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INPUT AND ANALYSIS OF PROFILES USING A MICROCOMPUTER

Susan Laflin

Computer Centre, University of Birmingham, PO Box 363,
Birmingham B15 2TT

Abstract

The majority of applications of microcomputers to Archaeology to date have used small cheap machines to input textual information. The text has often been compacted due to the limitations of the machine or the requirements of the user. This paper describes an attempt at the problem of shape input from drawings or profiles using a 48k Sinclair Spectrum (£ 130) and the RD digital tracer (about £ 60). Digitised outlines make large demands on the space requirements of the system, involving 100-200 digitised coordinate pairs for a typical profile.

Having input the profile from a tracer, the method then fits a B-Spline curve to the profile and stores only the control points of the B-Spline curve. This reduces the amount of data stored by an order of magnitude since the typical profile can be represented by about 20 control points.

Initially both profiles and control points are stored on tape (microdrive cartridge) for comparison and analysis, but it is expected that only the control points will be needed for long term storage or transfer to other systems. Programs will be provided to produce hard-copy of profiles generated from the control points, together with accompanying text information. A start will be made on comparisons and analyses of the particular cases where the profiles represent pottery.

Computer hardware

The first requirement for a project of this kind is a computer system on which to run it. I shall describe my own system and mention the other options currently available for a Spectrum-based system.

I use a 48K Spectrum, bought 2 years ago. The only difference between it and the Spectrum-Plus is the 'dead flesh' keyboard with which I find I can work quite well. In future only the 48K Spectrum-Plus, which is currently reduced in price to £ 130, will be available.

The next point to consider is the form of back-up storage to be used. The cheapest form is obviously a cassette recorder. The tapes can obviously be used to store either programs or data. This type of storage is very slow. I include the Sprint recorder in this category, although it is faster than most other cassettes. Some people might find this an acceptable compromise between cost and speed.

An improvement on cassette recorders is faster forms of tape storage, namely Microdrive and Wafadrive. Both of these systems use special cartridges containing a continuous tape loop. Both the quantity of information held on a cartridge and the speed of access are much greater than with cassettes. The system I use for this project comprises a microdrive attached to the Spectrum by Interface 1. These are supplied by Sinclair and are compatible with an RD tracer. The cost of Interface 1 and one microdrive is about £ 100. Additional microdrives are about £ 50 each. At present Interface 1 and a microdrive, bundled with some useful software, is available on special offer but may not remain at this special price for very much longer. Replacement cartridges have just been reduced from £ 5 each to £ 2. Each cartridge has room for about 40 complete profiles and 400 sets of control points. It is always a good idea to keep back-up copies of any sets of data. This is slightly easier with two microdrives on your system. In addition to the microdrive connections, Interface 1 also has sockets for RS232 and Spectrum network cables. These can be used to transfer both programs and data between Spectrums with Interface 1. The RS232 may also be used as a connection to some printers.

The other tape system available is the Rotronics Wafadrive. This comes as a single unit containing two drives, with RS232 and Centronics ports, with which you can run most printers. In theory the RS232 connections on Wafadrive and Interface 1 could be used to transfer information between the two systems, but in practice this will not possible until Rotronics produce suitable software. This they seem in no hurry to do. The wafas differ in size from microdrive cartridges so there is no possiblity of exchanging them. They are slightly slower in use but the case offers better cartridge protection than does the microdrive. They are also claimed to be more reliable. With two drives in the unit, it is easier to make back-up copies and the price (£ 130) is quite competitive. Unfortunately, however, the Wafadrive cannot be used simultaneously with an RD tracer since they both use port 31 on the Spectrum edge connector.

In addition to these devices there are a number of interfaces which allow various floppy disk drives to be attached to the Spectrum. I have not used any of them, so cannot discuss them in detail. In general they are slightly more expensive than microdrive or Wafadrive, but each disk holds more information than either a cartridge or cassette. If you wished to store several thousand profiles rather than several hundred then a disk drive is probably more useful.

The next essential item is some type of digitiser. It is possible to trace the profiles onto graph paper and then read off and type in coordinate pairs for every data point, but this is very tedious and rapidly becomes inaccurate as the user becomes tired. The three digitisers available for the Spectrum are the RD tracer, Grafpad and Touchmaster. The last two are supplied as A4 work surfaces together with a stylus indicator. In theory it is possible to place a sheet of paper containing the profile on the work surface and still detect the position of the stylus. They appear robust and well-made, but you would need to check that they satisfy your requirements. They cannot, unfortunately, be used simultaneously with back-up storage. They each cost about £ 150.

I have an RD tracer. This was the only digitiser available when I bought it. I have the A4 version costing about £ 60, but there is now an A3 version available for about £ 70. In the RD the measuring arm is moved over the top of the paper containing the profile, so there is no input problem.

Finally, I have an MCP40 printer/plotter. This can be used to produce drawings of the profiles either from the original digitised points, or from the control points. Although this is supposed to run from any Centronics interface, it is not compatible with the output from the Wafadrive. In order to use this plotter I have had to buy a Kempston interface unit with Centronics output to attach to the interface 1 edge connector. This cost two weeks delay and about £ 40. A plotter is only essential if you want to produce drawings of the profiles.

Thus, my basic system consisting of: Spectrum-Plus, interface 1, one microdrive and an A4 RD tracer would cost about £ 300 if bought in early 1985.

Input program

The RD tracer consists of three hinged plastic rods. One end of the device finishes in a circle with cross-wires. The other end must be rigidly fixed to a support base. The tracer will work on any area about 300 x 210mm. Since the same area need not be used on each occasion, the program initially reads in the four corners of the area used for the first run in a series and calculates the necessary calibration constants. Each profile in turn is then placed within the delimited area and the cross-wires placed over the first point on the profile. The program takes a measurement whenever a letter on the keyboard is pressed. With practice it is possible to input data with one hand moving the tracer head and the other on the keyboard. As the profile progresses, it is displayed on the screen. Input stops automatically when 200 points have been entered. It can be stopped before this by pressing a number instead of a letter.

The next question is: how accurate is this system? The software provided with the tracer takes the average of 5 readings from port 31 to calculate the x and y co-ordinates. I tested this by inputting the same pair of co-ordinates about twelve times. The result displayed on the screen was a large black patch. This I interpreted as the correct value plus an error of 2 or 3 pixel positions in any direction. Changing the program to take the average of 20 readings reduced the error factor to 1 pixel position, but this still left a 3x3 pixel square on the screen, instead of a single point. Increasing the number of readings still further improved the accuracy but slowed down the rate of recording. Taking 100 readings reduced the error factor to half a pixel or a 2x2 pixel square but increased the time to 5sec per reading, which is intolerably slow. I finally decided on 50 readings which gives an accuracy of 2x2 pixels and took 2sec per reading.

Having produced software which maps an A4 area onto the screen at this degree of accuracy and also allows for the problem that the tracer may not be correctly positioned when the reading was taken, the next step is to take a moving 5-point average to smooth the data. If the result is still not satisfactory, the user has the option of re-inputting the curve taking greater care this time, or smoothing the data again. When the profile is satisfactory, the digitised points may be stored in a microdrive file. At the end of each profile the user can either continue or terminate the program.

Fitting program

This program reads a profile from microdrive, fits a B-spline curve to it and allows the user to store the 20 control points which describe the B-spline curve onto another microdrive file. Both Bezier and B-spline curves are widely used in Computer Aided Design because they make it easy to alter the shape of a curve by moving the control points. The curve passes through the first and last control points and may be thought of as a piece of elastic attached to the first and last control points which can be pulled towards all the control points simultaneously.

The advantage of the B-spline curve over the Bezier curve is that it has more local control, which means that moving one point changes only a very small section of the curve. This makes it easier to edit the curve to any desired shape. Details of the equations used to calculate these curves can be found in textbooks on Computer Aided Design.

The curves I have chosen to use for pottery profiles are third order B-spline curves with 20 control points. This means that each point along the curve is calculated from the nearest three control points. These were shown by Hall & Laflin (1984) to give a suitable representation of such profiles. In their design, the user moved the control points around the screen in order to design the shape of the curve. In my program, the position of the control points is calculated in order to reduce to a minimum the area between the calculated curve and the digitised profile. The technique used at present has a very slow convergence time and can get stuck in a local minimum which is insufficiently small. Further work is needed to improve this feature.

Plotting Program

The third program in this series produces plots of the profiles used, on the MCP40 printer/plotter. This has 4 miniature biros mounted in the drawing head and produces output on a roll of paper 110mm wide.

It is possible that the Penman Plotter announced in late 1984 may be sufficiently accurate to act as both digitiser and plotter. Its output is quite impressive, but I have not had the opportunity to check the accuracy of the input.

To conclude, much still remains to be done, but the results produced so far are sufficiently encouraging to continue with this approach. I hope to report on future developments subsequently.

References

HALL, N.S. & LAFLIN, S. 1984 A Computer-Aided Design for pottery profiles. Computer Applications in Archaeology 12: 178-188