Shen Eric Lim
Simon Stoddart
Andrew Harrison
Alan Chalmers

Recent examples of geographical analysis of archaeological evidence from central Italy

1 Introduction

Geographical information systems have undergone a very great expansion in archaeology during recent years (Allen *et al*. 1990; Lock/Stančič 1995). Important and recent advances in the capabilities of GIS software have opened up new possibilities for data analysis and display. For example, developments in visualisation techniques (McLaren/Kennie 1989; Visvalingham 1994) have provided new approaches in a variety of application areas including archaeology.

The expansion has three, amongst other, important characteristics and concomitant questions. Firstly, readily available GIS software packages, requiring relatively cheap hardware (e.g., PCs), have both facilitated and constrained archaeological use. The packages have been developed for non-archaeological use where, for instance, time is often of a different order of magnitude. Are the current GIS packages entirely suitable for archaeology given their original aims? Secondly, certain assumptions of scale are made in building environmental and archaeological databases for analysis by GIS. For example, the extent to which DEMs provide an adequate realisation of the terrain of a site depends on the availability and characteristics of the original source material (i.e. maps or aerial photographs). How should archaeologists assess the relevant scale for the implementation of a particular project? Thirdly, GIS software has considerably aided the rapid assessment of theoretical questions of a broadly environmental and technological type which were prominent in the 1960s. The data sources are physically and environmentally deterministic and many approaches are technologically deterministic in the way in which certain GIS packages force the use of particular routines/algorithms. In the meantime, archaeological theory has begun to stress other, ideological, dimensions. Can GIS techniques address these more ideological questions?

This paper addresses these three issues in the light of two projects undertaken at the University of Bristol. The first was a project in the Department of Computing Science undertaken to develop a set of bespoke software tools for the exploratory analysis of archaeological and environmental data from the Valley of Gubbio whose first stage has already been published (Malone/Stoddart 1994) and whose analysis is now entering the secondary stage. The second was the work involved in preparing data for a TLTP (Teaching and Learning Technology Programme) project to aid the teaching of GIS, drawing on data from the Nepi area of southeast Etruria, 40 km north of Rome. This is in turn part of a longer term project covering the re-analysis of settlement from a larger area of southeast Etruria, drawing from material collected by the British School at Rome and the Soprintendenza Archeologica per l'Etruria Meridionale.

2 Strategies towards increased flexibility: The Gubbio example

The data for the survey of the Gubbio valley have been published in the form of distribution maps of discrete sites, alongside excavation results, environmental analysis and overall interpretation of the Gubbio valley in comparison with other areas of central Italy (Malone/Stoddart 1994). As outlined in the introduction to the publication, this does not do justice to the information available either from the archaeological or environmental survey. The trial project proposed within computer science was to set up a flexible and interactive system to explore the relationship between pedology and densities of archaeological artefacts (as opposed to discrete sites). As currently implemented the application is relatively simple and allows the overlaying of different types of maps and the graphical representation of frequency of site finds against landscape characteristics.

The aim was to develop a prototype system which would provide a test bed for investigating extensions to the GIS capabilities available in commercial systems. In most cases these existing systems have not been developed with the needs of the archaeological user in mind. For this reason, there is a requirement to specify and implement a set of customised tools for data analysis and display to support archaeological investigations. An important feature of our approach is the opportunity it provides for an archaeologist, computer scientist and geographer to work together in an interdisciplinary framework to develop new techniques for geographical analysis of archaeological data. An important element of this approach is the use of a prototype system to demonstrate these techniques and facilitate communication between potential users and system developers.

2.1 Specification for the Gubbio exercise

A trial area of the archaeological survey was selected for preliminary examination. Environmental data were supplied for the purposes of this exercise in two forms: contour maps and pedological maps. Archaeological data were supplied in the form of quantities of recovered material from point ccordinates which represent an area. The full detail allowed by the field survey collection strategy can be incorporated at a later stage.

These different arrays of information were to be overlayed on top of each other, allowing comparison of archaeological and environmental data. The environmental data can be divided (although not entirely independent) into topographical (height, aspect and gradient) and pedological (soil type, drainage etc.). The maps were to be rescaled and histograms were to be calculated which show these relationships. Figure 1 shows a histogram of finds at different contour levels.

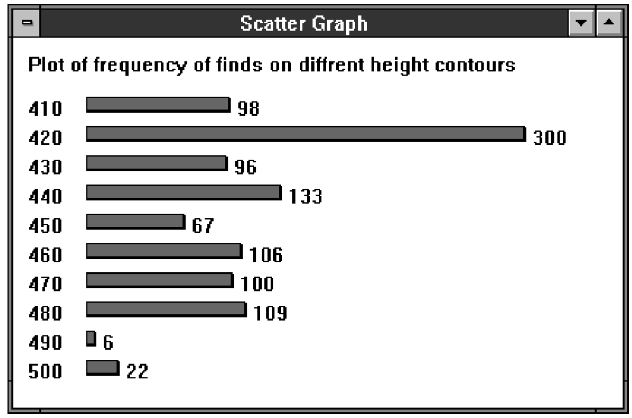

Figure 1. Frequency graph of finds at different contour levels.

2.2 Implementation

The prototype system is PC based, operating under Windows and developed in C++. The user interface is shown in figure 2. An important aspect of the system is the design of this user interface which enables an intuitive easy-to-use point-and-click interface for most of the system functions. Despite recent advances in GIS software, many commercial systems still make extensive use of command languages in which the user has to enter keywords and parameters via the keyboard. The approach developed here makes full use of an object-orientated language within a Windows environment in an attempt to maximise use in an intuitive and fully interactive manner. The use of a graphical user interface (GUI) and visual programming elements allows the user to interact more naturally with complex spatial data such as landscape models.

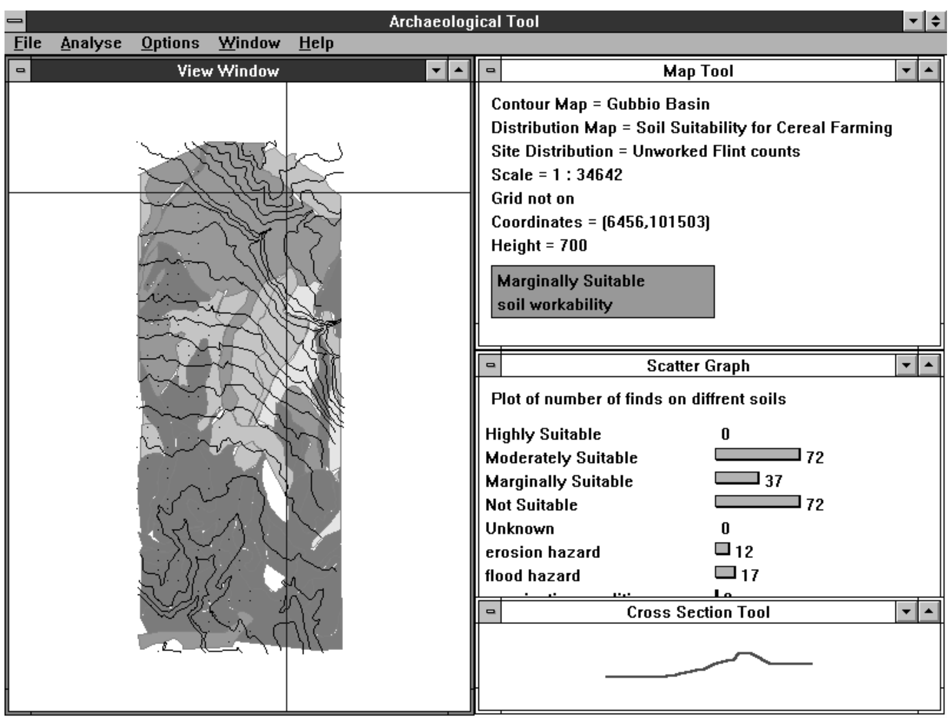

Figure 2. System for analysing information from the Gubbio region.

The limited amount of resources available for the development of this system to date means that we have focused on illustrating a series of possibilities, to stimulate further discussion of the possible uses of GIS in archaeological analysis, rather than concentrating on the development of a polished software system. The system currently scales and rotates maps and plots artefact locations following parameters determined by the operator, as illustrated in figure 3. This is an ongoing project where it is our intention to explore varied presentations of DEMs, with interactive control of interpolation, aspect, gradient and visibility, and to introduce specific types of statistical analysis.

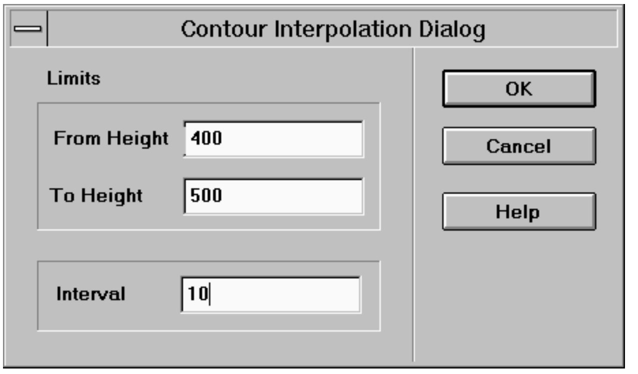

Figure 3. Contour interpolation dialogue box.

3 Strategies towards appropriate scale and ideological analysis: The Nepi example

The grand scale of the study of the South Etruria area is to visualise a changing political landscape over time principally from the middle of the second millennium through a series of major changes: Etruscan and Faliscan state formation, conquest by the Roman Empire, the decline of late Antiquity and the resurgence of the Middle Ages. The specific case study derives from an early stage in this process adopted for teaching purposes in the tutorial of GIS for a nationally funded UK computer aided teaching programme.

The Nepi dataset is characterised by two important facets: a fragmented terrain and a rich, but unsystematic, settlement dataset. The Nepi landscape is volcanic and dissected. The accuracy of the terrain model is therefore crucial. Horizontal distance is no measure of the physical effort in crossing terrain. The volcanic plateaux are apparently flat, but slight differences in height can also have a major effect on intervisibility. The dataset is rich, although in need of considerable data verification. One aspect of the richness is the presence of tomb as well as settlement data. These data have been usually collected by different strategies to the settlement data, but once integrated may allow a new dimension of analysis. It is well known that pre-Roman tombs were placed in visible positions outside towns, but geographical analysis might allow a more detailed analysis of this phenomenon.

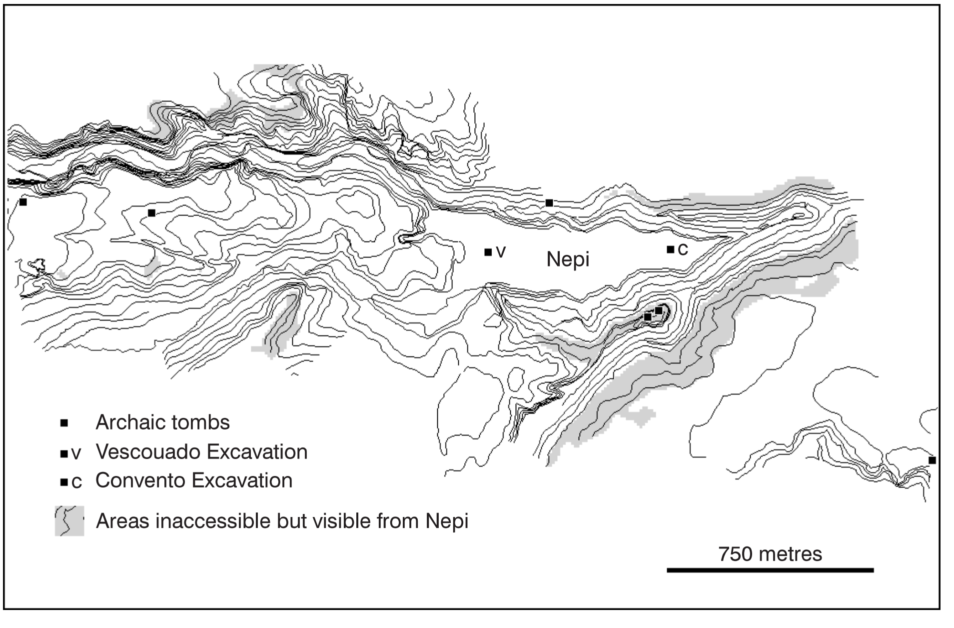

Figure 4. Location of tombs in zones of visibility and inaccessibility.

3.1 Problems of scale

In work on the Nepi dataset, considerable effort was devoted to the elaboration of height data at an appropriate scale. This becomes very important when visibility in this terrain is highly sensitive to small changes in height. The problem in assessing the scale for the analysis became particularly prominent given the difficulty of securing suitable maps which could answer the questions posed by a rich, but methodologically complex dataset. Satellite data are expensive and not necessarily sensitive to the needs of micro-analysis of site location. The most detailed digital data are available at 1:25,000 but still not necessarily sufficiently sensitive and also costly. One approach is to build up coverage from locally available maps at scales of 1:2000 - 1:4000 with concomitant problems of edge matching and error checking. Problems also had to be addressed in replacing cartographic symbols of significant drops in height over short horizontal distances (ravine edges) by digital data. A more satisfactory solution is to constitute the DEM from aerial photographic data, using photogrammetric software and this is currently being investigated.

3.2 Ideology

The rich dataset of tomb and settlement data can be played against each other. Figure 4 shows the concurrence of inaccessibility and visibility from the town at certain points in the landscape. These zones correlate very strongly with the presence of tombs which have a liminal quality in the ideology of the pre-Roman period. More detailed analysis on a broader landscape will allow the precise quantification of this relationship, drawing in minor settlements and roads into the equation.

4 Conclusion

These examples illustrate the need to increase interactivity, sensitivity to scale and broadening of the scope of GIS to less strictly environmental questions. New steps can only be provided by increasing the communication between specialists in different fields of activity and ensuring their mutual understanding.

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Shen Eric Lim
Department of Computer Science
University of Bristol.

Simon Stoddart
Department of Classics & Archaeology
University of Bristol.
e-mail: s.k.stoddart@bristol.ac.uk

Andrew Harrison
Department of Geography
University of Bristol.

Alan Chalmers
Departmenty of Computr Science
University of Bristol
United Kingdom
e-mail: alan@compsci.bristol.ac.uk