Desirable Attributes for a Data-bank of Archaeological Shapes

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Abstract

This paper discusses some possible methods for setting up a computerised bank of data relating to the outline shapes of archaeological artifacts. It suggests some properties that the methods of storage and retrieval should have to make such a system useful to the archaeologist.

In an earlier paper (Main, 1978) the author put forward a case for having a centralised data-bank of graphical information relating to the two-dimensional outline shapes of excavated objects. The paper dealt primarily with the 'typing' of artifacts by consideration of their shapes. This paper will be concerned with the problems of storage and retrieval of such shapes.

One of the problems of current archaeological practices of data-handling is expressed by Whallon (1972):

> 'If archaeology continues to progress as a science, it will inevitably lead to the analysis and re-analysis of data in new ways.......the result of combining lists of variables like this one after another in a single data bank will be an increasingly lengthy, massive, and complex catalogue of annotation classes and descriptors for the data bank, many of whose classes or descriptors will partially overlap or will be contradictory'.

In this paper, it is suggested that for one attribute of an artifact, namely its shape, the problem of what information to store in a data-bank is solvable, <u>provided that</u> the artifact's shape can be adequately represented by a series of one or more two-dimensional sections.

A solution is to store in our data-bank the maximum possible amount of information anyone could ever need to know about an object's shape, i.e. the entire shape. This might at first appear to be either impossible or to require an enormous amount of storage for each artifact. However, let us consider storing what we may call a profile of the object.

Definition. The profile of an object is a mathematical curve in two dimensions which matches the outline shape of the object to within a specified degree of accuracy. Define this allowable error as the profile error.

Normally, the profile error will be extremely small, and to all practical purposes the profile may be taken as an exact representation of the object's shape. However, the existence of this allowable error is crucial, since it allows us to store the profile of an object quite economically. Figure 1a, for example, shows the outline of a Scandanavian Bronze Age razor (the terminal has been omitted). The profile has been generated by passing a curve through 26 points which follow sequentially round the perimeter of the razor. The actual room required to record these coordinates, together with a small amount of extra information relating to corners etc., was 52 computer words. A magnetic tape can hold about 10 million words. Furthermore, the final profile has a maximum deviation from the original drawing of about 0.025%, expressed as a percentage of total perimeter length.

Workers in the numerical typology of artifacts have in some cases gone to remarkable lengths in an effort to capture the 'shape' of the object. Just one example is an elaborate factor analysis by Benfer (1967) of projectile points where he takes no less than 23 measurements from each artifact and even then finds it necessary to define a further two (apparently qualitative) attributes which he calls 'shape of point' and 'shape of base' (See Fig.1b).

It could be argued that both approaches to the recording of shape are essentially the same, since both involve measuring distances between selected points on the outline. However, the economy of the profile method derives from the fact that we record them in an organised way. Information is contained not only in the coordinates

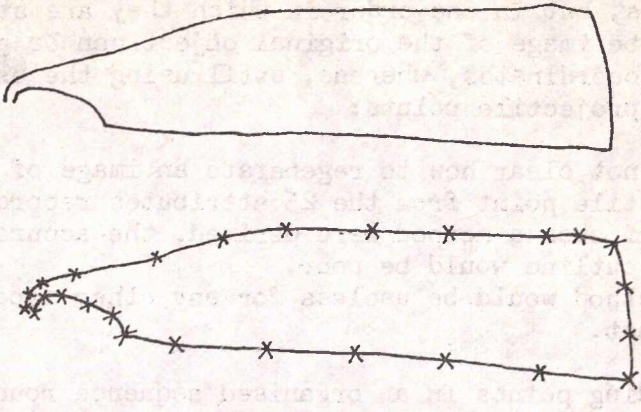


FIGURE 1a

CROSSES SHOW DIGITISED POINTS

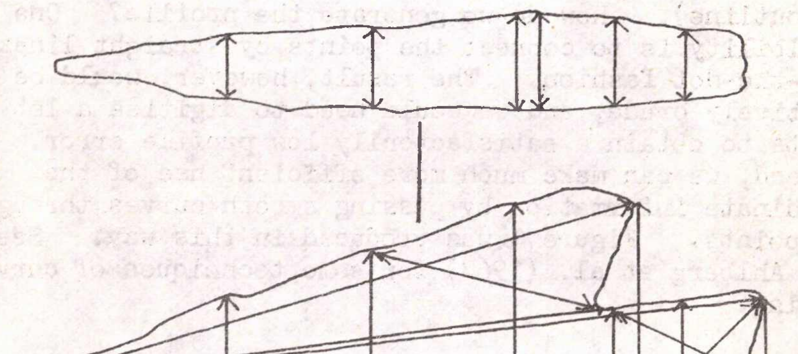


FIGURE 1b

MY UNDERSTANDING OF BENFER'S 23 MEASUREMENTS.

themselves, but in the order in which they are stored. An accurate image of the original object can be generated from the coordinates, whereas, still using the example of Benfer's projectile points:

a) It is not clear how to regenerate an image of the projectile point from the 25 attributes recorded.
b) Even if such a method were derived, the accuracy of the final outline would be poor.
c) The method would be useless for any other type of artifact.

By recording points in an organised sequence round the artifact's perimeter, however, we can begin to define a more or less standard way of recording the shape of any artifact. This consistency of representation is an essential first step in building up a good storage/retrieval system.

Let us now assume that we have recorded a sequence of coordinates round the edge of an artifact (i.e. 'digitised' its outline). How do we generate the profile? One possibility is to connect the points by straight lines in join-the-dot fashion. The result, however, would be relatively crude, and we would need to digitise a lot of points to obtain a satisfactorily low profile error. Instead, we can make much more efficient use of the coordinate information by passing smooth curves through the points. Figure 1a was produced in this way. See e.g. Ahlberg et al. (1967) for some techniques of curve-fitting.

Thus, a probable sequence of operations for generating a profile from a drawing would be

1) Decide on the profile accuracy required.
2) Digitise the drawing (or object). These coordinates, together with any necessary extra information about location of corners, etc. will form the coordinate representation.
3) Use curve-fitting on the coordinate representation to give the profile.

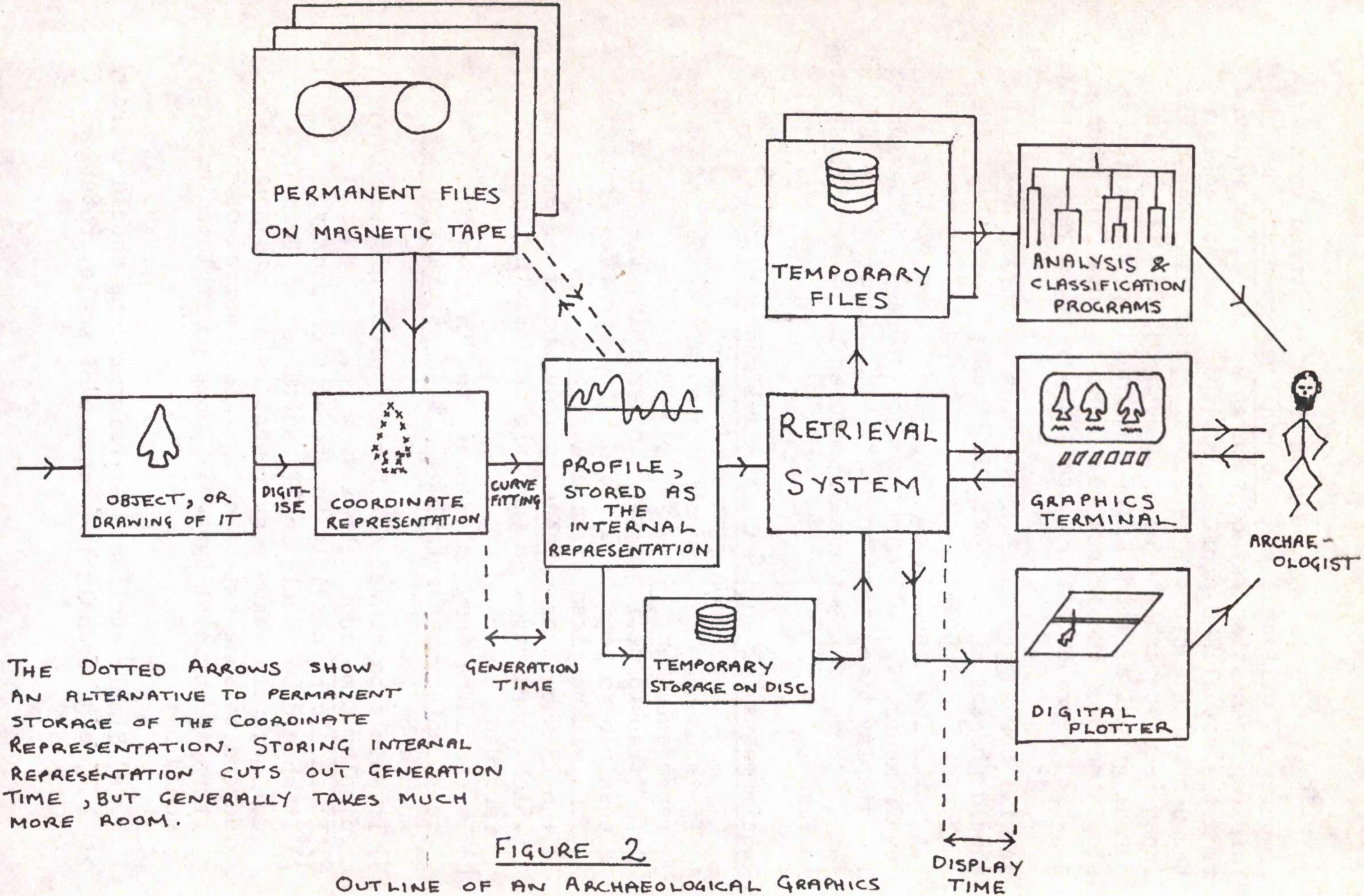
The actual form in which the profile is stored in the computer we will call the <u>internal representation</u> (I.R.) This representation may be apparently quite far removed from the actual 2-D profile, but this need not concern the user of the storage/retrieval system since both his input requests and the results he receives will be in normal graphical form. The internal representation is simply part of the 'black box' in between. The choice of which representation to use, however, is very important.

We will now suggest some properties which an <u>ideal</u> I.R. should possess. It should be stressed that there are any number of I.R.s possible, and in terms of the properties set out below, none is perfect, since some of the requirements e.g. allowing compact storage and having a low display time, tend to conflict. Compromises must be made. Some of the terms introduced below are illustrated in Fig. 2.

<u>Requirements for an ideal internal representation</u>

1) It is unique i.e. a profile can only transform to one representation.
2) The transformation must be reversible, i.e. it must be possible to reproduce the original profile from its I.R. without loss of accuracy.
3) The IR should be <u>reasonably</u> independent of precisely which coordinates on the original drawing were recorded.
4) It should be easy to generate the IR from the coordinate representation. i.e. <u>generation time</u> should be low.
5) It should be convenient for graphical display i.e. <u>display time</u> should be low.
6) It should be possible to store it compactly.
7) It should be 'analytically suitable'. This is a deliberately vague requirement, since its meaning will depend to some extent on what is required of the storage/retrieval system. Some possible advantages would be:

    a) Simple euclidean transformations should be easy e.g. translation, change of scale, rotation.



THE DOTTED ARROWS SHOW AN ALTERNATIVE TO PERMANENT STORAGE OF THE COORDINATE REPRESENTATION. STORING INTERNAL REPRESENTATION CUTS OUT GENERATION TIME, BUT GENERALLY TAKES MUCH MORE ROOM.

FIGURE 2

OUTLINE OF AN ARCHAEOLOGICAL GRAPHICS STORAGE/RETRIEVAL SCHEME

b) It should be easy to define (sensible) similarity measures between pairs of profiles, and to develop new measures for particular needs.
c) Combining, or 'averaging' IRs in some way should be possible. This is useful both for automatic classification and for efficient searching.
d) 'Features' of the original profile should be easily and automatically detectable in its IR.

Why bother with an IR?

The possibility of using the coordinate representation itself as the IR should be considered. It has, however, two very serious drawbacks.

1) A great many points would need to be digitised to attain reasonable profile accuracy.
2) Its analytic suitability is nearly zero. It fails to meet most of the suggested criteria above.

As can be seen in Figure 2 we have now in effect asked the storage/retrieval part of the system to operate exclusively on IRs. Having defined some requirements for the IR, what properties should the storage/retrieval programs possess? These are the properties which will most directly affect the usefulness of the whole system to the archaeologist. Apart from properties which would be desirable of any information retrieval system, there are some objectives specifically relevant to a graphics system designed for archaeological needs:

Objectives for storage/retrieval

1) A high degree of flexibility in the choice of criteria for searching.
2) A facility to define new profiles as segments of existing profiles - that is, a hierarchical system of 'windows' for looking at detailed areas of interest on an object.
3) It should be possible to locate features of the objects, either by referring to previously defined labels, or by automatic recognition of such features.

4) Facilities for generating new, perhaps temporary files from an existing file, containing subsets of the information on the parent file. In particular, it should be possible to generate files of measurements, angles etc. between chosen points on the profiles.

The facility for generating temporary files for special purposes from the permanent files is all-important. These files are what at present the archaeologist has to gene rate manually, with much duplication of effort, from the original objects or published drawings, whereas in our hypothetical data-bank of artifact shapes, there are an infinity of specialised files waiting to be called upon.

References

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