

28. A PC-based program to display surface data

S. Laflin

N. Perry

School of Computer Science, University of Birmingham, Edgbaston, Birmingham B15 2TT, U.K.
(e-mail (Janet) LaflinS@uk.ac.bham)

28.1 Introduction

The software described in this paper was written by one of us (NP) as a student project under the supervision of the other (SL). Although work submitted for undergraduate projects must always be the student's own work, there is no requirement that it be original research. Consequently this topic has a considerable overlap with previous projects carried out, both at Birmingham (Laflin & Sutton 1983; Welbourne & Laflin 1986 and other unpublished dissertations) and elsewhere (Scollar 1974; Briggs 1982; Harris 1986 and 1988; Aspinall & Haigh 1988; Boismier & Reilly 1988; Fletcher & Spicer 1988; Spicer 1988). However as the work progressed, it became apparent that the resulting package would be more complete and more efficient than many of the earlier projects and this merited its presentation at the Computer Applications in Archaeology conference.

The 'SURFIT' (SURface FITting) package has been designed to accept data recorded as a rectangular array of spot heights and to display it in a wide variety of ways, including:

- (a) Contour plots.
- (b) Mosaic and Dot-density output.
- (c) Fishnet or Wire-frame diagrams.
- (d) Perpendicular cross-section lines.
- (e) Three-dimensional histograms.

The software is designed to run on any IBM PC, PC-

clone or PS/2 systems and with most of the graphics cards currently available, and has been tested on many of these. For large amounts of data, a hard disk is recommended and a maths-coprocessor speeds up the response for those options involving a large amount of calculation. Although the program may be used on monochrome systems, the addition of colour can assist the visualisation of the data and facilities are provided to allow the user to choose colour schemes and customise the package to his or her own requirements.

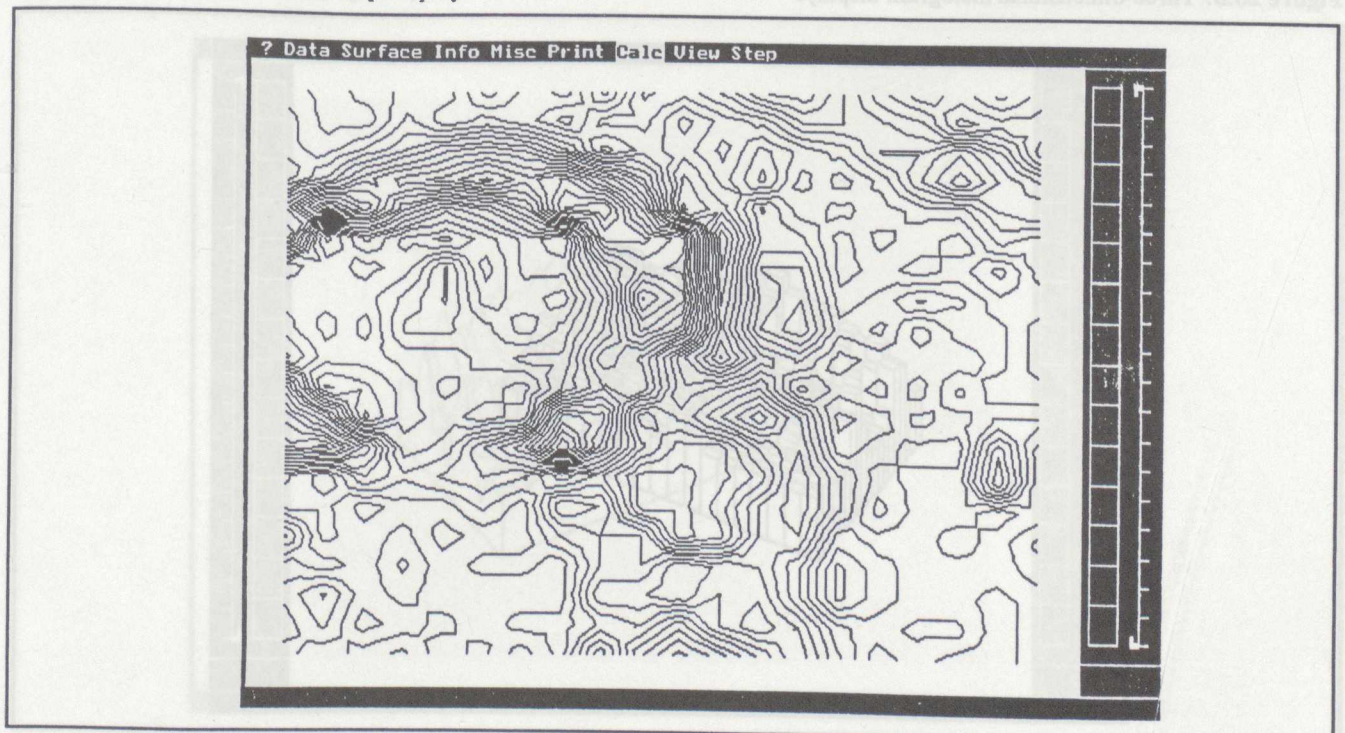
28.2 Display methods

The program offers six display methods, which will be discussed in the following sections. These are split into the two-dimensional methods (contours, mosaic and dot-density) and the three-dimensional ones (fishnet, histogram and cross-sections). The three-dimensional methods usually involve more computation, but allow the surface to be viewed from any angle and at any elevation.

28.2a Method 1: contouring

This form of output is well known to most people. The implementation uses a cell-by-cell routing algorithm to draw the image. The fastest method uses linear interpolation along the sides of the cell and between the corners and centre point (assumed to be the average of the four corner values). Better resolution is obtained, at some cost in speed, by using the equations for the

Figure 28.1: Typical contour map display.



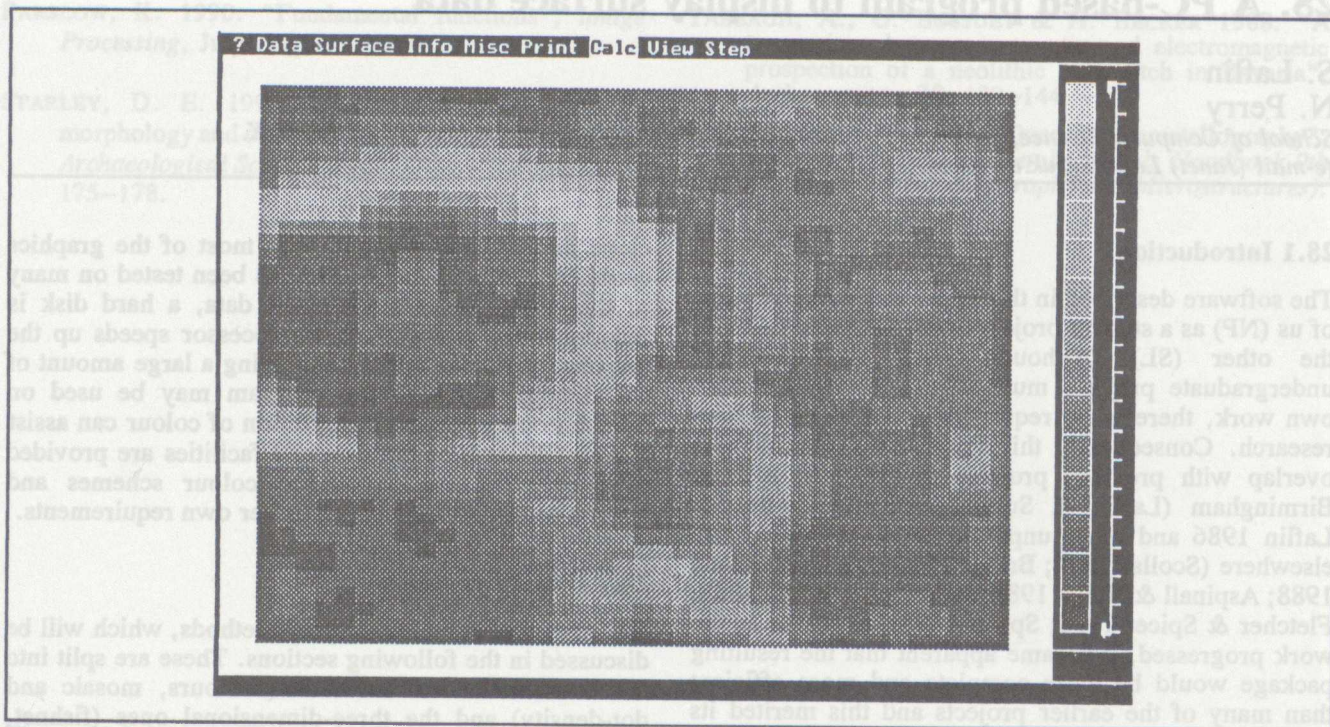


Figure 28.2: Mosaic display with 2x2 split.

bi-linear surface patch to obtain intermediate values and so generate smaller cells.

The use of a bi-cubic surface patch was considered, but at the resolutions obtained on most PC-screens, the difference in output between bi-linear and bi-cubic patches was scarcely detectable while the increase in time was unacceptably large. Consequently this option was not included. The theory of all these display methods was discussed in the second-year textbook (Laflin 1987).

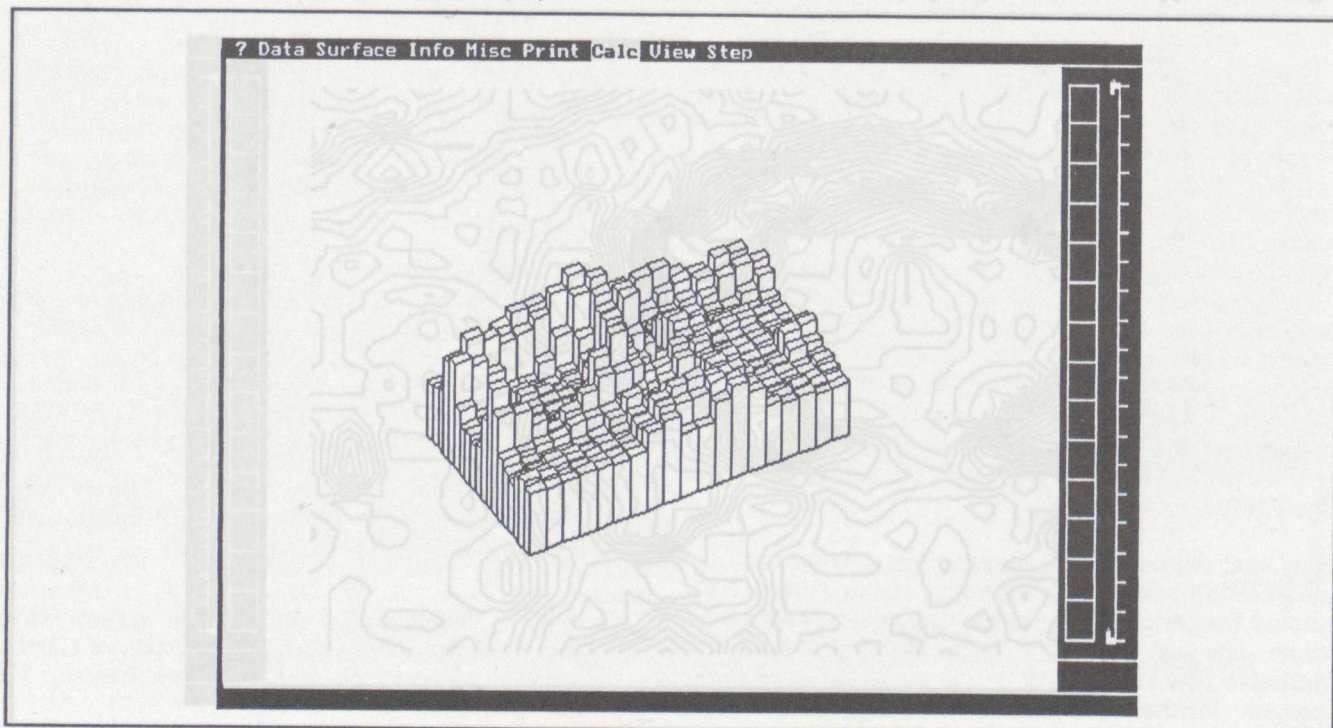
Fig. 28.1 shows an example of contour output for a

20x20 array at the lowest resolution — you will note some of the contours have sharp corners which become smoother at higher resolutions. When the addition of colour is used to indicate the height of the contours this gives a good impression of the shape of the surface.

28.2b Method 2: mosaic

The mosaic drawing routine uses a similar recursive algorithm to the contour one. Each data patch can either be coloured by the colour which maps on to the average height of the patch, or it may be split, using values from the bi-linear surface patch, into four

Figure 28.3: Three-dimensional histogram display.



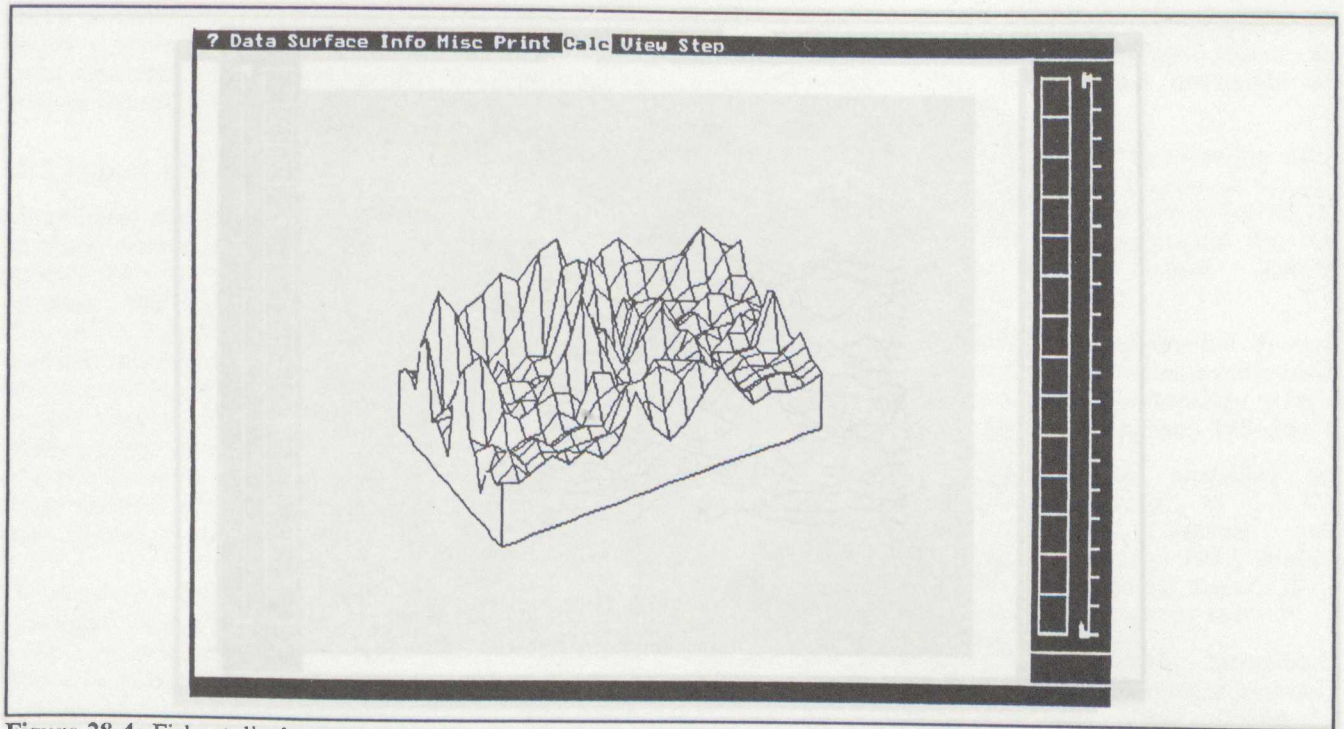


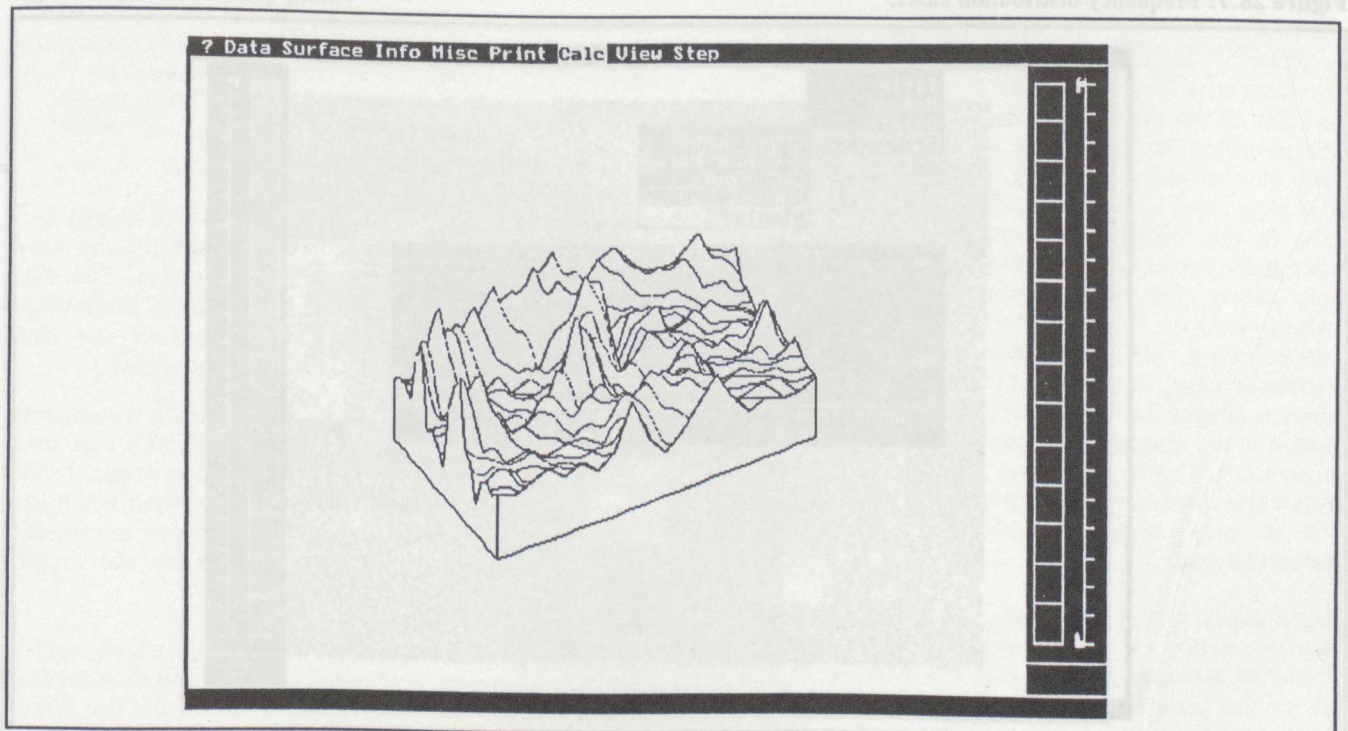
Figure 28.4: Fishnet display.

smaller patches and the process repeated. In order to improve the speed of the algorithm, certain optimisations have been made to the recursive procedure. When the decision is made to split the current patch, a check is performed on the colour mappings of the four corner heights of the patch. If all these heights are mapped on to the same colour, then no further splitting of the data is performed. This method is best suited to colour displays, but can also be viewed in grey scale, as shown in Fig. 28.2. It would also be possible to use patterns in place of colours, but this has not been implemented and would be unsuitable for larger grids.

28.2c Method 3: dot-density

This is a very familiar method of output to most archaeologists. The software is very similar to that used for the mosaic method, but the level of shading for a given patch is provided by a number of dots, the number being given as a percentage of the area taken from a cumulative frequency chart of the data. By using the chart, the density of the patches is more evenly distributed over the range of the data, giving a better result. The filling is performed using a random number generator, to reduce the chance of generating distracting patterns in the output. Examples may be

Figure 28.5: Cross-section diagram.



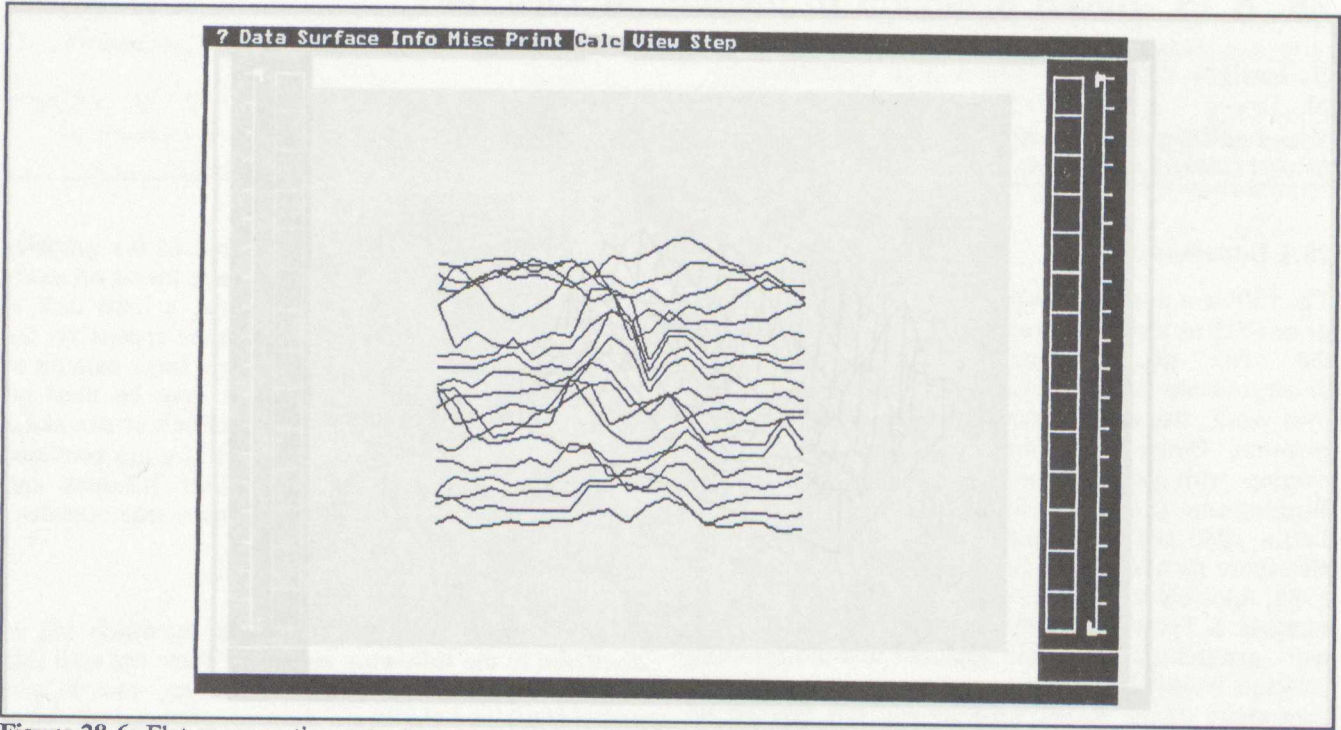


Figure 28.6: Flat cross-section output.

seen in Figs. 28.9 and 28.10 and it is felt that this option will usually be preferable to the mosaic method on a monochrome display.

28.2d Method 4: three-dimensional histogram

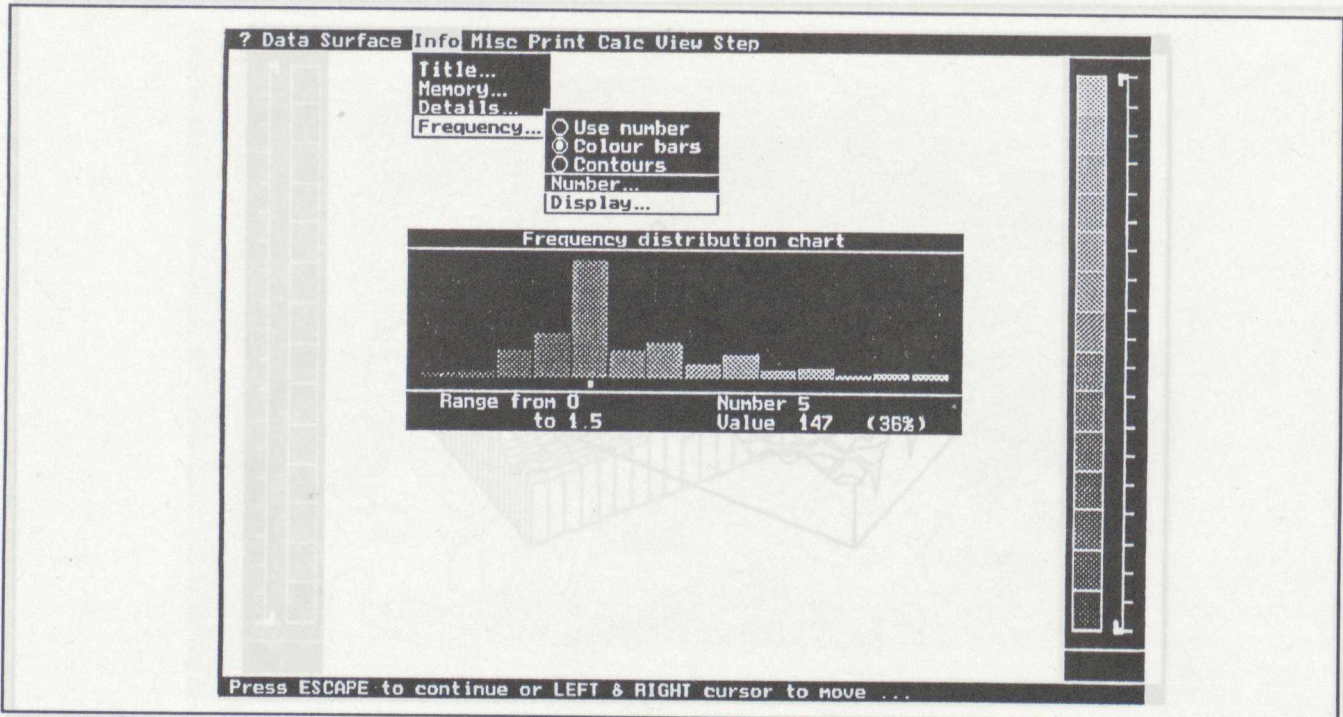
The three-dimensional histogram allows the user to view the data as a series of pillars, from any angle or elevation. Fig. 28.3 shows the display of a small set of data by this method. The same hidden-line removal method was used for all the three-dimensional routines. In the latest version of the program, hidden surface removal is achieved using the painters' algorithm. The

polygons furthest from the viewer are drawn and filled first and later ones overwrite these when their areas overlap. Thus the finished drawing gives a correct representation of the surface and the results are acceptably fast. Since all hard-copy output is generated as screen dumps, these are also correctly represented.

28.2e Method 5: fishnet diagram

The routine for the fishnet diagram closely resembles that for the three-dimensional histogram, both in offering a similar set of display options and in using the same hidden-line removal algorithm. The output

Figure 28.7: Frequency distribution chart.



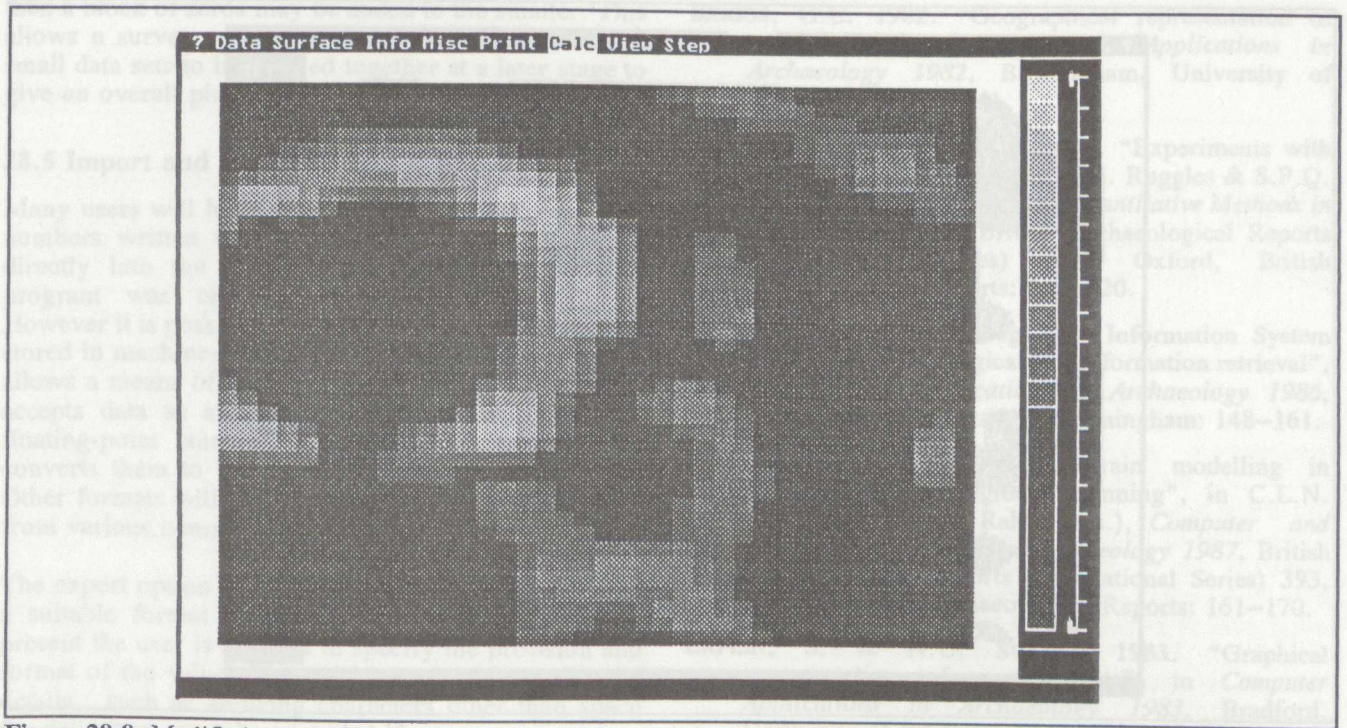


Figure 28.8: Modified mosaic diagram.

produces a drawing of a tiled surface instead of the set of pillars from the previous option and a typical example is shown in Fig. 28.4.

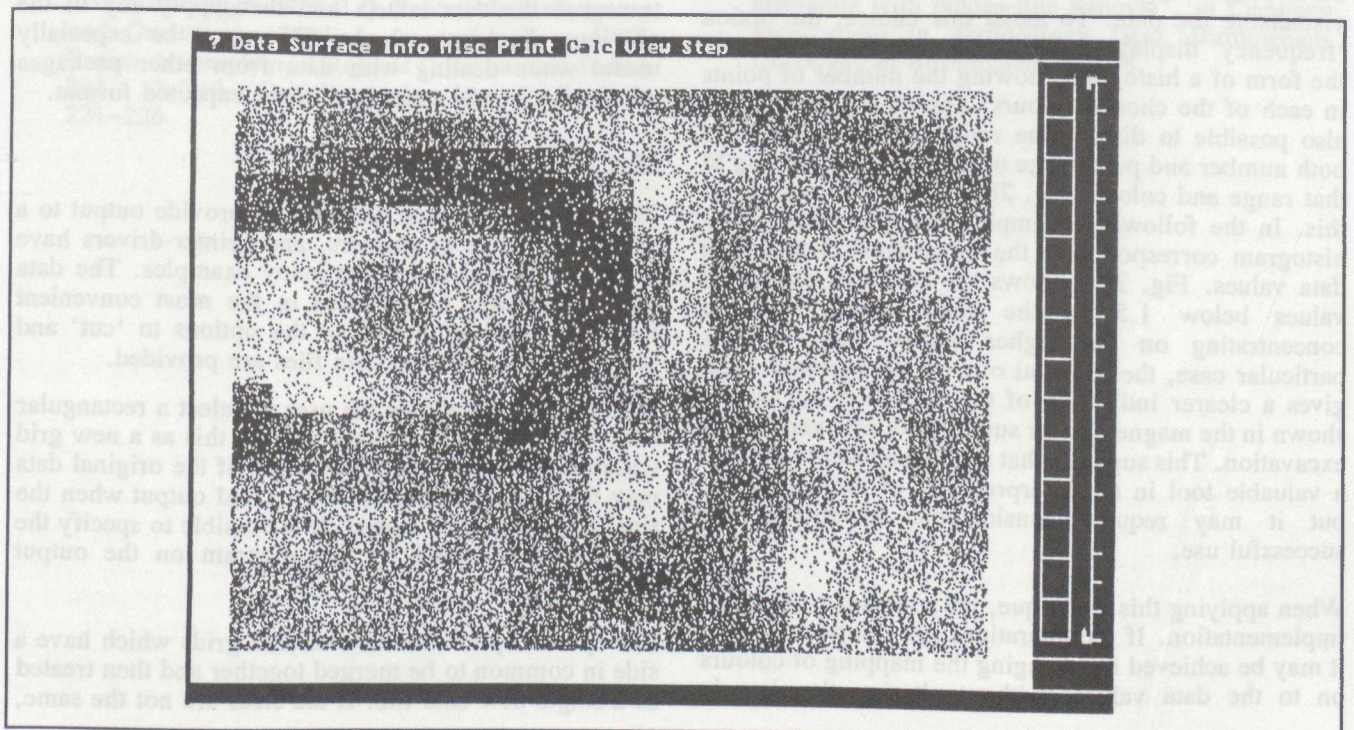
28.2f Method 6: linear cross-sections

This routine differs from the previous two in that it must always produce cross-sections perpendicular to the current viewing angle. This means that as the viewing angle is varied so the cross-sections intersect the data grid at different angles. Fig. 28.5 shows a typical display of a cross-section diagram. In order to generate the correct lines, the algorithm places an imaginary box

around all the data. The box is square and completely encloses the data grid no matter how it is rotated within the square. Lines are traced on the square and, for each point on the line, the intersection with the data grid, after rotation, may be calculated. If an intersection is found, the height on the grid is calculated and the point on the screen is found, using a further rotation. This method is very CPU-intensive because of the large number of floating-point operations needed and is one case where the availability of a maths-coprocessor allows a significant improvement in speed.

An additional option has been added to this menu, to

Figure 28.9: Dot-density plot.



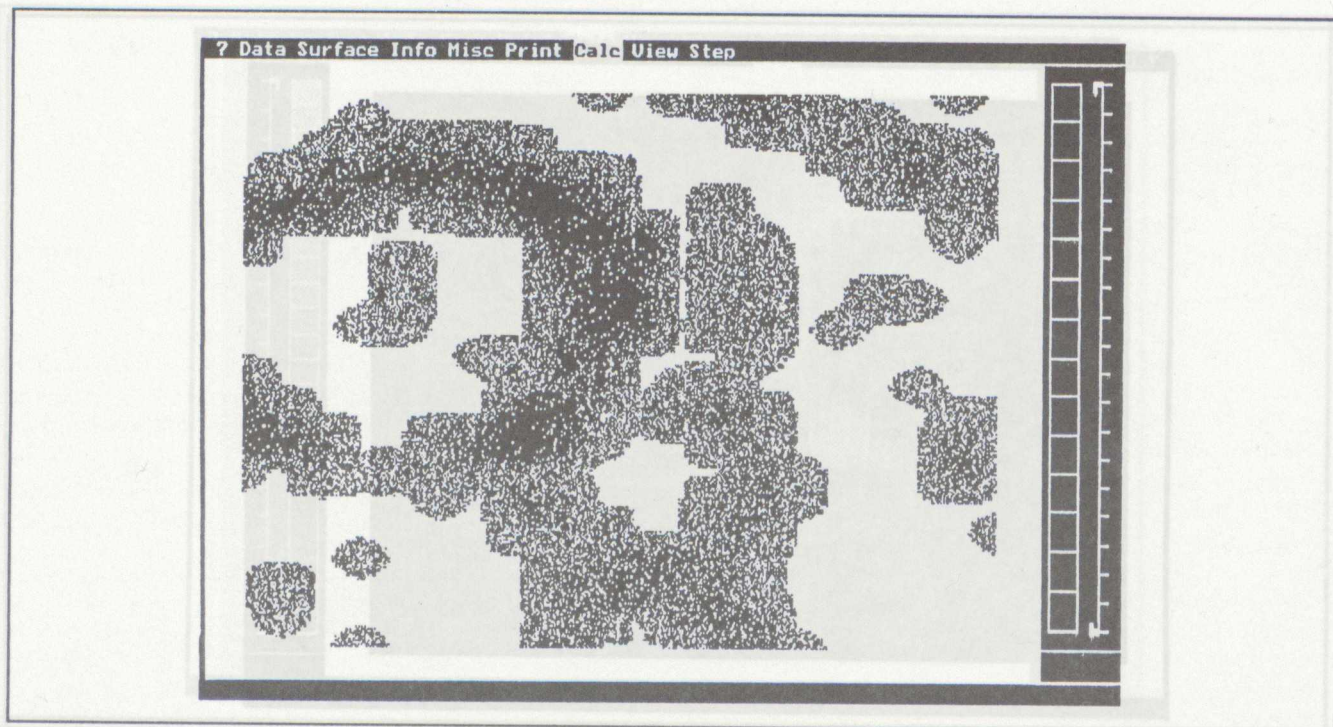


Figure 28.10: Modified dot-density plot.

provide the 'Flat' output, an example of which is shown in Fig. 28.6. This option draws a plan view of the data with lines drawn horizontally across the screen, and the height of the data grid at any given point is displayed as a displacement from the horizontal line. The data grid must be parallel to the screen edges for this mode of output. This method allows easy correlation of the relative positions of possible items of interest while at the same time allowing the items to be seen clearly.

28.3 Data analysis methods

Facilities are provided to adjust the mapping of colours on to height ranges and this should be a useful tool in visualising the data. To assist this choice, the option 'frequency' displays a frequency distribution chart in the form of a histogram showing the number of points in each of the chosen colours. For each column, it is also possible to display the range of data values and both number and percentage of points corresponding to that range and colour. Fig. 28.7 shows an example of this. In the following example, the maximum of the histogram corresponds to the range from 0 to 1.5 in data values. Fig. 28.8 shows the result of setting all values below 1.5 to the same colour and so concentrating on the higher values only. In this particular case, the removal of such background noise gives a clearer indication of the ditch and hut circles shown in the magnetometer survey and later verified by excavation. This suggests that such an approach may be a valuable tool in the interpretation of these surveys, but it may require considerable experience for successful use.

When applying this technique, the user has a choice of implementation. If the alterations are temporary, then it may be achieved by changing the mapping of colours on to the data values, without altering the data in

any way.

Alternatively, if permanent changes are required, the operation 'set limits' applied to the data will remove any extreme values by applying a specified maximum and/or minimum to the data.

The effect of this may be seen in the following examples of dot-density output. Fig. 28.9 shows the original data expressed as a dot-density plot. Again values below 1.5 are considered to be noise and Fig. 28.10 shows the dot-density output with these removed.

Other data operations allow the user to rotate or transpose the data matrix and then apply any of the previous display methods. This may be especially useful when dealing with data from other packages which may not be presented in the expected format.

28.4 Hard copy output

The package has been designed to provide output to a very wide range of printers, and printer-drivers have been written and tested for many examples. The data may not always be supplied in the most convenient form for publication and so the options to 'cut' and 'paste' output from the data files are provided.

The 'cut' option allows the user to select a rectangular area within the data grid and extract this as a new grid within a new data file. This subset of the original data may then be displayed as desired and output when the final form has been chosen. It is possible to specify the size to be occupied by this diagram on the output device.

The 'paste' option allows two data grids which have a side in common to be merged together and then treated as a single new data file. If the sizes are not the same,

then a block of zeros may be added to the smaller. This allows a survey which has been presented as several small data sets to be merged together at a later stage to give an overall picture.

28.5 Import and export of data

Many users will have their source data in the form of numbers written on sheets and will need to type it directly into the program from the keyboard. The program was originally written for such users. However it is possible that others will have data already stored in machine-readable form and the import option allows a means of reading this data. The current form accepts data as an ASCII file containing integer or floating-point numbers, separated by blanks, and converts them to the correct format for the package. Other formats will be supplied in future to allow input from various commercial packages.

The export option is intended to provide output files in a suitable format to interface to other software. At present the user is allowed to specify the precision and format of the values inserted in the data file and other details, such as allowing characters other than space for delimiters, may be provided if necessary.

The software developed in this project is now available as a commercial package and anyone interested should contact Nick Perry at Midland Programming Solutions (MPS) Ltd on 021-471-3516.

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