Knowledge Representation for Distances and Orientations of Regions

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ABSTRACT

From the perspective of cognitive informatics (CI), this paper proposes internal relations between distance and orientation knowledge of extended objects, and presents a formal representation of spatial knowledge. The connection relation is taken as primitive. Notions of near extension regions and the nearer predicate are developed. Distance relations between extended objects are understood as degrees of the near extension from one object to the other. Orientation relations are understood as distance comparison from one object to the sides of the other object. Therefore, distance and orientation relations can be internally related through the connection relation. The notion of the fiat projection is presented to model the mental formation of the deictic orientation reference framework. This paper introduces a new axiom to govern the connection relation in the literature and presents examples to show diagrammatically the internal relations between distance and orientation relations of extended objects.

Keywords: data integration; knowledge classification; spatial data

KNOWLEDGE REPRESENTATION FOR DISTANCES AND ORIENTATIONS OF REGIONS

When we open our eyes, we see a snapshot view of the spatial environment. We perceive and describe objects and their spatial relations in the snapshot view, rather than patterns of hues and brightness. A snapshot spatial environment is decomposed into objects and spatial relations among them. In snapshot views of spatial environments, objects are projectively as large or larger than the body but can be visually apprehended from a single place without appreciable locomotion (Montello, 1993, p. 315). They are vista spatial environments following Montello (1993), or the space surrounding the body following (Tversky, 2005; Tversky, Morrison, Franklin, & Bryant, 1999).

From snapshot views of spatial environments, we can recognize objects, describe their spatial relations, identify whether it is the environment in which we want to enter, even detect object movements. For example, when you have the first snapshot view of your office in the morning, you can recognize objects such
as a chair, a desk, describe their relations such as the chair is near and in front of the desk, identify whether it is your office, and detect object movements such as the chair has been moved a bit to the left than its location when I left yesterday. There are several interesting issues involved in the knowledge that people have about snapshot views of spatial environments.

From snapshot views, we only see part of objects and some parts may be blocked. However, we can recognize them. This can be evidenced by the Gestalt Theory (e.g., Koehler, 1929; Koffka, 1935; Wertheimer, 1958) and research in object recognition (e.g., Biederman, 1987; Buelthoff & Edelman, 1992; Humphreys & Khan, 1992; Spelke, 1990; Tarr, 1995; Tarr & Buelthoff, 1995). We can even recognize objects in snapshot views both from the real life and from the virtual world (e.g., films, TV programs, and photos). When you open your office door in the morning, you receive the light reflection from the chair and you recognize your office chair; when you see a photo of your office, you receive the light reflection from the photo and you also recognize your office chair. Recognizing objects either in the real environment or in the photo owes to the light reflection and to our recognition activity—we have knowledge about objects. The knowledge of objects resides in the memory and is awakened either by some external stimuli or by certain mental desires.

Secondly, object recognition means categorization. Objects in the same category are considered equivalent. Rosch, Mervis, Gray, Johnson, and Boyes-Braem (1976) argued that categories of recognized objects are structured such that there is generally one level of abstraction at which we find it easiest to name objects and recognize them the fastest, namely the “basic level category.” The basic level is the first categorization made during perception of the environment. This suggests a link between our spatial knowledge and our spatial descriptions. That is, the spatial knowledge acquired through perception structures language following Tversky and Lee (1999).

This article addresses spatial knowledge representations among objects where we assume a viewpoint and snapshot views of a given scene. The aim of the article is to provide a systematic representation of spatial knowledge, which can be acquired through perception and which can interpret semantics of spatial linguistic descriptions. The reminder

Figure 1. Spatial relations acquired through observation

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