Metaphors Create Theories For Users[1]

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Abstract

The notion of a spatial information theory is often understood in the sense of a theory underlying the design and implementation of geographic information systems (GIS). This paper offers a different perspective on spatial information theories, taking the point of view of people trying to solve spatial problems by using a GIS. It discerns a need for user level theories about spatial information and describes requirements for them. These requirements are then compared with various views on metaphors held in computer science and cognitive linguistics. It is concluded that a cognitive linguistics perspective on metaphors best matches the requirements for user level theories. Therefore, the user's needs for theories of spatial information should be dealt with by explicitly crafting metaphors to handle spatial information by human beings. The paper discusses traditional and possible future metaphor sources for spatial information handling tasks.

1. Introduction

The past decade has been characterized by the quest for stronger theoretical bases to support the work of researchers and developers in the area of geographic information systems (GIS). A widespread recognition that the field of GIS was suffering from the lack of appropriate spatial theories [Dangermond, 1986; Frank, 1987] spurred major national and international research efforts [Abler, 1987; Shepherd, Masser, Blakemore, & Rhind, 1989] which have since produced significant advances in our understanding of spatial information, its modeling, management, use, and diffusion.

These efforts toward spatial information theories have been most successful where they dealt with the traditional issues of representing information about space and spatial relations in formal and thereby implementable ways [Egenhofer & Herring, 1991; Günther & Schek, 1991]. They have furthermore established interdisciplinary networks dealing with the more elusive issues of how to communicate spatial information [Frank & Mark, 1991; Mark & Frank, 1991; Mark, Frank, Kuhn, & Willauer, 1992], how to describe its quality [Beard & Buttenfield, 1991; Goodchild & Gopal, 1989], and how to assess its value [Onsrud & Masser, in press]. All these efforts have considerably expanded the theoretical basis for GIS work and continue to do so for novel issues such as modeling temporal aspects [Frank, Campari, & Formentini, 1992] or dealing with cultural and institutional contexts of GIS use [Campari, 1990; Onsrud & Rushton, 1992].

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Reviewing this body of work, one might identify an emphasis on certain aspects of theory and a tendency to overlook others. This paper is based on the observation that most spatial information theories are oriented toward *machines* rather than toward their *users*. They emphasize formalism (which is a must for their implementation on machines), but are less concerned about explanations. After contrasting this traditional orientation of spatial theories with a proposed user orientation of theories (section two), the paper outlines the key requirements for user level theories (section three), shows how various views of metaphors match these requirements (section four), and presents a catalogue of source domains for GIS tasks (section five).

While the need for a better theoretical understanding of GIS user interface issues has long been recognized, this paper contributes a view of spatial information theories going beyond standard formalization approaches. It is intended to contribute a novel way to understand user interface metaphors for GIS and to clarify their relation to overall system design.

2. Spatial Information Theories - For Whom?

Most spatial theories developed so far have been optimized with regard to consistency within themselves and completeness for some domain of interest. The notion of theory motivating these concerns is that of a formal theory, founded on mathematical logic [Mendelson, 1964]. The main goal of these theories is implementability, making them *theories for designers and implementors.*

For example, spatial data models and data structures have been and continue to be formalized extensively. There have been rigorous treatments of geometric and topological data models at multiple levels of sophistication, ranging from simple raster or point and line based models to complete topological models [Egenhofer & Herring, 1991]. The corresponding spatial theories include spatial statistics, Euclidean geometry, differential geometry, graph theory, and simplicial topology. While tremendous progress has been achieved along these lines, much work remains to be done to address issues like transformations between data models [Herring, Egenhofer, & Frank, 1990] or modeling spatial data at multiple resolutions [Oosterom & Bos, 1989], to name only two important directions.

Thus, formalizing domains with mathematical rigor is of foremost importance and value in dealing with spatial information and is in no way being questioned here. Formalization by itself, however, is not enough to arrive at useful theories. Concentrating on the mathematical aspects of a theory underlying an implementation can lead designers to neglect usability aspects of the resulting system and can produce undesirable effects at the user interface. Theoretical refinements sometimes burden the users with an additional load of concepts they have to master if they want to use a system effectively. Depending on the tasks and users, some concepts of a formal theory may be completely irrelevant or even unintelligible to users.

Topological data models represent, in fact, an example of a domain where highly sophisticated implementations have sometimes been garnished with rather puzzling user interfaces. To acquire geometric data by manual digitizing or to do spatial analyses involving multiple layers of data, users suddenly had to cope with concepts