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Geospatial analysis as experimental archaeology

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ABSTRACT

In the more than 25 years since Allen et al. (1990), GIS and other kinds of geospatial analysis have become tools used almost as ubiquitously in archaeology as the trowel and the total station. However, can we consider it a "paradigm-shifter?" One fundamental distinction between archaeology and other scientific pursuits is the lack of a formal experimental procedure for testing large-scale hypotheses. We can experiment with some material culture methods or archaeological 'models' on a 1:1 analogue scale, but we rarely examine ideas about larger mechanisms; particularly those that encompass wide geographic areas in a formal experimental way. Geospatial technologies give us new tools and abilities to recognize patterns in archaeological sites and landscapes. Nevertheless, have they truly changed the way we make the transition from material remains to interpreting human behavior? We tend to present geospatial research that is either descriptive or methodological in nature rather than interpretive or explanatory. What is missing is the recognition that the 'patterns' we can see are an incomplete and abstract product of past human agency or behavior that cannot be worked backwards from, but must be envisioned as mechanisms in action. Within a mechanistic framework, we can experiment with archaeological research questions in much greater depth and detail, in a manner more akin to psychology than the 'harder' sciences. Although these techniques bring with them some theoretical assumptions and methodological challenges, their outcomes can provide logical and convincing visualizations of dynamic phenomena in enlightening ways. Presented here are several brief examples.

1. Introduction

This volume has set out the task of trying to define where we are going with our recent advances in computational and geospatial analyses. There is no doubt that our ability to examine and evaluate vast quantities of digital data is becoming ever more affordable and achievable since the publication of Allen et al. (1990) more than 25 years ago. Has this effectively changed the theoretical and methodological paradigms for archaeology as a discipline? Alternatively, are we merely entering a new playing field where coders and computer scientists devise the rules of the game rather than archaeologists? Given the technological complexity, how much freedom do we have to apply the theoretical ideas developed over the last 50 years in the discipline? How should we apply those ideas? Do we even know yet?

My contention is that geospatial technologies are not fundamentally *changing* the way we think about humanity, in the past or today. I realize that this may be a controversial statement, and one that would engender a great deal of scepticism given the enormous developments in technology during the last few decades. My point however, is that we still think about archaeology and the past in mostly the same ways that we did before we had such technologies. We still look for patterns in artifacts, features, and sites. We still define 'archaeological' landscapes by the presence of patterns of these same things. The 1960s and the 1990s were eras that saw dramatic changes in the fundamental nature of archaeological inquiry. New approaches changed what questions we were asking about the past and how or why we asked them. These were dramatic shifts in the paradigm, and archaeology evolved in new directions. Significantly, the shift affected not just the tools of archaeology but also the foundations of the discipline itself.

I do not see this occurring today. If anything, there seems to be (anecdotally) a greater shying away from discussing theoretical frameworks of archaeological inquiry with a far higher proclivity towards methodological discussions or purely descriptive presentation of project results. Geospatial technologies are providing clarity or detail to the questions we are asking about past people,

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but we still focus on artifacts, sites, features, and patterns of those things; the 'ordinary' matter of humanity. There is though, a vast amount of the metaphorical 'dark matter' or 'dark energy' of humanity (that which is not preserved in the archaeological record) tantalizingly coming into reach.

Yet, the questions we ask are not fundamentally changing, and therefore I believe the paradigm remains stubbornly in place. Remote sensing techniques are an excellent case in point. One could say that the resolution and detail provided by recent advances have initiated new perceptions about settlements and landscapes, and consequently stimulated new questions for archaeologists to ask. However, these questions are inevitably about the nature and distribution of material remains and not at all about what it even means to invoke the words 'site' or 'settlement' and how they actually connect to human behavior or actions. By their very nature, remote sensing methods highlight anomalies, objects, or large-scale patterns of archaeological materials (i.e. the physical record) and often fail to contribute towards a discussion of the things that they cannot observe, such as human relationships, social landscapes, and cognitive decision-making. I do not mean to imply, that it has to be that way, only that we are not witnessing as much paradigm shifting as we think we are.

2. Finding the middle ground

Nevertheless, geospatial techniques are giving us the ability to experiment with archaeological research questions in new ways. What we have long theorized about in a qualitative manner we can now examine quantitatively. Many of our traditional archaeological 'models' for past human behavior rely on generalized statements, broad assumptions, and mostly untestable hypotheses. Ideas about the adoption and spread of agriculture, domestication, population movements, sociocultural collapse, agency, being, and entanglement, etc. *ad infinitum*, derive from qualitative assessments of archaeological sites, assemblages, and landscapes with a near absence of causality-based or quantitative testing regimes. This is because our interpretations of dynamic human behaviors typically come from fragmentary, static, material remains and we have very few opportunities for seeing, or simulating, past causal processes in action.

The unrealized dream of Processualism in some senses was the holy grail of Middle Range Theory. In Binford's (1977; 1983) conception this consisted of four components:

1) Documenting the causal relationships between human behavior and material remains,
2) Recognizing signatures of those behaviors in the archaeological record,
3) Inferring past dynamics from observations of those signature patterns, and
4) Evaluating those inferences for their explanatory value.

Middle Range Theory was successfully critiqued or re-evaluated in a number of ways (e.g. Raab and Goodyear, 1984; Schiffer, 1985; Pierce, 1989), and Processualism itself much more comprehensively. Perhaps though, we should consider that, at its heart, Middle Range Theory is the formalization of a methodological approach, and not so much a theoretical one. The key use of the phrase 'explanatory value' leaves open the implication of the kind of explanation that is being sought; e.g. predictive, causal-mechanical, or thick description.

In other words, the objectives of Middle Range Theory are embodied in the experimental process and I contend that adherence to traditional Deductive-Nomological (Hempel and Oppenheim, 1948) or Inductive-Statistical (Hempel, 1965) covering law explanations is not obligatory; as Binford had imagined. Any number of theoretical ideas or objectives may drive it, but it may also be entirely contextual and not reducible to predictive principles or generalizations at all. The ultimate goal is to develop an understanding of, or at least ideas about, the dynamic human past, and to do so in a way that is consistent and convincing to the intended audience. This is the goal of all theoretical approaches. Geospatial techniques and methods are but a set of tools, and we need to learn the best ways in which to apply them for the explanatory objectives at hand. To do this we first have to understand the data itself.

3. Data and metadata

Humankind has always generated data, *not just physical data*. Some of that data makes its way to us in the current age, in various forms. As archaeologists, our formal datasets are excavated material remains, historic documents, and ethnographic information. Nevertheless, we all know that the spatial and temporal contexts of those materials is often far more important to our understanding of the past than the physical objects themselves. That context is not the formally generated datasets *per se*. Rather it is metadata; or data about data, the locations of data, its proximity to other data, its place in time, statistics about that data, the absence of data, etc. This may be quite distinct from computational metadata however; or data about the digital nature of the computer files that store archaeological information, which are important for other reasons. There are in fact many layers and kinds of metadata, and geospatial information is merely one of them.

In the past, we have had severe limitations on how we could handle archaeological metadata. Identifying and mapping geospatial relationships was difficult and the results were typically physical maps and notes, subject to a high degree of both recording and interpretive errors. Combining multiple forms, or instances, of spatial data was nearly impossible prior to the advent of GIS. You could physically see and hold most of what we dealt with archaeologically; both the material remains and the spatial information about them. However, geospatial data was much harder to collect and work with than the material remains, and its accuracy was often in question.

Today, we have new hyper-accurate and fast techniques for recording spatial data, almost infinite data storage, and a variety of software applications for combining, manipulating, and analyzing it. Our ability to deal with archaeological metadata is vastly improved over what it was even ten years ago. Undoubtedly, that ability will continue to improve in the future. However, applying that data in a meaningful and specifically theoretical way is still difficult. Are we intending to recreate the past? On the other hand, is computational modeling a pedagogical tool? Developing models and simulations that fit an existing computational framework does not abrogate the application of theoretical perspectives (cf. Whitley, 2016a; 2016b). Yet we often get so involved with the details of analysis that the objectives and assumptions are not clear.

4. Experimenting geospatially

The great benefit of the application of computational geospatial analyses is that we can both *model* and *simulate* a vast array of archaeological concepts and ideas on a representational scale, as if we would with traditional analogue experimental archaeology. We can also begin to apply representations of human action or mechanisms that go beyond material culture. In other words, the outputs may not be models of archaeological material remains, or predictions for where they might occur, but visualizations of relationships between people and places, economic stress, trade and

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