Chapter 27
Ordering:
A Reliable Qualitative Information for the Alignment of Sketch and Metric Maps

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ABSTRACT

Sketch maps are externalizations of cognitive maps which are typically distorted, schematized, incomplete, and generalized. Processing spatial information from sketch maps automatically requires reliable formalizations which are not subject to schematization, distortion or other cognitive effects in sketch maps. Based on previous empirical work, the authors identified different sketch aspects such as ordering, topology and orientation to align and integrate spatial information from sketch maps with metric maps qualitatively. This research addresses the question how these qualitative sketch aspects can be formalized for a computational approach for sketch map alignment. In this study, the authors focus on the ordering aspect: ordering of landmarks and street segments along routes and around junctions. The authors first investigate different qualitative representations and propose suitable representations to formalize these aspects. The proposed representations capture qualitative relations between spatial objects in the form of qualitative constraint networks. The authors then evaluate the proposed representations by testing the accuracy of qualitative constraints between sketched objects and their corresponding objects in a metric map. The results of the evaluation show that the proposed representations are suitable for the alignment of spatial objects from sketch maps with metric maps.

INTRODUCTION

Sketch maps can be considered as externalizations of internal representations of environments (Barkowsky, Latecki, Jan, & Richter, 2000; Tversky, 2003a). The information represented in sketch maps reflects human spatial knowledge acquired through observation rather than formal measurements. Therefore, the information in sketch maps is distorted, schematized, incomplete, and

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generalized (Huynh & Doherty, 2007; Tversky, 2003b, 2005). These cognitive distortions may be caused by the cognitive processes used to code spatial information into memory or to retrieve it from memory (Lloyd & Heivlyt, 1987). Cognitive errors documented in our previous studies (Schwering & Wang, 2011; Wang & Schwering, 2009; Wang, 2009) are neither random nor due solely to human ignorance. They appear to be a consequence of ordinary perception and cognitive processes (Tversky, 2003a).

Sketch maps are used in human-to-human communication. It is an intuitive way to express the spatial knowledge about an environment. The information in sketch maps can be used to contribute and query in an initiative way without technical constraints (Schwering & Wang, 2011). Processing spatial information from sketch maps and making it available in information systems requires computational approaches to represent, align, and integrate information from sketch maps. In sketch maps geographic features are represented as simple geometric shapes. People cognize only a few significant objects and their spatial configurations in terms of qualitative relations (Freksa, 1991; Wang & Schwering, 2009).

Qualitative representation and successful alignment of a sketch map with its corresponding metric map needs a set of relevant sketch aspects which are not subject to schematization, distortion or any other cognitive effects. In our previous studies (Wang, Muelligann, & Schwering, 2011; Wang, Mülligann, & Schwering, 2010; Wang & Schwering, n.d.), we identified a set of qualitative aspects, which are identified as being robust against cognitive distortions. These sketch aspects address ordering, topology, and orientation information in sketch maps.

Qualitative representation of spatial knowledge involves representing only the relevant distinctions in spatial configuration. These spatial distinctions are expressed in terms of qualitative relations. Common examples of qualitative distinctions include sets of relations for distinguishing the relative direction (left, right), distance (near, far), and topology (disjoint, overlap). A multitude of representation systems (known as qualitative calculi) have been proposed previously by other researchers (Freksa, 1993). These systems provide the semantics of qualitative spatial relations together with algebraic operations that act on these relations to facilitate spatial reasoning. The qualitative representation of sketch maps using these spatial relations will allow us to align the spatial information from sketch maps with the corresponding metric maps. The successful alignment of spatial objects will help to integrate spatial information from sketch maps into geographic information systems (GISs) as volunteered geographic information (Goodchild, 2007).

In the present study, we focus on the ordering aspects in sketch maps such as the ordering information of landmarks and street segments along routes and around reference junctions. We propose suitable qualitative representations to formalize these aspects in the form of qualitative constraint networks (QCNs). These qualitative constraints are tabularized to evaluate the suitability of proposed representations. The evaluation is done by testing the accuracy of obtained relations between spatial objects from sketch maps with their corresponding spatial objects in metric maps on 28 sketch maps. The results of the evaluation show that the proposed representations give high accuracy rate of qualitative relations between sketch and metric maps.

The remainder of this paper is organized as follows: In the following section, we briefly introduce related work and our previous work on sketch aspects. In section III, we propose qualitative representations to formalize ordering aspects, which are evaluated with respect to accuracy in section IV. Section V concludes the paper with an outlook on future work.