Chapter VIII
Cognitive Maps

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ABSTRACT

Cognitive maps are the representations that individuals use to understand, process, and navigate environments. The term cognitive map should not be taken as a literal metaphor as the internal representation will often violate principles of two-dimensional geometry, will rarely be either continuous or complete, and will often include non-spatial attributes, such as sights, sounds, or even aesthetic qualities, of a location. Research on cognitive mapping as made important contributions to both theory and application of geoinformatics by demonstrating how spatial information is acquired, structured, accessed, and schematized by the human information processing system. Theories of cognitive mapping have been expanded by through new frameworks, such as naïve geography, synergetic inter-representation networks, and geocognostics. Together, this body of research has provided a framework for the development of the next generation of user-centered geographic information systems.

INTRODUCTION

Geographic information systems have greatly facilitated the use of geographic information by both experts in the field and the general public through Web-based interfaces. The increased use of geographic information systems by all users will be facilitated through an understanding of human spatial reasoning (Kitchin & Blades, 2001; Slocum et al., 2001). In this article, the state-of-the-art of understanding the representation of spatial knowledge, or cognitive maps, will be reviewed. Much of this literature has been reviewed in several recent papers and books. In particular, the reader is invited to read Golledge (1999), Peuquet (2002), and Portugali (1996) for foundational readings on cognitive mapping.

The term "cognitive map" is one that is not without controversy. The term was coined by E. C. Tolman (1948) when he argued that rats in a maze had an internal representation or, cognitive map, of the environment, which would lead to the use of shortcuts in finding food. These maps were assumed to be used by humans as well and research over the years has attempted to delineate the nature of these representations. The term was further expanded in the classic work by Lynch (1960) and by Downs and Stea (1973). The next 30 years has seen an explosion in empirical research on the topic of cognitive mapping.

Some have argued that the term "cognitive map" is misleading, as it might be taken to be imply a particularly kind of two-dimensional or pictorial representation. Alternative terms, such as cognitive collage (Tversky, 1993) or cognitive atlas (Kuipers, 1982), have been introduced as a replacement to the term cognitive map to highlight a particular characteristic, such as the notion of multi-media (in a cognitive collage) or multiple scales or reference frames (in a cognitive atlas). The use of the term cognitive map in this article should not be taken a literal metaphor, but rather a useful catch phrase for the underlying representation of spatial memory.

FOUNDATIONAL ISSUES

The research over the past thirty years has highlighted the importance of cognitive maps in geographic communication, acquisition and use of geographic information, wayfinding, planning, and urban design (Evans, 1980; Kitchin, 1994). From constructing user-centered in-car navigation systems that impose minimally attentional demands on a driver to constructing urban parks that encourage public use, research on cognitive mapping can suggest appropriate parameters to consider in the design process. Most important are a number of foundational issues that have emerged over years of research (Mark et al, 1999).

Knowledge Acquisition

In early research on cognitive mapping with humans, Siegel and White (1975) argued that the acquisition of spatial knowledge starts with landmark recognition, followed by the learning of routes between known landmarks. With enough experience, one will eventually acquire survey knowledge in which the relative location of landmarks is fully understood. Further research on spatial cognition has indicated two problems with the initial conceptualization. First, it is clear that the acquisition sequence is not strictly linear (Allen, 1999). Second, survey knowledge is often never acquired despite years of experience. For example, Moeser (1988) found that student nurses lacked survey knowledge of a large hospital, even after working in the building for over three years, and instead continued to rely on directional signs and known landmarks to navigate through the space. In a recent in-depth study, Ishikawa & Montello (2006) found that that accurate metric knowledge was either gained in the first session or never learned, calling into question the learning parameters in the original conceptualization.

Despite these caveats, the distinction between landmark, route and survey knowledge remains a useful starting place. Most navigation systems are designed to support either route or survey knowledge. In the simplest case, point by point written directions, such as those provided by Mapquest (www.mapquest.com) and similar web-based mapping systems, are designed to support route knowledge, whereas floor plans are designed to support survey knowledge.

Hierarchical Structuring

While automated navigation systems often provide directions using street nodes (e.g, *turn left at Main St; Go 3.4 km*), humans often talk in terms of neighborhoods and landmarks (e.g., *when you get downtown, turn left at the Starbucks*). Neighborhoods form one of the basic organizing