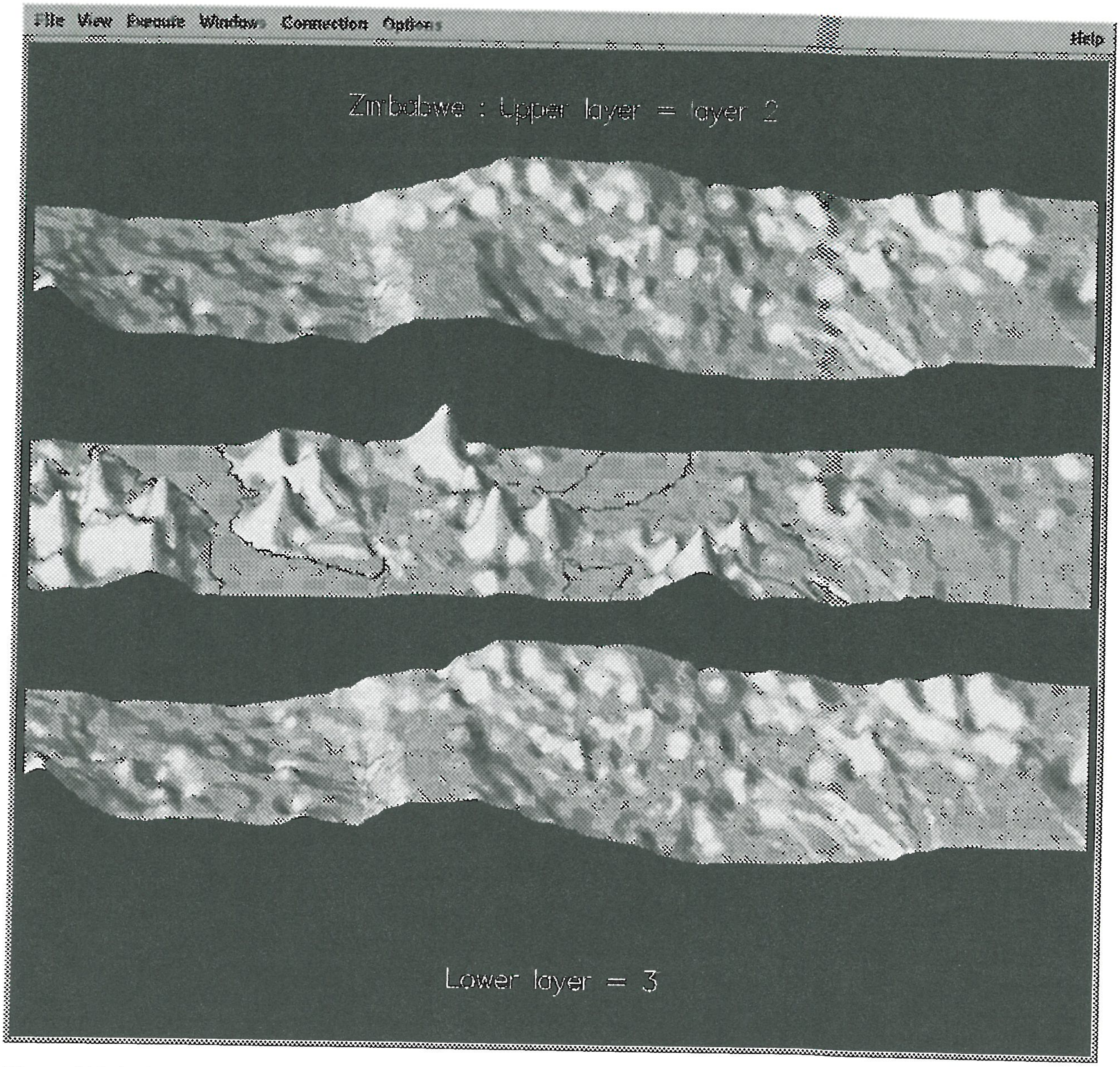


Figure 47.3: Isolating the differences between adjcent Rockware–modelled layers in Great Zimbabwe Data

displayed this is achieved by attaching a "scalar" tool to the isosurface tool (see Figure 47.1). Other indirect interactors include the slider and the dial (e.g. Figure 47.2). By clicking on the "windows" option on the canvas a panel will appear with a stepper. The value to be contoured can be typed–in or increased or decreased by clicking on the greater than or less than arrows respectively. Clicking on "execute" again will cause the program to recalculate and display the newly defined object. Researchers can use the visual programming editor to create new scenarios on the fly by simply using the mouse to connect boxes on the screen in any logical order and executing them (Figure 47.4).

The visual programming environment sketched above has been central to a number of recent experiments investigating archaeological deposits through drilled data (i.e. using augers and micro–cores). The following sections describe two series of data exploration experiments performed in this environment.

47.3 VISUALISING MICRO–CORED DATA FROM GREAT ZIMBABWE

Sinclair *et al.* (1992:32) have described how, in the *Urban Origins of East Africa Project* (UOEA), they have pursued a trend away from total excavation

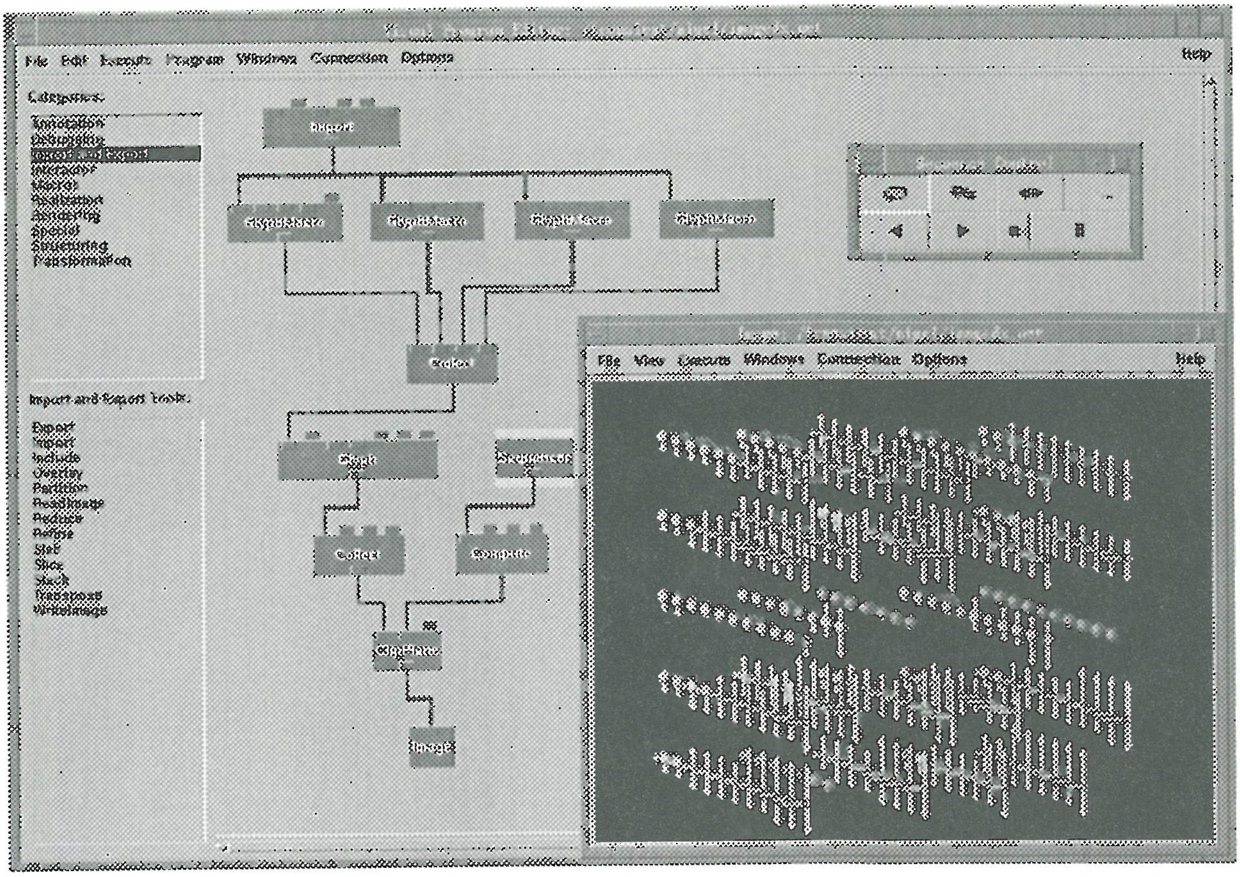


Figure 47.4: A frame from an animation with control panels

by down–sizing the scale of excavation while increasing the spatial coverage of archaeological investigations in nine east African countries through random sampling procedures and the use of micro–coring. The focus of this work is away from the better known — and more archaeologically visible — towns, characterised by stone architecture, towards bringing the more extensive mud–built quarters (between 3 and 700 hectares in area) within the UOEA's analytical frame of reference. Defining the extent of these *sites* and their internal stratigraphy is regarded as being a key element in the understanding of urban growth in eastern Africa (ibid:34–35).

At Great Zimbabwe a research programme involving the coring of an approximately two–kilometre strip through the site was undertaken. Correlating the results of some 200 cores, using the Rockware set of programs, Sinclair *et al.* (ibid.) generated regular grids of points describing the surface of six stratigraphic units within an area of twenty hectares (ibid:35–36). The resulting data set was given to the writers in order to investigate whether visualisation of the data could reveal potentially interesting features for further examination.

The data were presented to the writers as six files on a floppy disk which were each converted into DX format using a powerful data conversion utility developed by Nigel Thompson, and called *Cartographer.* The first experiment was to apply the "rubbersheet" tool to fit a surface to the data and thereby create a series of terrain maps which were initially examined in isolation. It was immediately apparent that because there were orders of magnitude of difference in the scales of measurement used in the horizontal and vertical dimensions (i.e. 100s of metres horizontally, but 10s of centimetres vertically), any interesting topographic features would be difficult to spot. Accordingly, the vertical dimensions were magnified to enhance topographic variations. However, as individual monochrome representations these models were largely uninformative and uninteresting. Furthermore, all the surfaces looked remarkably similar.

In an effort to highlight the topographic variation across each surface, the second step was to apply a "colourmap" to the models: the colour map followed the spectral range from blue (low) to red (high). The mapping was calculated for a range of zero to highest vertical value of all the layers. For each surface, the range of height values were normalised around the lowest height recorded for that layer, which was set to zero. Therefore the colouring represents height above the lowest point of each layer. The topology appeared much easier to understand, but it was still impossible to see any apparent differences in the shapes of the different surfaces; each seemed to be of a uniform thickness across their extent and appeared to echo the form of the underlying layers. The nature of the problem is by now clear: what is needed is a method which enables different aspects of two or more surfaces to be compared simultaneously.

To make visual comparison of the shapes of adjacent layers easier, the set of surfaces were displayed simultaneously, one stacked above the other in their correct spatial/stratigraphic order using the "collect" tool in DX. However, since the vertical scales had been magnified it was necessary to translate the modelled stratigraphic surfaces further apart — in the vertical plane — to prevent the enlarged peaks of an underlying layer surface protruding through the troughs of an overlying one. This enhanced representation of the data was then viewed from many different angles, using the 3D cursor to rotate the model. This proved unsatisfactory as the nearest surface to the viewer occluded the details of features on surfaces behind. Experimenting with the opacity levels — achieved by simple manipulations of the colourmap tool's control panel — of each layers were not successful in this particular case.

The use of animation proved marginally more successful. Two approaches were adopted: one was to display the surfaces in succession, the other was to animate the effect or running a cutting plan through the section of the stacked layers. In the former case, by arranging for each surface to appear individually, or as an accumulating stack, one could search for areal features (e.g. small platform which might indicate buildings). Running a clip plane across the sectional profiles was applied for the same reasons. The animation's were controlled using the very powerful DX "sequencer". The sequencer was applied to a compute function which selected the surface(s) to be displayed or the number of, and interval between, clip plane steps respectively. The animation's are *played*. using a sequence control (arranged as a set of Motif buttons which look just like the controls of a conventional VCR (see Figure 47.4). The sequences could be played as fast as the computer could process (i.e. real time on the PVS and proportionately slower on less powerful computers) either forwards or backwards or in palandromic mode. There is a pause and single frame control (advance or backward) buttons. The start and end points, as well as, step interval controlling which pictures to displayed can all be controlled by the user through a simple control panel. Any sequence can be stopped any point and the user can use the available interactors to modify the scene (e.g. zoom, pan or rotate the displayed objects, change the colour map, vertical exaggeration etc.) and the program will compute the sequence using the modified parameters. The result of this exercise was that the writers became convinced that there were interesting features in the data but that they remained tantalisingly ill–defined.

Our last experiments involved the application of simple mathematical functions, using the compute tool again, to highlight the difference in the thickness of each successive layer. Our method was to normalise the height values of each layer. Two slightly different normalisation procedures were adopted. In the first experiments, we subtracted the lowest height value from all of the measurements. In the second case we subtracted the mean height from all the readings for the layer. For the purposes of visualisation, the two layers being compared and the difference between the two were shown in the same window. Looked at from above, they were arranged with the upper layer in the top of the window, the lower layer in the bottom of the window and the difference map was placed centrally between them. (A monochrome version in Figure 47.3 gives a rough impression of the method). Again these visualisations could be sequenced and animated. The difference maps proved very stimulating. They appear to show a number of circular islands which we are tentatively proposing as candidate sites for buried structural remains. Further discussion with the local archaeologists and more research will help us clarify our interpretation in due course. What is immediately apparent from this work, however, is the power, relevance and ease of use of this visual programming environment to exploring archaeological questions in detail; evolving and switching between a rich set of methods fluidly, bringing into play a wide range of function from a relatively small, simple to use, tools which are ready to hand.

47.4 WHEN IT'S NOT HARD AND FAST: A CASE FOR VOLUME VISUALISATION

The circumstances behind the form of the data used in the previous section are not uncommon, but one is more likely to be confronted with data which has not been pre–processed and the features separated out for further investigation.

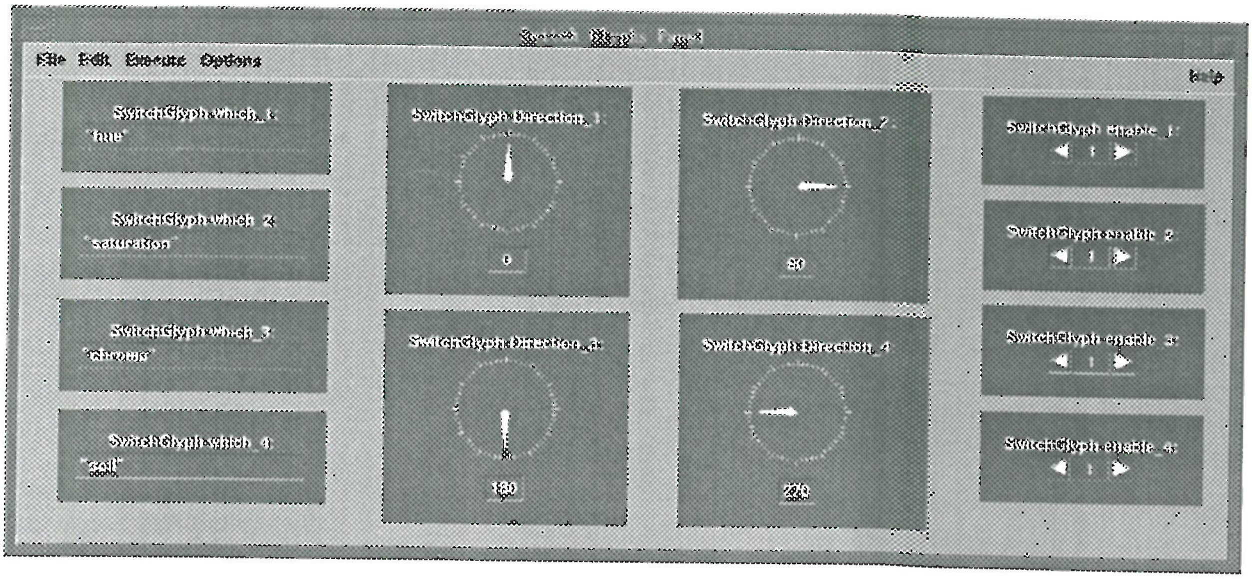
Raw archaeological data generally exist within a material continuum. The primary data collected are therefore 3D volumetric samples. Frequently, subsets of material are recognised and isolated as distinct archaeological entities; geometric objects (e.g. artefacts within a context or discrete archaeological features) bounded and separated from one another by clear stratigraphic interfaces. Such clearly delineated archaeological objects or features may be modelled as geometric edges and surfaces approximated by lines and polygons. However, another approach is to model these geometries as solids. This was the approach used in the Grafland solid model, which attempted to demonstrate that it is feasible to record archaeological deposits as 3D objects and not as a series of plans and sections. Grafland had several advantages over conventional archaeological representation methods, such as offering the ability to simulate alternative excavation methods for teaching (see Reilly 1992), but as implemented it also had several obvious weaknesses. For instance, the clean stratigraphic discontinuities were a little utopian for, as every experienced archaeologist knows, the definition of stratigraphic interfaces in the field for instance is often not a simple exercise. Archaeological deposits are mostly continuous volumes of material deposited as sediments. Discontinuities, characterised as so–called stratigraphic interfaces, reflect a change in the rate of deposition or the nature of the material being deposited. Alternatively, some intervening event has removed or modified material before the next stage of deposition continues. Between the 'changes' are volumes of largely homogenous material. However, often it is possible to inspect an archaeological section and note that material at level α and level γ are fundamentally dissimilar, but differentiating contiguous δ levels in between them has to be an arbitrary decision. Equally relevant are the post–depositional processes acting on archaeological formations. The action of animals (e.g. worms and rodents) and drainage, for example, may have important differential effects — effects which have crucial significance upon interpretation — within archaeological contexts and assemblages. A better visualisation model might be one that captured the fuzziness of the breaks and changes (in 3D) which characterise many archaeological deposits, but which also allowed the investigator to annotate the data and overlay interpretations concerning the whereabouts of interfaces for instance.

Volume rendering techniques, originally developed in the medical world to assist in the examination of magnetic resonance information, but now being exploited in the seismic and exploration businesses, partially fulfil these criteria. Volume rendering unlike surface rendering methods emphasise the underlying continuous nature of the data and avoids the necessity of artificially imposed surfaces and interfaces inherent in the use of geometric primitives in the rendering process such as those used in the Grafland model. Volume rendering may be characterised as tracing an imaginary ray of light through a volume and applying a function, based on the cumulative data values encountered in the volume, to generate intensity and opacity values, which are translated to pixel values in the displayed picture. (Detailed technical descriptions of the major varieties of volume visualisers can be found in Kaufman (1991)). Because each value contributes to the final picture, features within the data appear as translucent objects with cloud–like qualities. In principle, this means that every element in a data volume can be represented and *viewed* simultaneously, abrogating the need to define surfaces or interfaces explicitly. However, in practice the rendered view may become difficult to interpret when several semi–transparent features in the data are intertwined. To some extent this problem can be overcome by adjusting opacity levels. However, rather than relying on a single (i.e. static) view, the model can be interpreted much more easily by interacting with it (by rotating the model etc.).

47.5 VISUALISING AUGER DATA FROM POTTERNE

A set of auger data was provided by the Trust for Wessex Archaeology (TWA). The data was part of a much larger data set from Potterne in Wiltshire which has already been subject to investigation through visualisation methods (Reilly, Lockyear & Shennan 1990). An understanding of the stratigraphic make–up of the Potterne deposits is a key issue in the Potterne investigations. The auger data had not been explored using visualisation methods in any depth. Samples had been taken at 10cm intervals from 321 auger hole bores. Each sample record describes one 10 cm spit and consists of nine variables: auger hole number, *x*–, *y*–, *z*–co–ordinates, soil type, magnetic susceptibility (adjusted for wetness), Munsell: hue, value and chroma).

Our experiments so far have focused on a regular grid of data within the centre of the sur-



SwitchGlyph which_1: "hue"
SwitchGlyph which_2: "saturation"
SwitchGlyph which_3: "chroma"
SwitchGlyph which_4: "soil"
SwitchGlyph Direction_1: 0
SwitchGlyph Direction_2: 90
SwitchGlyph Direction_3: 180
SwitchGlyph Direction_4: 270
SwitchGlyph enable_1: 1
SwitchGlyph enable_2: 1
SwitchGlyph enable_3: 1
SwitchGlyph enable_4: 1

Figure 47.5: One of several user–defined control panel to drive iconographic display

vey. The point measurements were transformed into a 3D grid of cells by centring colour–coded translucent cubes over the sample locations. In effect we used voxel replication rather than interpolation to enlarge the representation for viewing. "Soil type" was displayed in this fashion. With low opacity, one notices several cloudy *layers* extending across regions (but not all) of the viewed data. These features were studied further by increasing the opacity values and running a clipping box through the data — generating a series of sectional profiles through the data similar to those first used on the Potterne excavation data (see Reilly, Lockyear & Shennan 1988). Again animation was exploited to investigate which viewing angles were the most revealing.

Of course, one could systematically examine all the variables in the dataset in this fashion. Later one could start combining variables in the visualisation so as to facilitate investigation of correlation's. It occurred to the writers that certain Exploratory Data Analysis (EDA) techniques which have proved valuable elsewhere for investigating high–dimensional datasets could be extended through 3D display. In particular, it was thought that the so–called "star plot" (e.g. Williams, Limp & Briuer 1990) could be made more effective through the use of "glyphs".

47.5.1 Exploring high–dimensional data through iconographic displays

Glyphs are three–dimensional programmable icons which can be used to represent some property of the data being examined. They also provide an invaluable tool with which to annotate data and offer considerable potential for investigating high–dimensional data sets. Glyphs are significantly more sophisticated than coloured markers, such as those used to denote the presence and location of various types of artefact within the contexts of the Hamwic pit project (Colley, Todd & Campling 1987). The attributes of the glyph (e.g. size, position and colour) are data–driven. Scalar data, such as magnetic susceptibility and Munsell values from an auger survey, may be represented simultaneously by placing a sphere (or another shape) at the appropriate location, with size, colour and texture (surface pattern) colour each denoting a different variable (see Figure 47.4).

When dense plots of glyphs are displayed on a screen they create what has been referred to as an "iconographic display" in which the variations in shape, size, spacing of the glyphs create patterns, called textual gradients or contours, indicate potentially interesting structure in data (Smith *et al.* 1991:192–193). It has been possible to exploit DX's 3D glyphs to extend the EDA potential of "star plots" into interactive 3D iconographic displays.

47.5.2 Manipulating iconographic displays

To demonstrate the effectiveness of the idea, we produced a visual program which allowed the user to build and interactively change a 3D iconographic display. In brief, each variable at any data point can be represented by a rocket–shaped (arrow–shaped) glyph. Colour and orientation denotes the variable represented and size indicates magnitude or presence/absence of the variable, for instance.

A set of control panels were designed to enable the user to drive the displays. From the panels (e.g. Figure 47.5) the researcher can activate those variables to be displayed, set glyph (i.e. variable) orientations and colours, define the dimensions of a clipping box and control its path. By driving the clipping box through layers the researcher can search for texture regions which signify clusters of variables and changes. The clipping box may be driven vertically or horizontally through the iconographic display. Looked at in section the stacks of stars look like signposts or battleship charts. This is another simple method for checking the relative strength of some variable(s) down through the formation.

Each of the Munsell components and magnetic susceptibility were assigned glyph positions and colours (the method can be extended to much larger numbers of variables). Inspection showed that layers and clusters of texture (i.e. groups of glyphs) were indeed apparent (e.g. Figure 47.4). What is particularly interesting is that when the iconographic display and the volume rendering of the soil types are combined several glyph–textured *layers* occur where no change in soil type is recorded.

47.6 CONCLUSIONS AND FUTURE DIRECTIONS

Powerful commercially available visualisation environments now enable archaeologists with little or no formal training in computer science to subject their data to sophisticated data visualisation investigations. Multiple large data sets, even those collected from different collection points, can be registered and visualised simultaneously. Indeed the same data can be displayed in a number of ways within the one visualisation to reveal previously unnoticed structure. Two promising new methods have been introduced — volume visualisation and 3D iconographic display. Both techniques allow the investigator to look at the structure of archaeological deposits, as recorded in core samples, without recall to the drawing of lines or the making of categorical decisions about the whereabouts of the boundaries of contexts. It is clear that these methods have considerable scope for integrating several types of data to stimulate greater insights. For instance, one may combined geometry's describing contexts (e.g. layers) with point distributions (e.g. artefact or sampled variable) and volume rendered data (e.g. paleo–environmental details). The range of combinations is staggering. However it is the ease of use aspect of these systems which will enable archaeological data explorers to free their imaginations and look for new relationships and insights in their data. The methods developed above are likely to be extended and refined in the future. We expect a great many more archaeological investigators to adopt similar systems now that they have reached a level of user–friendliness that the archaeologist can focus on the archaeology and not be distracted by the complexities of programming.

47.7 SUMMARY

Until recently, the application and development of data visualisation methods in archaeology was restricted to a small group of researchers with access to research systems, often requiring considerable experience and training in programming of such systems. Restrictions of availability, access, useability etc. are now largely overcome by off–the–shelf advanced visualisation systems with their sophisticated functionality and user–friendly interfaces.
Using experimental studies using auger data, we demonstrate some of the latest data exploration potential of systems that enable multiple visualisations of large, complex, multi–dimensional data sets to be realised in environments which do not require deep knowledge of computational methods. Two novel approaches are introduced: volume visualisation and 3D iconographic display.

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