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What can GIS + 3D mean for landscape archaeology?

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ABSTRACT

Until recently Geographic Information Systems (GIS) have held center stage in the archaeologist's geospatial toolkit, and there is no doubt that archaeologists have moved beyond the map—but into what? In the early years, criticisms voicing GIS as environmentally-deterministic were abundant. What methods and tool have archaeologists used to overcome these criticisms? New geospatial technologies such as airborne lidar and aerial photogrammetry are allowing us to acquire inordinate amounts of georeferenced 3D data— but do these 3D technologies help overcome criticisms of environmental determinism? Together—GIS + 3D— can link georeferenced 3D models to underlying data adding a ground-based humanistic perspective lacking in the bird's eye view of traditional GIS. This paper situates GIS and 3D within a semiotic framework to offer some ideas on using 3DGIS to intertwine environmental and cultural factors to work toward new approaches for landscape archaeology.

1. Introduction

Until recently, Geographic Information Systems (GIS) have held center stage in the archaeologist's geospatial toolkit, and there is no doubt that archaeologists have moved beyond the map—but into what? Old questions persist and new questions arise as we push boundaries and explore new horizons— questions such as: Is GIS more than a tool? Is GIS contributing to theoretical advancements in archaeology? These are big questions. To narrow the scope, I have set forth four objectives: (1) briefly summarize criticisms of GIS as “environmentally-deterministic”, (2) provide some approaches archaeologists have used to attempt to overcome such criticisms, (3) bring 3D technologies into the discussion, and (4) finally explore what GIS + 3D can mean for landscape archaeology.

GIS allow us to capture, store, manipulate, analyze, and visualize geographic data. Since 1960 with the development of the first operational GIS, i.e., Canada Geographic Information System (Tomlinson and Toomey, 1999), people have been using GIS to integrate seemingly disparate data sets and generate new data as well as perform complex spatial analysis resulting in new knowledge. At first glance, GIS seems tailor-made for archaeology because the discipline is inherently spatial; and in fact, archaeologists were some of the earliest adopters of the technology. In the late 1980s and early 1990s, archaeologists increasingly used GIS as a part of their toolkit, not only to manage archaeological data, but also to identify spatial patterns that potentially correlate to human behavior (e.g., Allen et al., 1990; Lock and Stancic, 1995). Early analytical applications adhered to processual goals such as predictive modeling—using GIS to calculate the probability of locating archaeological sites and correlating variables to human behavior (e.g., Kvamme, 1999; Lock and Harris, 2006; Wescott and Brandon, 1999). However, soon GIS became criticized for being environmentally deterministic; predictive models were criticized because they tended to rely on environmental variables at the expense of “social” variables (Cope and Elwood, 2009; Daly and Lock, 2004; Gaffney and van Leusen, 1995; Kwan, 2002; Schuurman, 1999; Thomas, 1996). In defense of these early applications, GIS tend to preference environmental criteria for two reasons. First, GIS was developed as quantitative software; however, many of the cultural data with which archaeologists deal are qualitative in nature (e.g., Allen et al., 1990; Lock and Harris, 2000; Leszczynski, 2009). Second, GIS-ready environmental data (e.g., soil, geology, vegetation, hydrology, and terrain) are more readily available. In contrast, social data must be collected, classified, and then converted and/or linked to GIS data before it can be used —and this process is never straightforward often requiring new GIS tool development (e.g., Agugiaro et al., 2011; von Schwerin et al., 2013).

In the 1990s, post-processualism raised questions about the sterility, so to speak, of processual approaches. Post-processualism

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sought to bring human agency, symbolism, cosmology, indigenous perspective, gender, cognition, and more interpretative aspects into archaeological studies (e.g., Conkey and Gero, 1991; Hodder, 1985; Trigger, 2006). Along these lines, phenomenological approaches to landscape began to take shape that contrasted first-person experience through self-reflective bodily experience to a bird's eye view so typical of GIS (Tilley, 1994); in a sense, bringing the qualitative vs. quantitative debate to the forefront. Visibility analysis in GIS proved ground-breaking to integrate computational approaches with phenomenological goals affording more reflexive and experiential methodologies (Van Leusen, 1999; Wheatley, 1993). However, GIS practitioners made obvious that GIS has its limitations in regard to human perception because it tends to create abstract realities that reduce human complexity (Gaffney and van Leusen, 1995; Gillings and Goodrick, 1996; Stead, 1995). For example, viewshed applications "critically confuse the concept of 'vision' with that of 'perception', and in so doing simplify once again the full complexity of people-place relations and dynamics" (Gillings and Goodrick, 1996). To counter such shortcomings of GIS, Gillings and Goodrick (1996) proposed integrating GIS with VRML (Virtual Reality Modeling Language) to facilitate "a sensual and experiential mode of engagement with the material remains of the past."

More recently, Marcos Llobera (2012:504–505) tackles this problem in his article "Life on a Pixel: Challenges in the Development of Digital Methods Within an "Interpretive Landscape Archaeology Framework". To overcome, or move beyond, criticisms that the quantitative nature of GIS divorces archaeology from human experience, Llobera contends that we need middle ground/bridging concepts to: (1) situate models and methods within context-rich narratives, (2) explore how processes play out within particular contexts rather than seek universal norms of behavior, (3) shorten the gap between empirical information and narratives, and (4) generate multiple scenarios as feedback to results. In other words, as archaeologists we cannot simply use GIS as a deductive tool but rather we must also use GIS as part of an inductive PROCESS, where we tack back and forth between various data and methods to formulate new hypotheses and as a consequence provide fertile ground to drive theoretical growth (Daly and Evans, 2006; Landau et al., 2014).

Some GIS approaches can be rightly criticized for being environmentally deterministic and overly quantitative due to both practical issues involving data and software availability, and the underlying theoretical assumptions driving research objectives. Some of these limitations, however, can be overcome and cultural information can be integrated into GIS analyses if they are explicitly grounded in archaeological and/or social theory and interpreted within a society's particular historical, sociopolitical, and ideological circumstances (Llobera, 1996; Lock, 2000; Lock and Harris, 2006). To overcome these shortcomings, archaeologists cannot employ GIS as an unbiased tool. Instead, they need to think of GIS as a form of practice that must be situated within archaeological theory; they need to use theory-inspired cultural variables in GIS—realizing that places are socially created as well as linked to both space and time (Tschan et al., 2000).

2. Semiotics: a bridging concept for landscape archaeology

Space is often defined as locations with no social connections; in contrast, places are imbued with human meaning(s) (Relph, 1976; Tuan, 1977). However, space is not a blank canvas serving as a neutral backdrop for human action (Tilley, 1994), we all transform spaces into places in relation to physical surroundings and cultural/personal experience (Hu, 2012; Wheatley and Gillings, 2000). Early social theorists such as Morgan, Durkheim, and Mauss posited evolutionary and functional theories to explain the roles of bounded spaces and built forms (i.e., built environment) in social life (Durkheim and Mauss, 1963; Morgan, 1965). In reaction to these theories, symbolic approaches such as structuralism emerged that understood architecture and space as reflecting cultural rules (Lawrence and Low, 1990; Lévi-Strauss, 1963). Pierre Bourdieu (1977) and Giddens (1979, 1984), posited practice-oriented perspectives to insert human agency into the production and reproduction of social meaning and relations; however, such approaches continue to treat spaces as neutral backdrops for social practice (A. Smith, 2003). Semiotics—a theoretical framework that views cultural phenomena (including built forms and bounded spaces) as systems of signs or social configurations that convey culturally constructed meaning (Burks 1949)—seeks to make space an active agent in cultural re(production).

In this article, I explore the potential of semiotics, as one way, to explicitly link GIS data and methods to social actions. Semiotics is grounded in the belief that to understand the *what*, it is necessary to understand the *how*. This means that archaeologists must investigate the mechanisms that were used to send specific messages— whether ideological, political, economic, etc.—and GIS provides some of the tools for such analysis. According to Charles Sanders Peirce (Buchler, 1978), a triadic relation exists among signs, objects, and interpretant. In this relationship objects become signs when, and only when, individuals assign meaning to them. This means that for archaeologists to reconstruct the meanings of ancient signs, they must take into account who is creating these signs and whom these signs are targeting. Senders, or addressers, send messages via signs to receivers, or addressees (Goffman, 1983; Jakobson, 1980; Parmentier, 1987; Silverstein, 1976). Archaeological remains provide evidence to help identify the identity of both senders and receivers; however, identifying senders is often more straightforward than identifying receivers, particularly across vast landscapes. GIS provides tools to identify receivers and ultimately to better understand how people communicate with one another.

Furthermore, semiotics asserts that people have interactive relationships with the built environment— comprised of building forms and bounded spaces—both creating their surroundings and simultaneously finding their behavior influenced by them; the ways in which different groups of people respond to these "signs" influences how they interact in a landscape. Along these lines, semiotics provides two fundamental concepts—audience and indexicality that can be used to bridge GIS and social theory. The concept of audience is important because culturally constructed messages are created with a particular audience in mind, which means that people are targeted. One way this can be accomplished and identified in the archaeological record, for example, is via architecture in the form of barriers and facilitators that either inhibit or facilitate social interaction among different social groups.

The concept of indexicality is relevant because it provides an ideal perspective for investigating how architectural arrangements worked together to convey messages and direct sociopolitical interaction. Indexicality is based on the concept that adjacency and spatiotemporal context are critical elements in communication. Architectural indexes are signs that help to structure how people negotiate their physical surroundings (Buchler, 1978; Gardin and Peebles, 1992; Jakobson, 1980; Parmentier, 1987; Preucel and Bauer, 2001). Components of the built environment such as buildings, roads, walls, and stairs are often aggregated and organized into spatial configurations (indexes) that convey meaning. These components can be arranged in different ways; however, their meanings change depending on what is placed next to what and on their larger spatial context.

These ideas strongly relate to a structuration approach (Llobera, 1996, 2001; Daly and Lock, 2004) focused on *how* landscapes can

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