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Geographic event conceptualization

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Introduction

Dynamic aspects of geographic-scale phenomena form a growing topic in spatial sciences. As the technology advances, for example, in monitoring such phenomena using sensor networks (Worboys and Duckham 2006), the need for a basic understanding of the conceptualization of dynamic processes by cognitive agents becomes pertinent. The formal characterization of these conceptualizations is necessary to automate the identification and characterization of conceptual structures that discretize continuous dynamic processes into conceptual units. This research addresses the issue of transducing data, such as recorded by sensor networks into conceptual knowledge.

While research on the characterization of cognitive events has a long history within several sciences (for an overview see, Casati and Varzi 1996; Zacks and Tversky 2001), we still lack a good understanding of the conceptualization of geographic events. Our research, therefore, aims at the core of conceptual structures of geographic events. The research we report here does not aim to identify event boundaries in the first place, as, for example, reported in research on the perception of the structure of events (Zacks et al. 2001). In contrast, our research presupposes the existence of event classes as identified by topological and geometric transformations that characterize the behavior of regions, e.g., RCC calculi (Randell et al. 1992), and the 9-intersection model (Egenhofer and Franzosa 1991). For static relations, for example, the RCC calculus has demonstrated cognitive adequacy (Knauff et al. 1997).

We are employing a grouping paradigm as one of the most important methods to elicit conceptual knowledge (Cooke 1999). The main idea of such tasks is that conceptual knowledge plays the central role in rating the similarity of a given stimulus. Stimuli are assessed as similar if they are instances of the same concepts, and assessed as dissimilar if they are instances of different concepts. If other aspects of the stimulus are controlled, grouping experiments can provide important insight into the internal structure of conceptual knowledge.

The research questions that interest us are whether the formal specification of gradual topological changes corresponds to the cognitive conceptualization thereof. Specifically, questions that need to be addressed from a cognitive perspective are:

1. Whether it is sufficient to take only topological characteristics of gradual changes into account.
2. Whether the identity of regions influence the conceptualization, which leads to the distinction between TPP and TPPi in the conceptual neighborhood graph (see Fig. 1).
3. Which other factors influence the conceptualization of gradual topological change? For example, the proportion of the regions involved and the availability of a referent, i.e. one region's movement is related to the fixed position of the other.

Methods

To realize our event experiment, we are using a purpose built software tool that allows for grouping animated

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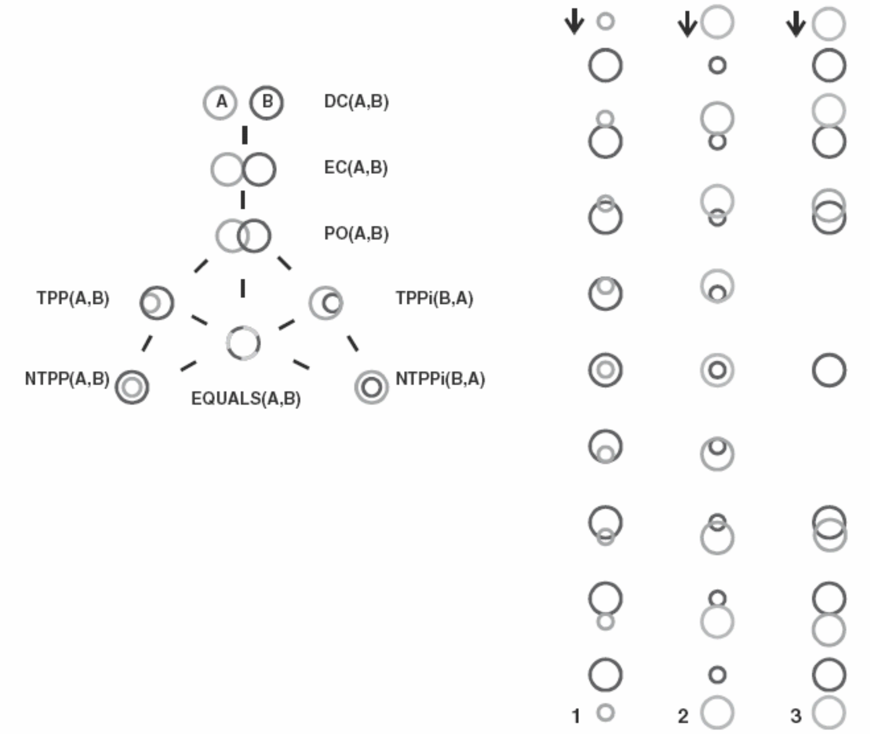

Fig. 1 Conceptual neighborhood graph for topological relations (left part) (Egenhofer and Al-Taha 1992). Gradual changes in topological relations caused by translation (right part), three basic scenarios: (1) A is smaller than B and A is moved over B; (2) A is larger than B and A is moved over B; (3) A and B have the same size, shape, and orientation and one of them is mover over the other

icons representing different event characteristics displayed on a computer screen. In contrast to other card sorting/grouping tools (e.g., Harper et al. 2003; Knauff et al. 1997), it is especially designed to use animated icons.

Design

The animated icons show simple geometric figures and topological transformations representing the behavior of two regions. The transformations of the regions change the topological relations gradually, a concept also referred to as conceptual neighborhoods (Freksa 1992).
We start with the gradual changes in topological relationships as identified by Egenhofer and Al-Taha (1992). Therein, the first focus lies on translation. Egenhofer and Al-Taha (1992) identify three scenarios for these gradual changes (see Fig. 1):

1. A is smaller than B and A is moved over B (or B over A).
2. A is larger than B and A is moved over B (or B over A).
3. A and B have the same size, shape, and orientation and one of them is moved over the other.

Conditions 1 and 2 are conceptually similar. Their differentiation makes sense if we take into account two regions with their own (constant) identities. Additional variations we introduce are (1) different sizes of the regions to test whether the proportion has an influence on the conceptualization, and (2) different directions from which one region moves toward another region or from which they move toward each other. We do not change, however, the direction during movement. This design leads to 9 x 3 x 3 = 81 variations. We doubled the icons to test whether the same animated icons are placed in the same group, which results in 162 animated icons. The nine basic cases we distinguish are:

1. A is smaller than B and A is moved over B.
2. A is smaller than B and B is moved over A.
3. A is smaller than B and both move toward each other.
4. A is larger than B and A is moved over B.
5. A is larger than B and B is moved over A.
6. A is larger than B and both move toward each other.
7. A and B have the same size and A is moved over B.
8. A and B have the same size and B is moved over A.
9. A and B have the same size and both move toward each other.

Cases 3 and 6 are not differentiated by Egenhofer and Al-Taha (1992). Likewise the cases 8 and 9 do not appear in their original characterization.
The participants see a screen that is divided into two parts. On the left side of the grouping tool the animated icons are presented in random order. The right side of the grouping tool is empty at the beginning of the experiment. In this part, the participants have to create groups of animated icons that they rate as being similar. The interaction with the tool was kept simple.
Five follow up tasks are required by the participants after they finished the main tasks, i.e. after they placed all available animated icons into groups:

- Each group that a participant created should be labeled by a linguistic expression. This expression should not exceed three words.
- The spatial changes in each group should be described in no more than 25 words.

- The basic changes in spatial relations should be named explicitly.
- For each group a symbol should be drawn that captures the spatial changes that occur in that group.
- The participants are asked to create a hierarchical order (taxonomy) of the groups.

Discussion and outlook

The first part of the experiment helps us to answer basic questions on the conceptual structure that underlies the changes that two regions can undergo. Furthermore, it provides insight on whether cognitive similarities are reflected in the underlying formal description. The second part of the experiment sheds light on the relation between conceptual structures in interaction with different modalities, here, graphics and language. The identification of these relations is necessary for the design of multimodal information systems. Thereby, we will elaborate on the relation between language and graphics through a common conceptual structure (Jackendoff 1997; Klippel et al. 2005; Tversky and Lee 1999). An additional aspect is the relation of a static medium and the constraints it places on representing dynamic processes. Instead of representing events as sequences of snapshots of states, we explore the possibilities to represent them graphically as first-order entities. The basis for these considerations are the cognitive conceptualization processes as explored in this experiment.

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