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Space, Time, and Technology
Incorporating Time into GIS

The framework for creating a Temporal Geographic Information System (TGIS) has existed since the 1980s* The major stumbling block in adopting this technology has been limitations on the power and storage capacity of computers. However, we are very close to achieving the necessary computing power. Thus, the challenge is threefold: to understand the differences between merely storing out-dated data and the storage of data histories for automated spatio-temporal analysis; to identify the basic elements of temporality in planning data and how they relate to a revised form of analysis for decision-making; and, to focus on long-term effectiveness during the planning stage of implementing a TGIS. This article presents an applied framework for the use of TGIS in urban and regional planning. TGIS technology allows true spatio-temporal analysis, incorporating historic trends into the basis for decision-making. As CRM professionals, we can play a vital role in identifying the methods and applications for TGIS.

The role of information in planning is to support problem solving by helping the planner locate, evaluate, and analyze relevant data in order to identify a range of solutions. The goal is to make data analysis meaningful, to turn data into information about trends, preferences, development patterns, or the locations of economic changes. GIS has helped planners get part way there. When census data was merely a report and a map, it was difficult to compare these findings with zoning, commercial real estate values, or other relevant data. GIS allows planners to compare the current state of a community on any given level, from a single property block to entire jurisdictions, with any custom combination of data types.

Planners like GIS because its information can be used to plan for the future of their communities. What they fail to recognize is that this analysis lacks temporal depth. We know how things are today, but can we really plan for the future without knowing the social, economic, and physical trends of the community? Common sense and previous planning disasters tell us we can't. Just as planning departments need preservation planners to help make the connection between heritage and development, planners need GIS tools that facilitate information analysis of both current and non-current data.

The structure of GIS facilitates flexibility in data management and information analysis by providing links between three types of data that describe entities: spatial location, descriptive attributes, and temporal existence. Time-series data involves capturing the contents of the entire database at regular intervals regardless of the degree of changed data. This results in the perceived frequency of change being dependent upon an external measurement of time rather than on the rate of change inherent to the subject of the data. Time-encoded data are typically stored in a separate database once they have become non-current, thus becoming unique and separate entities rather than retaining their association with the subject of the data. In current GIS, time is typically the fixed element, but is rarely the controlled or measured element. TGIS allows each of the three data types (spatial, temporal, attribute) to be fixed to a specified value, controlled to a range of values, and measured, depending upon the query.

To both control and measure the temporal element acknowledges that each entity exists in time, as well as in space. This temporal existence is measured by events that in some way alter the entity. In a TGIS there are three principle types of data stored to describe an entity: states, which are comprised of the features and attributes traditionally considered as geographic information (in a temporal GIS different versions of features would be stored, viewed, and analyzed); events, which are the occurrences that cause one state to change to another, creating a chain of versions for a given feature; and, evidence, which is the source documentation notifying the user that an event has occurred or that a new state now exists. Examples of states include topography, districts, parcel and building boundaries, streets, open space, hydrology, and vegetation. Events include zoning hearings, determinations of eligibility, transactions, construction projects, natural disasters, and public improvements. Evidence includes deeds, nominations, building permits and inspections, property assessments, and cultural resource surveys.

In a TGIS the state of the temporal map at any one time consists of the vertical compilation of object versions. Each object goes through mutations due to external events. An event may affect more than one object, but does not necessarily affect all objects. Data histories can be considered the string of mutations and versions that describe an object. Community histories would be the string of overall map states. The capacity to establish relationship links between evidence and events, and between events and states allows TGIS to integrate non-current data for immediate and complex spatio-temporal queries. Common query types

include concentration, connectiveness, contiguity, description, measurement, and propinquity.

A hypothetical application for this type of spatio-temporal analysis requires us to assume that a community implemented a TGIS at the beginning of the century, and has been storing the states, events, and evidence of the physical environment through today. Suppose this community wanted to determine the retirement rate of buildings in order to identify potential areas of blight or opportunities for new construction. To determine the retirement rate of the building stock, the analyst needs access to all building permits to establish a sample period, typically spanning between 15 and 30 years. From these permits, the analyst extracts the demolition permits and the construction date of these buildings, and determines the life span of each building. The mean average of these life spans represents the retirement. With the accumulated data in the TGIS, planners could determine the retirement rates in various districts, compare the differences in those rates, and conduct analysis on the events and evidence in those areas to determine causal trends for variances in rates. When building demolitions are viewed in this manner, relative to the entire building stock rather than as isolated events, it becomes clear that encouraging maintenance to support natural life spans would be more productive than attempting to prevent building abandonment. So, the TGIS helped prove the soundness of a preservation strategy for the community.

The potential uses of a TGIS in CRM are numerous and only limited by our hesitation to adopt this technology. The preservation planning goals of a community are more likely to succeed if a TGIS operates in tandem with its planning department and other decision-making institutions. This is due to the fact that TGIS models historic trends, while processing other data types. CRM professionals are, inherently, experts in temporal analysis, and therefore have an opportunity to shape the outcome of this emerging technology.

Note

* Gail Langran, *Time in Geographic Information Systems*. Diss. University of Washington, Seattle, 1989. (Ann Arbor: UMI, 1989. 9000269).

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