SPACE, TIME, AND GIS

Michael F. Goodchild

Geographic information systems are designed to deal with data arrayed in space, and over the years they have gained a reputation for taking an essentially static view of the world. There are good reasons for this, of course, and they stem from the early connection between GIS and maps, and the notion that GIS is best understood as a collection of maps stored in a computer. Maps are expensive to produce, since humans must be involved in the elaborate process of acquiring and compiling data, editing, annotating, and printing, and today the U.S. Geological Survey estimates that a standard topographic sheet costs on the order of $100,000 if prepared from scratch. To justify their cost, therefore, maps must be useful for as many purposes as possible, and for as long as possible – and it follows that maps will emphasize the comparatively static features of the Earth's surface over the dynamic ones. Topographic maps show contours, placenames, roads, railroads, rivers, and lakes, all of which are expected to remain largely the same throughout the lifetime of the map; and a GIS developed to store and manipulate such maps will also tend to favor such static features.

This emphasis on the static and cross-sectional suggests that GIS will be of little interest to historians whose emphasis is on the dynamic and longitudinal. But GIS's ability to represent the geographic context of historical events nevertheless proves useful, even though that context is comparatively static. The static topography of the Gettysburg battlefield may provide insight into the direction of the battle, and the static layout of Salem may similarly inform our understanding of the trials and the social networks that gave them context (Knowles, 2002). GIS also proves useful in overcoming some of the geographic issues, such as moving county boundaries, that make it difficult to examine changes through time in census records (see the National Historical GIS, www.nhgis.org). Despite these examples, however, it is hard to escape the simple view that history is about time and geography is about space – and that historians run the risk of losing sight of time if they adopt GIS.

There have been many attempts to raise awareness of the importance of time within the GIS community, and to develop models that can be used to represent dynamics. An early book by Langran (1993) identified the types of changes that can occur in boundary networks, particularly in land ownership, and more recently Peuquet has published a series of articles and books on modeling dynamics (see, for example, Peuquet, 1994, 1995, 2001, 2002). The arsenal of techniques for analyzing spatio-temporal data has been growing rapidly (see the STARS open-source software developed by Serge Rey and his group, stars-py.sourceforge.net), and the potential of the Global Positioning System (GPS) for tracking animals, people, and vehicles has led to a burst of renewed interest in the time geography of Hagerstrand (see, for example, Miller, 2005). These by and large are research efforts, however, that do not transfer easily into the world of commercial GIS software, so from the perspective of practicing historians and historical geographers the most important development of recent years is probably the introduction of object-oriented data modeling, a new paradigm of representation in GIS that makes it far easier to model dynamics.

In order to store data in a computer it is necessary for the designer of the system to make certain assumptions about the nature of those data. For example, many computer applications are based on the assumption that the data to be stored are in the form of entries in a rectangular table – Microsoft Excel began with this assumption, although it has grown somewhat beyond it over the years. GIS similarly began with the assumption that the data to be stored was found on maps, and initially those maps were of very specific types. Object-oriented designs have finally liberated GIS from the constraints of this “map metaphor”, by introducing a different set of assumptions that are much more general. First, we assume that everything to be stored in a GIS is an instance of some class, such as the class of battles or the class of trees. Second, classes can be specializations of more general classes and inherit their properties, so the class of battles in WWII might be a specialization of the class of battles. Third, relationships of various kinds can exist between classes and the instances within classes. Battles, for example, might be related to the class of military commanders, and the entry Austerlitz in the battles class might be related to the entry Napoleon in the military commanders class.

Within this framework location in space and time becomes one of the distinguishing attributes of each feature or instance – and location may change through time as features move around the landscape. Object-oriented data modeling allows GIS users to keep track of dynamic as well as static features, to visualize them in various ways, and to analyze their patterns. It is even possible to include features that have no known or associated location on the Earth’s surface, such as the pay scales of the British army in the 1890s, again moving significantly away from the map metaphor.

At UC Santa Barbara doctoral student Alan Glennon and I have recently built an object-oriented data model for the representation of geographic flows, using the examples of migration, military campaigns, and rivers, and with support from ESRI and the National Science Foundation. One of our case studies is Napoleon’s Moscow campaign, and we have drawn much of the relevant information from Minard’s map, which shows not only the route of the army but also a chart of daily temperatures (see ags.ou.edu/~gdi/flow/). With tools like these we now have the ability to represent complex movements in space and time, such as the movements of armies at the Battle of Waterloo, and to create snapshot visualizations of the state of the battle at any point in time – a far more powerful approach than the traditional methods used to depict battlefield movements in map form.

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