Archeologia e Calcolatori
20, 2009, 75-84

ARCHAEOLOGICAL COMPUTING THEN AND NOW: THEORY AND PRACTICE, INTENTIONS AND TENSIONS

1. Introduction

In line with the theme of this Conference, my aim here is to outline the historical development of archaeological computing although my particular focus is the relationship of this development with the role of theory in archaeology. To understand this relationship it is important to consider how understandings of theory in archaeology have changed, particularly since the 1960s. These changes in thinking have been fundamental to much of archaeological practice and have changing implications for how we do archaeology, how we think about life in the past and how we collect, structure and interpret data and draw conclusions.

Embedded within this evolving matrix is the use of computers. Of course this is immediately problematic as the word "computers" includes a wide variety of philosophical understandings, uses and approaches, even so here I will attempt to consider how using computers interacts with theory. For example, can we unpick the complexities in both the development of computing and theory to identify similarities and influences, can we identify how, or if, computers restrict and/or enable certain understandings of theory and its application, what are the intentions behind any particular computer-based analysis?

Since the early 1990s one area of computer usage in archaeology, the use of Geographic Information Systems (GIS), has grown exponentially reflecting the importance of working with spatial data and spatial analyses of various kinds. Although this post-dates much of the theoretical debate taking place during the decades from the 1960s to 1980s, the use of GIS rekindled aspects of those debates albeit within a spatial context and will be used here to illustrate some of the tensions that still exist between archaeological computing and theory.

Inherent within this discussion are sub-texts that will become clearer as I move through the paper. First of all the tension between quantitative and qualitative – using quantitative and qualitative data but perhaps more importantly attempting qualitative understandings and interpretations of the past. Computers are good with quantitative data and at one level all data are quantitative but much archaeological interest is in the qualitative aspects of life, material culture and landscapes. This tension can be seen as a part of the post-modern "crisis of representation" and I will attempt to demonstrate it through the use of GIS in archaeology: is it possible to represent within

computer programs the more subjective and qualitative understandings of what it means to be human?

Fundamental to much of what we do as archaeologists is scale, implicit in all archaeological work although rarely explicitly discussed or theorised, this is the second important sub-theme. We routinely move from pot sherds to questions of social and economic relationships, but to what extent is such multi-scalarity enabled or hindered by computer technology? Again, I will try to address this through GIS and the relationship with different theoretical approaches.

2. Historical development

In the spirit of the Conference from which it derives, this contribution is intended to be an overview, and as such inevitably parts of the discussion have already been assigned to print elsewhere and in more detail, not least in Lock (2003). Even so, I am attempting to raise issues and move archaeological computing beyond its everyday practical applications which are not contexts isolated from theoretical issues but an integrated part of a holistic whole – theory and practice cannot and should not be separated (although, of course, explicit theory can be ignored, and often is). Indeed, it is frequently the tensions that are raised which are as important for the development of the discipline as addressing the original intentions of the analyses themselves.

The traditional sequence in the development of archaeological theory is from Culture History to Processualism in the early 1960s, to Post-Processualism in the late 1970s/early 1980s, the latter two being a reaction to what went before (Trigger 1989). Fundamental to these changing views are the differences in the relationship between data and theory and interpretation (Hodder, Hutson 2003). Of course implicit within this are implications for methodology, for, if we have data on the one hand and interpretation on the other, then it is methodology which provides the framework for getting from one to the other. Not surprisingly then, methodology has changed considerably through these three approaches.

Culture History was deeply empirical with people like Gordon Childe spending large amounts of time collecting data about artifacts and sites. Through inductive reasoning it was felt that interpretation would emerge from all of this data, and, with enough data and enough thinking, patterns of explanation would become clear (Childe 1925). This employed a one-way relationship, from data to theory/interpretation.

Unhappy with the intrinsic subjectivity of Culture History, people like Lewis Binford in the 1960s argued for a more scientific "New Archaeology" largely based on inductive reasoning and the process of hypothesis testing (Binford 1964), subsequently to be called Processualism. This methodology

of setting up a hypothesis, accepting or rejecting it and then moving on to formulate another creates a two way relationship between data and theory. As we will see later, central to this approach was the use of quantification, statistics and inevitably computers.

By the late 1970s/early 1980s there was an increasingly strong reaction to quantification by people who were more interested in the qualitative aspects of life in the past and the social and cultural context of archaeology in the present. Post-Processualism is a generic term for a whole range of approaches, sometimes called "interpretative archaeologies" (Thomas 2000), but in essence their relationship between data, interpretation and the individual in the present is much more fluid and non-deterministic. The so-called hermeneutic spiral creates a web of analytical relationships without a fixed or final result but rather an historical narrative which is explicitly situated within the cultural web of the author.

Obviously the changes from Processualism to Post-Processualism had implications for the use of computers and the relationship between computers and theory. I suggest that this move can be characterized as one towards contextuality and specifically towards data-rich contextuality (Lock 1995). The 1960s saw an emphasis on the "scientific approach", on positivism, i.e. moving towards "an answer", and overall a reductionist archaeology. Through the 1980s we see a softening of positivism and an acceptance that there can be equally valid multiple interpretations of the same evidence, that archaeology is a humanist discipline rather than a science and as such requires rich contextualized data environments capable of producing a two-way narrative between data and author.

This changing relationship is not a simple one and was partly driven by theoretical developments but was also mirrored by changes in technology, in many respects creating a reflexive environment suitable for theory to flourish. While early technologies such as mainframe computers and multivariate statistics were data minimal and reductionist they did match some of the main theoretical concerns of the time which were also data minimal in requirements. Classification and typology, popular in the 1960s and systems modelling in the 1970s, for example, only needed alpha-numeric input in the form of values for a series of variables (Doran, Hodson 1975). With the advent and rapid development of micro-computing and associated software through the 1980s, a data rich and data enriching environment became the norm. Exploratory, non-linear approaches were encouraged through the integration of a range of data types including text, images, spatial data and video enabling a non-confirmatory dialogue with the data.

A final point to be made within this historical overview is the importance of models, a term which has many definitions but here is taken at a general level to mean some form of simplification of a complex reality to enable understanding.

The importance of models has been recognized for a long time in archaeology by both Processualists and Post-Processualists. Clarke (1972) developed a classification of models into heuristic, visualizing, comparative and organizational devices arguing that they were not "true" but part of the hypothesis generation and testing procedure which resulted in interpretation. Subsequently, Shanks and Tilley (1987) have acknowledge the central role that models play in the process of understanding describing them as heuristic fictions.

Of course the use of models and modelling was a fundamental part of archaeological reasoning before the use of computers. Interaction between the data model (variables recorded and the structure of data) and the theoretical model (methodologies to be employed) providing the link between an unknowable past and statements made about the past in the present. What is crucial about using a computer is the introduction of a third link in this chain, the digital model. It is within this that both the data and theoretical models have to be represented; if they cannot, then obviously a computer cannot be used. It is the complex web of interpretative links that are created between these three models that enable data richness to be developed and enabled within today's technology, just as they were responsible for restricting them in the 1960s and 1970s.

3. The importance of scale: from landscape to the individual

Scale is fundamental to much of this argument and while we all deal with scale in almost everything we do as archaeologists it is usually implicit rather than explicitly presented and discussed. Part of the problem with scale is that it can mean different things – being a concept, an analytical framework and a lived experience (Lock, Molyneaux 2006).

The arguments in this paper focus on one important difference, that between analytical scale and phenomenological scale. Take, for example, the ditch of an Iron Age hillfort; this could be represented by an analytical scale of 1:20 in the drawing of its section showing the shape of its cut and the stratigraphy of its fill. As archaeologists we all understand this convention and how to interpret the representation in terms of its construction, dating, fill history and abandonment. Phenomenological or lived scale, however, is something completely different, as argued through Ingold's idea of the "dwelling perspective" (Ingold 1993, 2000). These were monumental structures built to impress with the distance from the bottom of the ditch to the top of the rampart often being several times the height of a person – how would this size affect people who engaged with it either through its construction or through other encounters such as first seeing it? The sociality involved in building such a structure and the physicality of moving around it are the qualitative understandings based on the lived experience of scale (Lock 2007).

Scale also plays a central role in the changing methodologies and modelling of quantitative and qualitative approaches. Through the 1960s and 1970s there was a strong focus on the high-level economic modelling based on methodologies such as Central Place Theory (CPT) and Site Catchment Analysis (SCA). CPT, and its associated Thiessen Polygons, established site "territories", site hierarchies and whole networks of social relationships based on economic interaction (Grant 1986). The economic potential of a site was claimed through its catchment and SCA similarly building into networks of social relationships (Ellison, Harriss 1972). The ultimate of these high-level analyses at the scale of social "systems" was Systems Theory itself, where the different elements of a "society" were often worked out through a computer simulation of interacting subsystems and feedback loops (Doran 1970).

It is normal for the early adopters of a new technology to initially use it to carry on doing the things that they are used to doing, and so it happened to a large extent with GIS in archaeology. Economic influences were modeled through buffering, for example salt and flint resources around Beaker sites in Spain (Baena *et al.* 1995), and Thiessen Polygons around hillforts (Lock, Harris 1996). As this took place more than ten years after the first Post-Processualist writings, it is not surprising that GIS and its applications were criticized as being theoretically poor and substantially environmentally deterministic (Wheatley 1993; Gaffney, van Leusen 1995). The issues raised centred on the people: where are the individuals in these sorts of analysis? Even if prehistoric people could think spatially in terms of maps viewed from above, where everything is visible from a position of nowhere as in these analyses, they still spent most of their time experiencing their physical world from an individual embodied perspective.

One emphasis of Post-Processualism is on this very human scale that is missing from the above, the phenomenology of landscape (Tilley 1994), experiencing the world through the human body and senses, often described as humanizing the landscape. In the early 1990s GIS-using archaeologists were quick to realize that the technology offered some potential for these approaches, firstly through visibility studies, either line-of-site, binary viewsheds or the more sophisticated and subtle cumulative viewsheds, visibility indices and banded or Higuchi viewsheds (Wheatley, Gillings 2000). Similarly movement is very much at the human scale, through least cost paths, least cost surfaces and accessibility indices (Llobera 2000). Both visibility and movement techniques locate the analyst within the landscape thus immediately changing the scale from landscape to the individual while at the same time attempting qualitative understandings rather than quantitative analyses. Since the earliest applications, visibility and movement studies have become commonplace, in fact almost routine, within many GIS applications. A force within this "routinisation", and perhaps a major force, is an element

of technological determinism – both visibility analysis and movement studies are an integral part of many commercial GIS software packages, almost push-button solutions. But such ease of use can become a part of the problem rather than the solution, it can emphasise the existing tensions despite the good intentions of the analysis, and it can accentuate the gulf between the practice and theory of computer applications (Lock 2001). Ways of closing this gap and reducing these tensions are explored below through examples of GIS applications.

My first example is based on the work of the *Hillforts of the Ridgeway Project* where we excavated three of the many Iron Age hillforts associated with the prehistoric trackway known as the Ridgeway (Gosden, Lock 2007). The Ridgeway runs east-west along the top of the scarp slope at the northern edge of the chalk downlands of central England. The Uffington White Horse, the only prehistoric chalk cut figure in England is associated with one of the hillforts, Uffington Castle.

One tension within viewshed analyses is that they are static whereas vision is often associated with movement thus producing visibility patterns that can change in both subtle and dramatic ways over short distances. This combination of visibility and movement we explored through attempting to assess the location of the hillforts, initially by generating a simulated Ridgeway through an east-west biased least cost path which matched very well with the modern Ridgeway (Bell, Lock 2000). At various locations along the modern Ridgeway, although not directly on it, are hillforts and it was remarkable that for each of these the simulated Ridgeway deviated from the modern path to go through the hillfort. This is particularly interesting because, when first constructed in the 7th/6th centuries BC, these sites had opposing east-west aligned entrances suggesting that the Ridgeway is older than the hillforts and they were located on the trackway to incorporate it running through the middle of each hillfort.

By generating a series of near view viewsheds, one every 250 metres restricted to a maximum of 2 kilometres visibility range, along the Ridgeway and then accumulating them to produce a visibility index we attempted to simulate "walking along the Ridgeway". Our interest here was to see whether the hillforts were located to be visible to people walking along the track, the logic predicted that if they were, their position would correlate with the high visibility areas of the index. There is no such correlation, so local, short range, visibility does not seem to have been important within the choices that determined the positioning of the hillforts.

Visibility, of course, is more complex than as suggested by a simple binary viewshed, not least because it works differently at different scales and is often, though not always, reciprocal (Wheatley, Gillings 2000). Shifting scale to explore the long range visibility to and from the hillforts,

the results are interestingly different with Uffington Castle having the largest panoramic view, and being very visible within its landscape, whereas others are not and have much more restricted views. As mentioned, the Uffington White Horse is next to the hillfort, perhaps a tribal icon meant to be seen and, as suggested by excavation, was a central religious place perhaps serving a wide area (Miles *et al*. 2003).

While visibility and movement move the application of computers and GIS beyond the high-level socio-economic modelling typified by CPT and SCA, they still fall short in representing recent theoretical developments. These are initial moves towards a human scale and the representation of qualitative understandings although, of course, there is much more to being human than just seeing and moving. Another focus of Post-Processual interest is the archaeology of practice and the idea that it is through doing things and engaging with the material world that we construct understandings of it. This is interesting here because it chimes with the often claimed multi-scalar potential of GIS. For example, practice can be identified at the individual level, perhaps breaking a pot and discarding the sherds in a pit, at the group level if it happens often in a similar way across a site, and at a regional level if it happens at many sites. The connections between recognising practices and GIS functionality have been explored using one of the hillforts on the Ridgeway as an example (Daly, Lock 2004). At Segsbury Camp, within a single excavation trench containing a roundhouse and pits, a single pit is linked to the fill layers within it and pottery and other artifact counts within those individual layers. The idea here is to try and identify repeated practice, in this case the deposition of various sorts of artifacts in pits. If this is repeated in pits across Segsbury, and in pits within other hillforts, these scales of behaviour could constitute group practices, in this case ritual behaviour in the form of votive offerings.

As mentioned above, attempts to go beyond visibility and movement in any sort of theorised way are rare and my second example of how this may be approached is the work of Vuk Trifković and his case-study of the Mesolithic and Neolithic sites in the Iron Gates Gorge on the River Danube in Serbia (Trifković 2005, 2006). Here the focus is very much on humanizing the landscape: how can GIS be used to link people, landscapes and archaeological theory, how can GIS become central within constructing the narratives of past life that are expected within archaeological interpretations today?

One important aspect of this work is the use of banded, or Higuchi, viewsheds which give a much more subtle understanding of visibility than a basic binary viewshed where something is either in view or not. Landscape features have different visibility characteristics at long, mid and short ranges of viewing. Using Ingold's ideas of taskscape (Ingold 1993, 2000), that is landscapes becoming meaningful through activities, daily routine and practice,

it is possible to link people's activities with different qualities of visibility. Resources such as lithics, wild boars and deer can be mapped through their distributions and territories and then peoples' movements to reach those resources can be modelled. Integral to this modelling are changing visual characteristics, so, for example, the areas where boars could be hunted as seen from near and far distances.

Another important aspect of this work in terms of assimilating theory into practice, is linking the scales of the individual, the household and the landscape through the GIS-based integration of excavated data and landscape reconstruction. For example, at the site of Vlasac the details of individual burials and the plans of houses were used to connect people with their surrounding landscape, both in terms of resources and the tasks involved in exploiting those and in terms of prominent visual characteristics. The orientations of some houses and graves were found to align on very visually dominant cliffs at mid and far distances established through banded viewsheds. Similarly, the "view" from certain graves was interesting in being focussed on the river, perhaps continuing connections established in life through fishing and the importance of the river. Aspects of an individual's biography can be constructed through skeletal evidence, grave goods and domestic architecture, connected through the multi-scalar functionality of GIS with the landscape around to try and model a richer understanding of past life and death.

4. Conclusion

My conclusion is really one of reiterating various points made above. Firstly I would like to emphasize that theory, whether explicit or implicit, is central to archaeological computing. It is through the construction of a thoughtful relationship between theory and the technology that the boundaries of that technology are pushed and extended. The intentions of an analysis should not be determined by what the technology will do but by the archaeological questions being asked and the form of the resulting narrative being sought. This will inevitably produce tensions as the match between GIS and other computer technologies with much recent archaeological theory is not an easy one. These tensions should be made explicit, however, they should be discussed and published, for it is addressing the tensions which will move GIS applications beyond the routine push-button analyses that will dominate if not. Within this general argument I have tried to show that the two subthemes of scale, and incorporating qualitative understandings, are not only central but are beginning to be approached.

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ABSTRACT

This paper is a brief and personal historical overview of the development of archaeological computing and its relationship with changing archaeological theory. I outline the changes in theoretical approaches through the 1960s to 1980s and how these relate to archaeological data, methodologies, the use of models and interpretation. Two sub-themes within the paper are the importance of scale and the representation of qualitative, as well as quantitative, data and interpretations. Through the use of Geographic Information Systems (GIS) applications in archaeology, I discuss various aspects of recent theoretical approaches and how they have been represented through archaeological computing. Because this is not an easy relationship, I suggest that the intentions of an analysis will inevitably produce tensions between practice and theory. It is by confronting these tensions that the discipline of archaeological computing will move forward beyond technologically determined push-button solutions.