An Empirical Study on Pertinent Aspects of Sketch Maps for Navigation

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ABSTRACT

Navigation systems which employ sequence-based directions have been found not effective in facilitating the spatial ability for humans to be aware of themselves in an environment. Traditional maps are found easily conveying the configuration of spatial objects but having difficulty to facilitate the correspondence to spatial objects in the real world. Sketch maps as schematic map-like representations have been suggested being a possible way of achieving goals of facilitating both navigation and spatial awareness. Moreover, sketch maps as externalizations of cognitive maps have been proved as reliable representations for human spatial thinking. In this study, the authors investigate the characteristics of directions given in two different forms: sketch maps and verbal descriptions (turn-by-turn instructions). The investigation addresses three aspects of spatial relations which are orientation, street topology and sequential order and their representations using existing qualitative reasoning calculi. The results of this study demonstrate sketch maps as a better direction-giving method and provide insights of applying sketch-map-like components for navigation.

Keywords: Navigation, Orientation, Qualitative Spatial Reasoning, Sequential Order, Sketch Maps, Street Topology, Verbal Descriptions

INTRODUCTION

Traditional metric maps are developed through a data-driven approach where large amount of data are presented for various purposes. Human cognitive maps, however, are developed through a cognitively conceptual approach which builds on coarse, fragmented, and distorted spatial knowledge and refine over time (Klippel, et al., 2005). Studies on schematic maps, a similar form to sketch maps with simplified and distorted information, show that using fragmented, schematic, or distorted information on maps (while retaining local network structure) does not degrade the wayfinding performance as well as the development of spatial knowledge (Mei linger, et al., 2007). Recent studies (Chipofya, et al., 2011; J. Wang, et al., 2011) on alignment of sketch and metric maps have demonstrated the feasibility of using sketch maps as a reliable source to visualize survey knowledge of a local environment. In this study, we empirically assess navigational directions given in both forms of sketch maps and verbal descriptions in three aspects: orientation, street topology and sequential order. The results demonstrate
the advantage and reliability of using sketch maps for navigation over verbal descriptions. In this collaborative effort, the study initiates the understanding of how sketch maps represent spatial objects and their relationships, as well as implications to the design of maps for navigation. Specifically, we address the following two research questions:

- What are the pertinent aspects of sketch maps that are keen to orienting and directing wayfinders?
- What are the main differences between directions given in the form of sketch maps and those given in the form of verbal descriptions?

In the remaining of this paper, we introduce the background and related work that shed light on using sketch maps for navigation, the design and methodology of our experiment, the preliminary results, and the conclusions and future directions.

**TRADITIONAL METRIC MAPS AND NAVIGATIONAL SYSTEMS**

Traditional metric maps provide the ease of acquiring spatial knowledge of an environment but it is difficult for users to create the correspondence between map objects and objects in the environment. The challenge is establishing the corresponding relationship between the wayfinder, the world, and the map (Klippel, et al., 2006; Levine, 1982; Liben & Downs, 1993). Klippel et al. (2010) analyzed You-Are-Here (YAH) maps as a means to facilitate the awareness of wayfinders in an environment and to plan routes. They suggested a checklist of designing criteria (e.g. perceptibility, completeness, placement, and alignment) that are critical to provide adequate information to develop cognitive configuration in wall-mounted YAH maps.

Navigational systems that utilize sequence-based directions facilitate the ease of navigation but greatly degrade a person’s awareness of an environment (Parush, et al., 2007). Development on mobile navigation using GPS offers potentially easy-to-follow, turn-by-turn instructions as well as YAH information. As long as people follow a specific route, a complete map is not necessarily acquired. Studies show that mobile navigation systems provide navigational facilitation but degrade spatial knowledge acquisition in both driving and walking (Ishikawa, et al., 2008; Parush, et al., 2007). Therefore understanding the advantage of using the forms of map and verbal description for navigation is the main purpose of this study. This is also the key to achieve both goals of realizing the ease of navigation and spatial awareness.

**SKETCH MAPS**

Cognitive maps are mental models that encompass the internal processes enabling people to acquire and operate information about their environment (Downs & Stea, 1973). Researchers in environmental cognition have depended largely on individuals’ hand-drawn sketch maps as externalizations of cognitive maps of their daily environments. Blades (1990, p. 327) carried out an experiment on sketch maps and found out that “the same subject will consistently produce the same map”. This result indicates that sketch maps are a reliable method for environmental representations.

As introduced at the beginning of this article, the way humans perceive space is different from the way space is measured for traditional map production. Tversky (2005) outlined such differences as follows: in traditional maps, space is primary and the geometry of features is measured and located in the space; for humans, spatial objects are primary and they have spatial relations to each other with respect to certain reference frames. Therefore, a map metaphor such as sketch maps of internal cognitive representations of space is misleading in some ways (Kuipers, 1978; Taylor & Tversky, 1992). e.g., sketch maps are often schematized, simplified, categorical, and consisting of numerous distortion errors (Montello, 2005; Tversky, 2003, 2005). Since people do not perceive absolute locations and quantitative relations between spatial objects but rather relative locations and
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