GRASP : GRAPHICAL ROUTINES FOR ARCHAEOLOGICAL
PLANS AND SECTIONS

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1. Introduction and Methodology.

GRASP is an experimental package of routines written in Algol 60 by the authors during 1976 and implemented at the University of Keele. It is not yet fully developed and future modifications and additions are envisaged. GRASP is designed to bridge the gap between the sketches of sections and plans which are produced at an excavation, and final publishable drawings for inclusion in the report. The starting information required by GRASP is a series of coordinates in two dimensions which specify the position of layers, structures, or individual objects of interest. An outline drawing appears on the graphics tube and this is modified and shaded interactively using light-pen and sense switches until the user is satisfied with the appearance. A hard-copy drawing can then be produced on a digital plotter - either then and there while the next drawing is being developed, or it can be 'off-lined' for plotting at some later time.

The types of shading that have been developed are designed to satisfy the requirements of "moderate realism" - a method of drawing which attempts to match to some extent the original appearance of the section or plan. Moderate realism was chosen for the development of GRASP mainly because it is far more difficult to produce, from the computer point of view, than any other technique, and it was felt that if we could imitate this style we could certainly imitate any of the more formal and stylised techniques.

As implemented at present, GRASP requires the coordinates which specify the lines of the section/plan to be punched on paper tape, though it can be easily modified to accept any other form of input. These coordinates could, in theory, be taken as a series of measurements from the actual section or ground plan, and either punched on to paper tape later or typed in at a remote console on site as direct input to the GRASP program. In practice, however, the archaeologist will probably want to make a pencil sketch of each section, both as an aid to his interpretation and as a useful error check on the measurements he has made. In this case, the tapes can be prepared later from the pencil sketches by the use of digitising equipmentsuch as the D-MAC Pencil Follower attached to a paper tape punch.

GRASP stores the coordinate information as distinct groups of x-y pairs. The coordinates in each group are connected by straight lines to form the lines of the drawing, e.g. part of the boundary of a layer or the outline of a sandstone block. These lines may be selected in any combination by the user to form a closed outline corresponding to a layer from a section or feature of a plan, and may then be 'shaded in'.
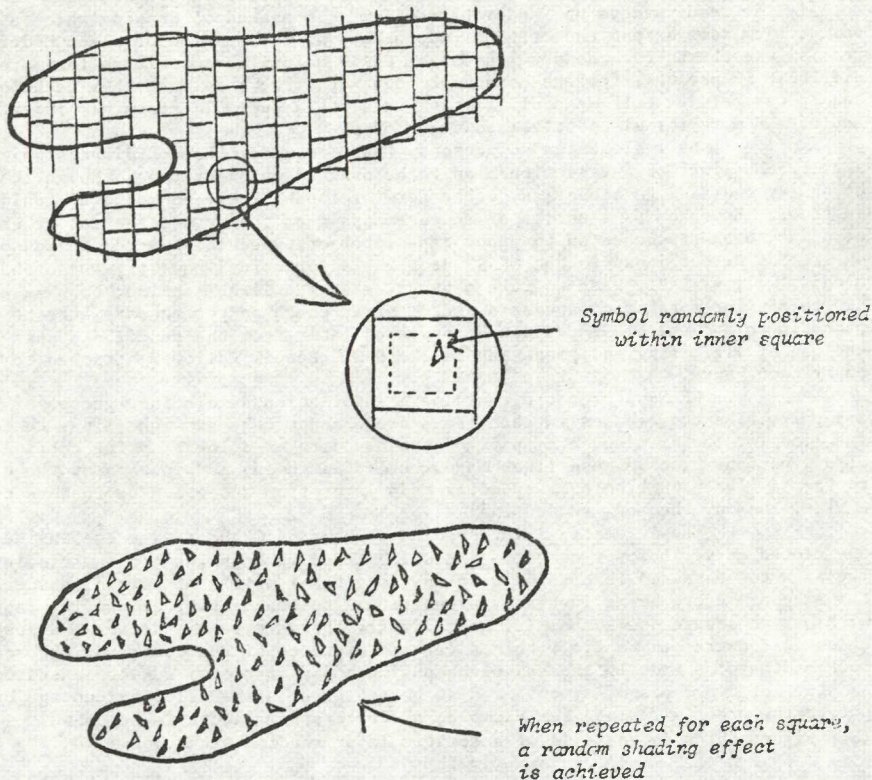
The automatic layer shading segment of GRASP shades the inside of any closed curve, however complex, including those with 'holes' in the middle. The area to be shaded is covered with an (imaginary) matrix of adjoining squares, the size of square being inversely proportional to the density of shading required. Within each square one symbol (of a previously chosen type) is drawn at a position which is constrained to lie within a certain distance of the centre of the square, but is otherwise randomly chosen, using a simple pseudo-random number generator. A mixture of two types of symbol is also possible, at a specified percentage of one to the other allowing, for example, a rubble/sand mixture to be drawn. (See Figure below for details of automatic layer shading technique.)

So for automatic layer shading the user specifies the following parameters:

1. Density of shading
2. Symbol type 1
3. Size of symbol 1
4. symbol type 2
5. Size of symbol 2
6. Percentage of symbol 1 to symbol 2

(See Fig. 5). Thus complete standardisation of shading is possible since the user can produce exactly the same effect in another area simply by specifying the same six parameters. Symbols types currently available are rubble, gravel, humus, clay, squiggles and points, though these could be altered to suit another style of drawing. (See Fig. 1 for examples and Fig. 3 for the effect of density variation). Many of the symbols have random orientation built-in to avoid too much regularity in appearance. Several facilities other than automatic layer shading are available, namely: pebble-drawing, line drawing, output of text, single stippling. These are described in Section 2.

Joining-up of sections (and plans) and reverse plotting. After the final version of a section/plan has been plotted on the digital plotter, the pen is left in such a position that the next section/plan plotted will match the end of the previous one, and in this way sections which are adjacent on site can appear as one long continuous drawing. It is also possible to specify that a drawing is to be plotted in mirror-image form, allowing sections which were adjacent on site, but were sketched from opposite directions, to be matched up in the final drawings.

Symbol randomly positioned within inner square

When repeated for each square, a random shading effect is achieved

AUTOMATIC LAYER SHADING

2. The processing of a section.

The DMAC process:

The section to be processed is first transferred from the drawing made on site to paper tape by means of a DMAC pencil follower. The four corners of the site drawing are digitised to specify the borders of the picture, then each "line" bordering the edge of an area to be shaded is digitised with special symbols to specify the start and end of each line. Any line can be caused to be output on the final plot by means of a special symbol on the tape, so that features such as sandstone blocks can be accurately plotted.Text may also be caused to be output by digitising the point where it is to appear and punching the text on the keyboard. The whole section may be reversed by the inclusion of a special character at the start of the tape, and a scale may also be associated with the section. For convenience of correction, the section may be digitised onto more than one tape.

The Shading process:

The computer program used to shade the section consists of a control segment which passes control to various facilities as directed by the user, and to which control is returned after the selected facility has performed its task. Thus the facilities of the program may be used in any order. The user controls the program by means of lightpen selection of an item in a menu displayed on the screen by the control section. The various facilities are contained in different segments so as to save space in the machine.

The user will normally begin by inputting the paper tape from the DMAC process. The tapes are read in any order, and a picture of the section appears on the screen. Note that the section outline does not appear on the final magnified version. The various facilities may then be chosen by the user as described below. In all of these facilities, control is held by one or more sub-menus to allow repeated use of the facility without reselection from the main menu. Return to control is by means of selection of an EXIT option.from the sub-menu. Except where otherwise stated, all effects generated on the screen are also generated in coded form in the "plotter file", i.e. the storage area for the information needed to produce the final magnified output section.

The facilities contained in the program are now described.

i) Selection of the area to be shaded:- The lightpen is used in conjunction with the sense keys on the display to select "inner" or "outer" lines. These lines are re-displayed in dotted form to show which line has been selected (figure 2). Wrong selections can be cancelled by use of one of the keys, and another of the keys indicates to the program that the selection is complete. After selection, the chosen lines are displayed with increased brightness, and all connections are made visible so that inner lenses can be seen (figure 5). The user may then return to the control section to select the shading facility. (see iii).

Also included is the facility for selecting a line on the screen for . inclusion in the plotter file.

ii) Amending the picture:- This facility allows the user to change any part of the picture by pointing at an item with the lightpen and pressing a sense key to select any of the following options:
  a) delete item from screen only (i.e. leave it in the plotter file).
  b) delete item from plotter file only.
  c) delete item from plotter file and screen.
  d) move an item from one point on the screen to another. The corresponding information in the plotter file is changed to record this movement.

iii) Shading the specified area:- The current area, i.e. the one defined by the use of the facilities in i) above, can be shaded to convey a realistic impression of its nature as observed on site. The user may specify a mixture of two types of stipple as described in section 1. The program stipples the defined area and the stipple appears on the screen. The user may then either exit to control, delete the last stipple displayed, remove it from the screen only, to save space in the display file, or specify another stipple for the same area without redefining that area. If the stipple is deleted from the screen it is replaced
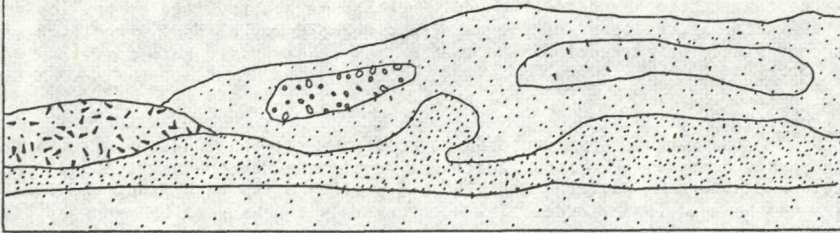
Figure 1: *Samples of various stipple types.*

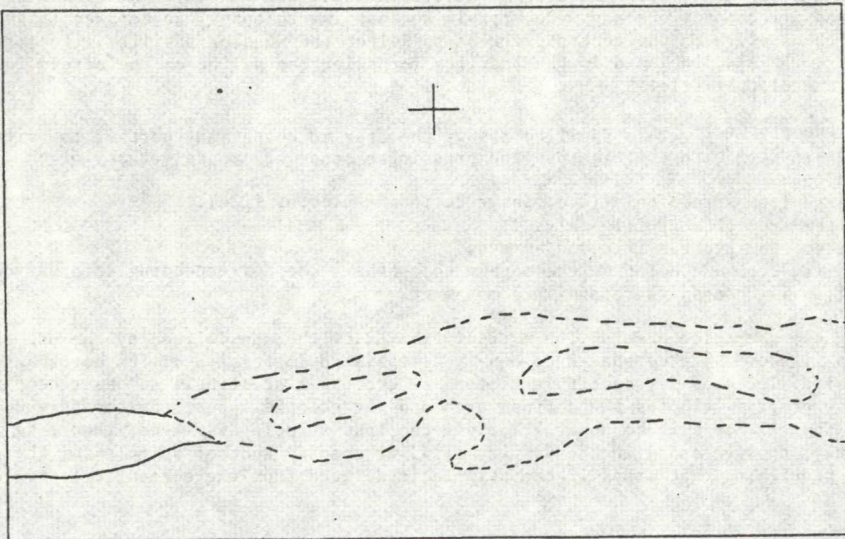1 SELECT   2 END   3 CANCEL   4 PLOTSTORE   5 INNER   8 EXIT

Figure 2:   *Example of dotted line display of selected lines, with line selection menu.*

by a legend describing its parameters as a guide to the user for surrounding stipples.

iv) Drawing large pebbles:- There are two options open to the user:
   a) Programmed pebbles: these are of fixed shape, and on selection of this option a sample of 20 pebble shapes is displayed along the top of the screen (see figure 4a). The user selects one of these with the lightpen, together with a size and orientation . By positioning the tracking cross and pressing one of the sense keys, the user may generate in any desired place a pebble of the kind chosen, with the option of having it randomly oriented. There are also facilities for deleting and moving pebbles.
   b) Random pebbles: The user may generate the basic frame for this pebble type by chosing with the lightpen any number of the 24 axes on which the pebbles are constructed. As each axis is chosen its number disappears from the screen to indicate its selection. The orientation is also specified by lightpen selection, then the pebble is positioned by use of the tracking cross and the sense keys used to specify minimum and maximum axis length (see figure 4b).

v) Drawing new lines on the picture:- It may be required to construct lines on the screen picture, e.g. a line may have been omitted from the DMAC tape, a pair of adjacent layers may be so similar in appearance as to necessitate a dividing line to distinguish them, or a line may be deleted by accident. The desired line may be constructed using the lightpen to position the tracking cross, and pressing a sense key to either define a point or join the current point to the previous point. The line so constructed may optionally be included in the plotter file.

vi) Single stipple option:- This enables the user to generate at any point a single stipple mark from the six available, with control over the size of the stipple mark generated. This facility is useful for shading small areas of, say, a sandstone block.

vii) Generation of text: Text may be positioned on the screen and included (optionally) in the plotter file. The tracking cross is used to position the first character, and the size and font of the characters are chosen from a menu on the screen, and the the text is entered via a teletype. After entry, the user has the option of cancelling the text, or may choose to include it in the plotter file, or to exclude it.

viii) Producing the magnified plotter output:- During the course of the program, the details of all the stipples, pebbles etc. are stored in the plotter file. When the user is satisfied with the picture on the screen, he may instruct the program to produce a magnified version of the picture on the graph plotter. The purpose of magnifying the picture is to achieve, by photostatic reduction of the plotter output, very fine detail in the shading and line drawing despite the relative thickness of the plotter nib. (Figure 6). The user may also arrange that a disc or magnetic tape dump be produced containing relevant information, so that the picture may be regenerated at some time without the need to re-specify all the stipples etc.

ix) Plotting direct from the screen:- The plotter output described in viii) above is produced by direct program control of the plotter. There also exists the facility to plot direct from the screen using a utility program. This program has no magnification factor, but merely plots whatever is on the screen, and can be called by the user to obtain a copy of, say, the original outline of the section with explanatory text as a key to the magnified plotter output.

x) Miscellaneous facilities:- These include an option to input from disc or magnetic tape the dump of the information required to regenerate the section as described in viii) above; a command for clearing the screen and restarting the program; facilities for tracing values of certain variables for fault diagnosis.
               Other facilities which will be included in future include the automatic joining together of two or more sections for side by side comparison and overall site viewing; graded stippling to achieve a gradual change of density across an area; simplification of the data recording process by some form of on site recording of the section measurements; automatic placement of large pebbles.
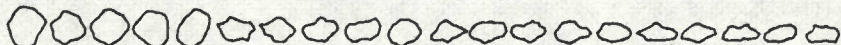   The program in its present form is also applicable to plans and maps, and it is intended to use it to experiment with various permutations in the arrangem-

```
DENSITY -
   1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18
  19  20  21  22  23  24  25  26  27  28  29  30
BUT 1 TO SELECT
```

Figure 3: *Range of density for "point" stipples. Also shown is density selection menu.*


```
1 SELECT   2 MOVE   3 DEL LAST   4 DELETE   5 POS   6 POS RAND   8 EXIT
SCALE -
   1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18
  19  20
BUT 1 TO SELECT
```
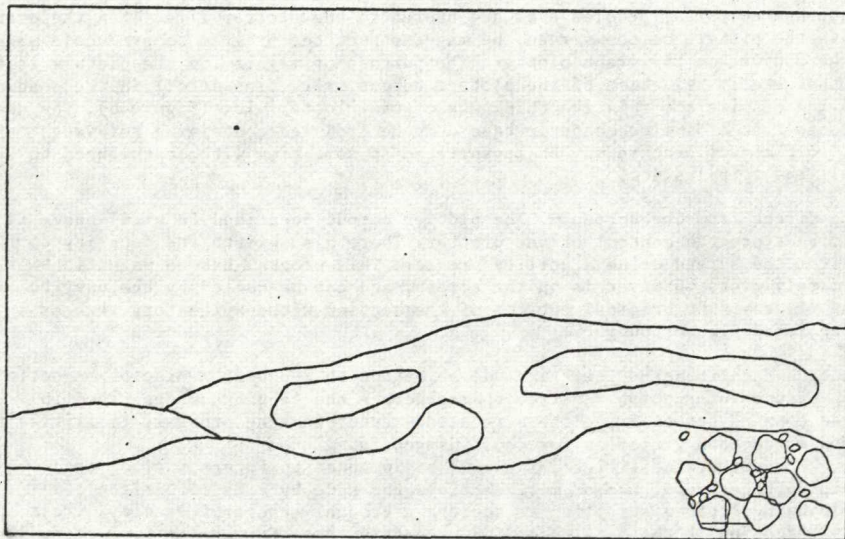

Figure 4a: *Programmed pebble menu with scale selection list and examples of pebbles produced.*

```
    0        2        4   5   6       8   9  10  11
  12  13  14                      19  20      22

         GO
         EXIT
```
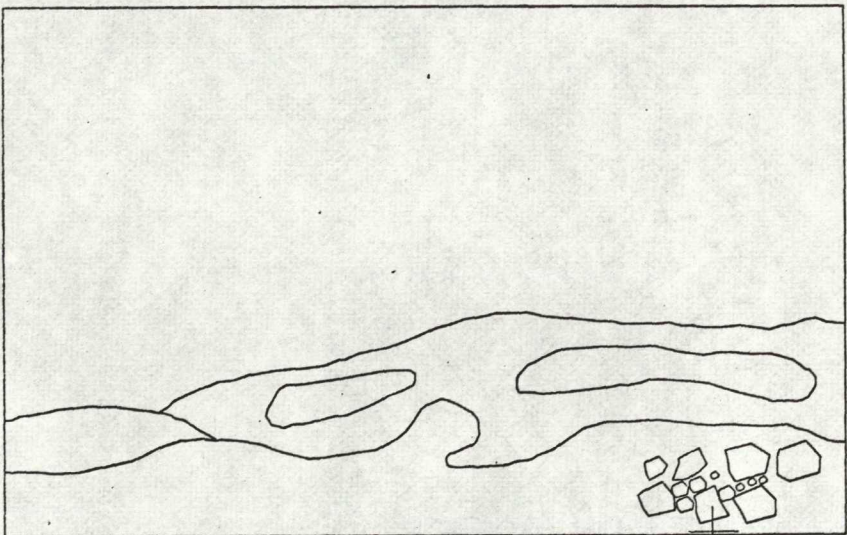

Figure 4b: Random pebble menu with axis selection list: missing numbers denote chosen axes. Note also samples of random pebbles.

```
1 RUBBLE   2 CLAY   3 HUMUS   4 POINT   5 GRAVEL   6 SQUIG

      SIZE 1 -

       1  2  3  4  5  6

      BUT 1 TO SELECT
```
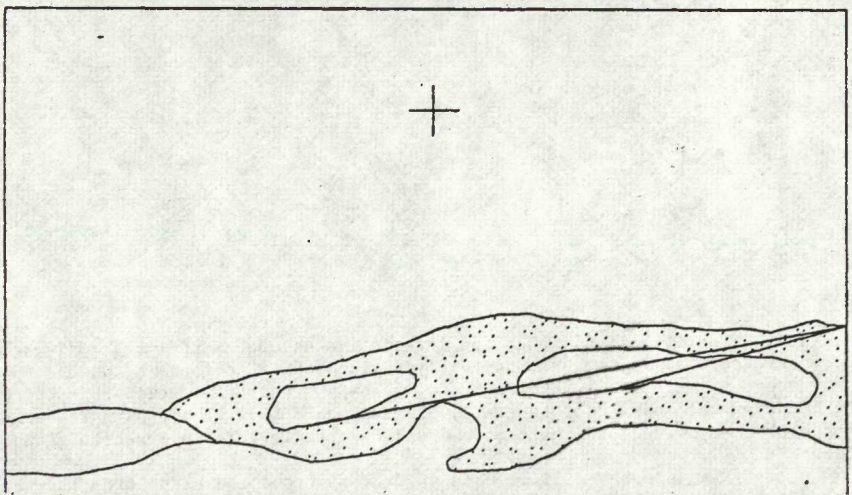

Figure 5: Stipple size selection menu with samples of each size. Note also shaded area with "inner" lens connections.
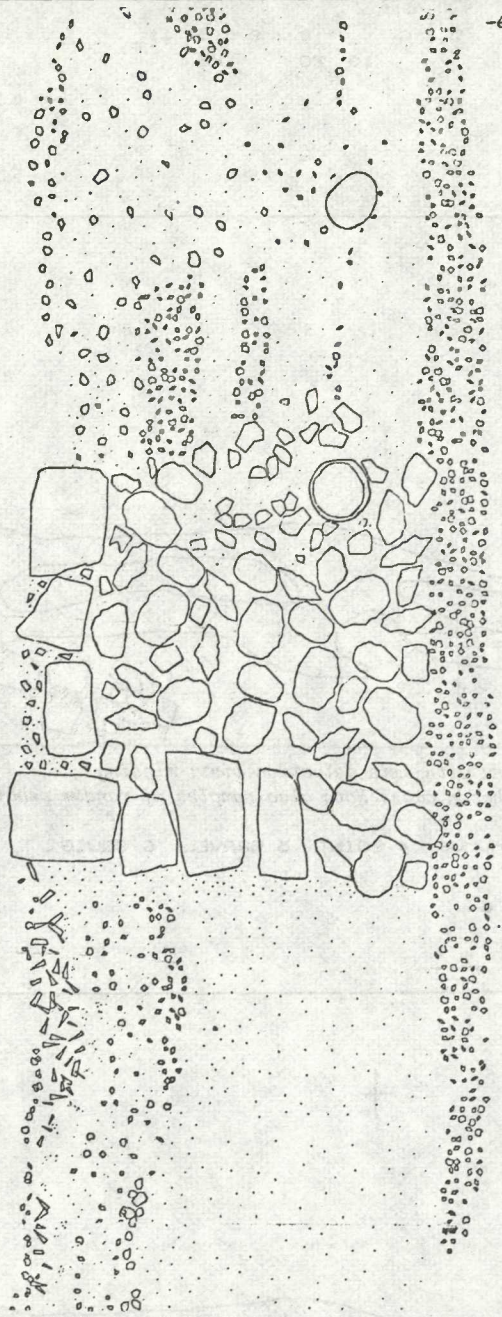
Figure 6: Final output version of a complex section after reduction.

ent of Mediaeval floor tiles. Although the interactive nature of the program is of great use, it is not essential if the user is fairly certain of the effects he wishes to create. The program could easily be adapted to allow the user to specify stipple types and other items on the input data tape. The program could thus be operated remotely with only a graph plotter needed, which is more easily available than interactive graphical facilities.

The program will be used to draw sections and plans from the Greyfriars, Stafford excavation (1976) and this should provide ample opportunity for revision and innovation.