– BOOK REVIEW –

COMPUTATIONAL APPROACHES TO ARCHAEOLOGICAL SPACES

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In many ways archaeology is a spatial enterprise. The field practice of archaeology, that is survey and excavation, could be boiled down to locating and recording objects in three-dimensional space. The analysis of archaeological data, whether in the field or laboratory, is often done with regard for spatial distributions of artefacts and associations between them and their depositional contexts. And many archaeological interpretations are oriented around how different spaces were used in the past, from economic or social considerations on why people located settlements in particular places to contemplations on the spiritual or astrological orientations of particular features.

The widespread adoption of geographic positioning systems (GPS) and geographic information systems (GIS) in archaeological survey, excavation, and analysis has been a natural outcome of this. It would not be reaching far to say that most archaeologists today, and especially those working in heritage management, are at least somewhat familiar with these technologies. The methods surveyed in *Computational Approaches to Archaeological Spaces*, however, deviate from commonplace approaches to the manipulation of spatial data in archaeology. GIS plays a supporting role here, but the book highlights methods representing a wider range of digital approaches to the three declared foci of the text: spatial analysis, spatial modelling, and spatial experience.

The chapters are roughly divided up along these lines. In Chapter 2, Bevan and colleagues introduce statistical concepts for assessing archaeological data: point-pattern analysis to evaluate spatial distributions of archaeological features, and aoristic analysis for evaluating temporal distributions. These types of analyses make use of Monte Carlo simulation to determine whether or not a given spatio-temporal pattern falls within expected ranges for a given process with an estimated degree of uncertainty. Examples using distributions of artefacts in the tomb of Qin Shihuang in Xi'an and locations of iron-age sites in the West Bank are used to illustrate how point pattern analysis can shed light on spatial arrangements, while an example from Jōmon period Japan is used to demonstrate aoristic approaches to temporal uncertainty. In chapter 3, Kvamme demonstrates the use of template-matching algorithms (which are often included in GIS packages) for detecting archaeological features in remotely sensed images. By having some ideas about the shapes of things being sought, these algorithms can be deployed over a rendered surface in order to detect similar shapes. Simulated surface data are first used to test and calibrate the algorithms, and these are then applied to aerial photos of earthworks in North Dakota, USA. Chapter 4 focuses on a statistical approach called 'Integrative Distance Analysis', which, as the author, Clark, defines it, measures variation within and between data classes through the application of a series of statistical measures which are 'mapped' onto one another through a data superimposition method. Clark demonstrates the method with an ethnographic dataset from the Northwest Coast of North America. The objective of this approach is to tease out patterning in complex datasets; archaeologists, who straddle the ontological gap between counting shells in eroding middens to grand interpretations of hierarchical societies with elaborate belief systems, arguably deal in these on a regular basis.

On the spatial modelling front, Rivers, Knappett, and Evans discuss network models in chapter 5. The approach advocated here is the use of networks (mathematically tractable graphs of nodes and vectors) to explore different interaction scenarios and consider their ramifications; the authors apply this method to the case of Aegean trade networks, evaluating whether the networks evident in archaeological deposits deviate from an optimal network which the physical geography of the Aegean Sea would dictate. This 'exploratory' approach to modelling is further emphasised in Chapter 6, in which Premo investigates the influence of habitat fragmentation on the evolution of altruistic behaviour within the framework of an agent-based model (ABM) of food-sharing. ABMs simulate the interactions of individual computational 'agents', whose actions over time produce emergent patterning. Premo shows that, by keeping models simple, parameter spaces can be more fully explored and considered in terms of real-world phenomena. In Chapter 7, Barton provides several computational modelling case studies undertaken over the past twelve years, illustrating a range of approaches in GIS and ABM. While the case studies themselves are valuable methodological examples, the greater value of this chapter lies more in its message about changing approaches to modelling in archaeology, emphasising a move away from using simulation to reconstruct past archaeological systems, to using archaeological data to test models developed largely in the computational sphere (this reflects a trend also noted more generally for archaeological simulation in a recent survey study; see Lake 2014).

But as computational models become more commonplace, there is greater hazard of models being applied without considering their underlying assumptions. For example, Optimal Path (also called 'Least Cost Path') models are commonly used GIS functions that calculate, based on a set of known landscape parameters such as slope or landcover, the relative costs of traveling different paths

between two points on the landscape; however, different algorithms can be used to assess costs which may have significantly different implications for the evaluation of an optimal path. In chapter 8, Herzog dissects the method, identifying some key assumptions of the model which are often under-considered when these are used in a 'push-button' fashion within GIS platforms. This chapter serves as a good reminder that the user-friendliness of software should not deter the archaeologist from understanding the rudiments of the methods they apply.

This leads into three chapters on a topic very frequently investigated in GIS-based archaeological studies: visibility. In Chapter 9, Lake and Ortega argue that computing constraints that once limited the application of viewshed analyses are now overcome, demonstrating this by computing nearly 30,000 viewsheds on 529 Neolithic and Bronze Age stone circles in Great Britain on a standard desktop computer. The authors then conducted a series of statistical assessments and Monte Carlo simulations to assess the probability that the locations of stone circles were chosen to facilitate visibility of the surrounding landscape. However, most visibility methods used in archaeology were developed in tandem with GIS, and are by and large two-dimensional affairs. In Chapter 10, Paliou discusses methods for the evaluation of visibility in three-dimensional spaces, specifically focusing on 'visualscapes' in urban and architectural settings where terrain-based viewshed methods are of limited use. Chapter 11 also discuss how 3D spaces, once digitally rendered, can be fruitfully analysed. Earl and colleagues discuss their work at the Roman site of Portus, where the University of Southampton holds a field school and extensive work has been done in building graphical reconstructions. Using lighting simulations within a 3D reconstructed basilica, building design is considered in terms of patterning in light and shade at different times of day or given different aesthetic components (for example, curtains). The methods employed in these chapters consider more experiential characteristics of space, but where assumptions about real past spaces are made explicit within the modelled space rather than remaining confined to the imagination of the archaeologist.

Applying the methods discussed in these chapters requires some degree of technical expertise, but that technology and expertise also makes their verification by non-specialists more difficult. In the final chapter, Ducke discusses the issue of reproducibility in computational analyses, which archaeology is only beginning to come to terms with in the digital age. Until recently, software packages capable of handling large scale datasets were prohibitively expensive, making the reproduction of research extremely difficult. Freely available open source software alternatives are becoming increasingly more sophisticated, facilitating greater degrees of reproducibility; but of course, this also depends on the willingness of researchers to share data, code, and methods openly. The call for reproducibility in computational research is a fundamental one which has the ability to make real advances toward equalising the relationship between archaeologists in 'theory-and-methodology producing' and 'theory-and-methodology consuming' parts of the world (see Mizoguchi 2015).

For regular readers of JPA, spatial analyses using GIS should be familiar; however, other computational approaches to space have been more sparsely applied in the region. Computer simulations of voyaging have a long history in Pacific archaeology, and many have punched above their weight (e.g. Ward *et al*. 1973; Irwin, Bickler, and Quirke 1990), but so far these have been almost exclusively aimed at the settlement of the Pacific (although see Montenegro *et al*. 2008 for an exception). Network analyses and three-dimensional spatial reconstructions are currently rare in Pacific contexts, but the numbers of applications are growing (for the former, see Terrell 2010; for the latter, see Mulrooney *et al*. 2005; Jones *et al*. 2015). The potential for the expansion of applications of network-oriented approaches is particularly striking given the long-standing regional interest in prehistoric exchange and interaction networks (e.g. Kirch 1991; Weisler 1998; Walter *et al*. 2010). And while it is not hard to imagine how the methods presented here might be useful for research purposes, simulations and three-dimensional reconstructions in particular could also be of tremendous value in terms of public outreach and education.

While its running theme is computational approaches to space, this book is neither a textbook treatment of the subject, nor exclusively a collection of case studies. Some chapters are more case-oriented than others (for example, Premo's study of the evolution of altruism in Chapter 6) and a few offer quite detailed methodological instructions (such as Herzog's treatment of optimal path models in Chapter 8), but overall chapters generally provide basic overviews of the methods surveyed and some general ideas about how they can be applied. As such, this book would be of limited utility to someone with a specific methodological goal and perhaps too methodological for a general interest reader. It is primarily a sampling of cutting-edge techniques in the realm of spatial computation in archaeology, and would likely be of greatest benefit to researchers who are seeking digital solutions to a given spatial problem, or someone with an established specialisation looking to broaden their methodological palette. It is not hard to imagine this book being pulled from a shelf and loaned out by a supervising academic to a graduate student with the instruction: 'Have a look at some of these.' For those already inclined towards spatial analysis or those merely curious about the potential of spatial approaches to address archaeological questions, this book is a treasure-trove of methods waiting to be applied.

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