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Historical GIS

Enabling the Collision of History and Geography

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Explaining much of what exists today or has happened in the past can be approached from both spatial and temporal perspectives. Often overlooked by traditional methodologies and paradigms, the locational element can provide significant new analytical perspectives and explanations that open up fresh opportunities for research. The use of Geographic Information Systems (GIS) technologies in the pursuit of historical research is emerging as an intriguing approach to understanding our world and its underlying historical dimension.

Keywords: *historical GIS; geographic data; GIS*

Space and time characterize most of what individuals and governments do on this planet, let alone the universe. Just about every static or dynamic feature, phenomenon, or trend has a locational and a historical component attached to it. Recognition of this fact has reinvented the nexus of historical and geographical perspectives. Indeed, when a traditionally nonspatial research issue is set in the context of its locational characteristics, that problem is often metamorphosed into a new and clearer light through the visualization of geographic patterns in the data. The expansion of such spatial perspectives into other disciplines is largely the result of the greater use of digital information and the application of a methodology known as Geographic Information Systems (GIS).

History is one of those disciplines. Following generations of research primarily focused on the history of those whose names we already knew, social historians are reimagining the lives of those who left us little by way of explaining themselves to us. This has broadened to include more geographically influenced fields of study such as regional or environmental history (Knowles, 2002; Owens, 2007). As GIS technologies improve the ability to analyze changes over both time and space, disciplines have begun to converge. From the perspective of a noted historian:

> Geography is the study of spatial differentiation, history the study of temporal differentiation. Historical GIS provides the tools to combine them to study patterns of change over space and time. (Knowles, 2002, p. xii)

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Historical research examining the lives of ordinary people—whether these are townsfolk in ancient Teotihuacán, Medieval merchants crossing the Mediterranean, Native Americans engaging in trade, slaves serving masters in tobacco plantations and cotton fields, or pioneers living at the margins—demands the ability to synthesize processes in dynamic and nonlinear ways. This requires the ability to manage large arrays of data and variables (Gregory, 2002). In addition to written documents, historical maps record locational attributes, fundamental to reconstructing historical settings, and thus display data not often contained by other written sources (boundaries, landscape features, etc.) or that have been destroyed by the progress of time and development (Rumsey and Williams, 2002). This capability of GIS to manage, analyze, and visually portray spatially referenced data is leading to it being embraced by history scholars and students alike.

The timing of the development of GIS coincided with the digital information revolution, involving digital translation, manipulation, and dissemination of data (Goodchild, 1992). The capacity to digitally manipulate spatial data has enabled research to build on top of the quantitative revolution and arguably transcend it by incorporating the visual intuition that can be gained from spatial display. In other words, GIS has extended quantitative analysis by making it more intuitive through the presentation of patterns in a graphical format (such as maps).

> One of the chief virtues of GIS is that it allows the visualization of spatial data as well as providing a means of utilizing fuzzy data. Although the quantitative science prefers clear and precise ''facts,'' GIS provides a way to include data that is not so pristine. It presents geographers with ways to visualize spatial arrangements and, in the process, recovers intuition from the wasteheap to which it was relegated during the quantitative revolution. (Schuurman, 2004, p. 7)

Visualization, how humans interpret visual images, helps generate meaning from data by conveying it in graphical form from which spatial patterns can be discerned. It is this capability that helps GIS surpass the boundaries of conventional analyses.

Geographical Data and GIS

In the simplest sense, geographical data describe spatially referenced information. Thus, the data have two main components. First, there are the traditional qualitative or quantitative characteristics that are typically recorded in rows as in a conventional database or spreadsheet. These describe the attributes of the feature/phenomenon/trend and are logically labeled ''attribute data.'' Types of attribute values include categories, ranks, counts, amounts, ratios, and so on. Each of these entries is also represented by a spatial characteristic. This spatial characteristic could be a point, line, or area (i.e., polygon); each of these has location coordinates and can therefore be mapped. This spatial/locational information is labeled ''spatial data.'' Popular coordinate systems (such as latitude and longitude) are combined with appropriate map projections (i.e., how the spherical form of the globe translates onto the flat surface of a map) to enable the spatial patterns to be displayed in cartographic form (Mitchell, 1999). Thus, in combination, geographic data on each feature provide information on what an object is along with information on where it is located (Gregory, 2002).

Much of the data used by historians are ‘‘geographically enabled’’ data, although the spatial component is often not used. Every feature has its attribute characteristics but also has at least two locational coordinate data entries (three if elevation is considered), plus a temporal entry if it is being located in both space and time. Given that both spatial and attribute data are recorded in the GIS database, it allows this information to be exploited in more ways than would be the case for a conventional one, promising fruitful new avenues for research. Further, such data are well suited to graphical display (e.g., maps) and not just in tabular or text form.

The geographic characteristics of attribute data take the form of discrete features, continuous phenomena, or aspects that are summarized by area. A discrete feature of an attribute, such as a point location or a line, has an actual location that is very specific, that is, it is either there or not. Continuous phenomena are always present, such as elevation, temperature, and so on. In the database, a value for the attribute is determined for the location in question. When dealing with continuous data, it is typical for point values for a variety of locations to be collected; the GIS can then be used to interpolate between these. Alternatively, the attribute data for an area can be summarized and applied to that geographic extent as a whole. For example, the number of households in each census tract of a city could be tabulated, and the whole census tract be assigned a quantity or density. The feature value is applied to the area as a whole, not to specific locations within it. This is an especially popular method of dealing with social/demographic/economic/political data.

Once the attribute and spatial data are collected, these can be represented in the GIS in either a vector or a raster representation of reality.

In the vector version, each feature is recorded in a row in a table that contains attribute information and shape data and is based on a geographic location (Gorr and Kurland, 2006). The latter can be initially defined in terms of (at least) two locational coordinates (such as x and y). This easily describes a point in space. Connecting the dots enables GIS to identify a line; drawing a border with a line enclosing an area creates a polygon. The resulting geographic representation is such that the feature is now a discrete point location or event, a line or an area.

In contrast, the raster version of reality begins with a matrix of cells, or pixels, that cover continuous space. For a feature, a value representing the attribute is assigned to the whole cell. Pixel size becomes an issue: too large results in information being lost, while too small becomes too burdensome without providing additional insight. Satellite and other remote-sensed imagery, such as weather patterns seen on television programs, are typical examples of raster representation.

The ability to use visualization as a means of increasing spatial analysis is central in GIS. The fundamental starting point for this is assigning locational coordinates for the geographic features (points, lines, polygons, and pixels). This is known as georeferencing. For example, you could create one ‘‘map’’ of roads in a region during the Civil War (i.e., lines), another of areas under Union or Confederate control (i.e., polygons), another of army headquarter locations (i.e., points), and lastly two raster images of elevation (interpolated from point data within the cells) and land cover (indicating predominant vegetation in the cell). Because each feature has a specific location, these maps could be combined by aligning identical coordinates. This layering of geographical data can improve visual display and lead to better intuitive conclusions about relevant historic events and decision making. For example, one researcher has attempted to discover what General Robert E. Lee could see of the battlefield at Gettysburg when he hurled General George Pickett's men against Union lines to understand why Lee did not modify his command to move forward (Knowles et al., 2008). Taken farther, the GIS can combine the different areal representations (i.e., the ''maps'') and their features to create a new layer with the attributes of all the ''maps.'' This overlaying became the platform for a variety of analytical techniques, collectively called ''spatial analysis.'' This is different from computer cartography or mapping in that it creates much more information and new data through the combining of features than can simply be collected from maps or data alone.

This can be taken farther again through the use of quantitative and statistical analytical methods that consider locational factors, which are called spatial statistics. While traditional quantitative methods assume observations are independent, spatial statistics assume that these are related to each other, with geographically closer observations being more related than those farther apart. In the disciplines of geography, statistical analysis often contains a spatial component (e.g., point or area pattern analysis, spatial autocorrelation, geographically weighted regression, etc.), with or without spatial visualization. At present, however, it seems that many of these display and analysis methods are out of the mainstream of non-geography-related disciplines.

The Acronym GIS

It is not by coincidence or error that we have yet to define the acronym. This has undergone a change in some academic circles since the early 1990s, and continues to be the subject of research and discussion. Definitions of GIS span a wide range, from the simple claim that ''in GIS, maps become supermaps'' (Davis, 2003, p. 2) to complex philosophical theses that it represents a major epistemological shift in the scientific method approach (Goodchild, 1992; Schuurman, 1999).

Typical definitions of Geographic Information Systems refer to its capability to digitally input, manage, analyze, map, and provide statistical output related to spatial data. These often spend considerable ink detailing the hardware, software, and procedures commonly labeled as GIS. The common thread is the linking of information to its geographic location, through the analytical and data management powers provided by computer technology.

> Seldom does anyone ask how their GIS software decided on the boundaries of the colored polygons that illustrate areas of different income levels in a city. Nor is the spatial analysis routine that determines daily delivery routes for a courier company likely to be disputed. GISystems are assumed by the vast majority of users to produce true results. (Schuurman, 2004, p. 9)

In contrast, Geographic Information Science (GIScience) pursues these issues. GIScience is the theory that provides the foundation of GISystems. Since the early 1990s Michael Goodchild has been a driving force for the need to focus on the basic ontologies that underlie GIScience instead of simply the pursuit of the technological application. He suggests that we need to examine how spatial data and their relationships are represented in a digital form. This envelops intellectual property belonging to social sciences and computer sciences, human geography, and GIS (Longley, Goodchild, Maguire, & Rhind, 2000). As Schuurman (2004, p. 32) notes, ''GIS researchers use the tools of computer science to create ontologies, but the concepts of philosophy to refer to the spatial entities manufactured by different methods of encoding.'' For us, this means that the data structures manipulated by the software will impact how features/phenomena/trends appear on the screen, which then will impact our analyses of ''reality.'' No one has yet suggested that the potential gains from combining visuality with quantitative analytical capability are risk-free.

Samples of the Collision: Historical GIS Research

Our focus here is on the application of GISystems to research in historical GIS. The collected papers in this issue are examples of the use of visualization and related GIS capabilities to enhance historical study. It is our goal to provide a wide cross section of topics and applications, to better illustrate the gains that can be accomplished when history and geography collide in a digital world.

Taking advantage of the visual and conceptual possibilities presented by GIS, the works presented by Schuppert and Dix, Wenzlheumer, and Morel-EdnieBrown highlight the descriptive powers available to the researcher. These papers also explore related issues of georeferencing historical maps and diagrams, and the usefulness of integrating spatial and temporal information from different sources.

Temporal data are also depicted in different forms: Boeckel and Otterstrom use choropleth maps, while Dobbs shows the power of point display. The research by Fyfe provides us with an example of the insights gained by using buffers. This paper then goes further to combine these with spatial trends through the use of a software package add-on called Hotelviz.

Spatial analyses, especially in terms of measuring and displaying densities, are found in a number of the papers here. The works of Dobbs and DeBats illustrate the application of kernel density measures. Fyfe combines the buffer element with graduated circle display, while the research by Tiller and Gong shows the power of point display combined with spatial interpolation through kriging.

Statistical analyses are also built into the GIS methodology. The work of Fyfe displays descriptive frequency measures. Dobbs incorporates Spearman's correlation, while Boeckel and Otterstrom use analysis of variance (ANOVA) in their approach. Four measures of social network analysis are presented by Wenzlheumer. Finally, the paper authored by Groote and others employs a number of serial and spatial autocorrelation tests, serially and spatially lagged dependent variables, and econometric modeling using LIMDEP (Limited Dependent Variables Models) to reach their conclusions.

All the research presented here, from exploratory descriptive approaches to complex theoretical modeling, show the capabilities of using a spatial perspective to reach conclusions that may not be achievable otherwise. GIS provides the avenue for such expanded perspectives so that historians and geographers will be able to tell us far more than we knew before, and occasionally more than those who experienced the past understood about their own circumstances.

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