Interactive assistance with spatio-temporal problem solving in unfamiliar large-scale environments

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Motivation

Assistance with spatial problem solving tasks like wayfinding or route planning from specific locations to specific other locations gained much attention in spatial cognition research (e.g., Richter & Klippel, 2005) as well as cognitive psychology (e.g., Denis, 1997; Tversky & Lee, 1999). However, assistance with pre-visiting of unfamiliar large-scale environments, for example, planning an individual journey or a city tour in a foreign country, has been considered in the literature only seldom (e.g., Dirlich et al., 1986). This problem involves the selection of multiple locations in unfamiliar large-scale environments under consideration of spatial and temporal constraints.

Planning an individual journey is an ill-structured problem (Simon, 1973). Depending on the knowledge available at the beginning of the spatio-temporal planning task the initial state is weakly constrained. Furthermore those constraints are available at different levels of granularity: visiting a specific museum, a city, or a part of a country. Although, journeys are usually constrained in time, yet, there are no well-defined optimization criteria. Since goals of people who travel for leisure are open-ended, most of the plans are 'good enough', in order to account for unexpected changes and situations in the future.

Consequently, the illustrated problem solving task can not be totally outsourced to a computational constraint solver, but rather requires collaboration between an assistance system and a journey planner.

Research questions

The thesis aims at development of an assistance system which supports users at spatio-temporal planning. For that purpose, I'm going to define a representation structure of the spatio-temporal problem domain, which:

- Makes it possible to specify spatio-temporal constraints at different levels of granularity,
- Facilitates the generation of alternative spatio-temporal configurations.

Weakly specified constraints contribute on the one hand to a high computational complexity and on the other hand to large solution spaces. Observation of large solution spaces is a cognitively demanding task (Knauff et. al., 2002). Sharing the constraint satisfaction process between a user and an artificial constraint solver allows for pruning of significant parts of the problem space. However, the assistance system should provide an interaction model to establish an adequate dialog with a user. Such interaction model should resemble *human decision space*, and provide *navigation operations* which facilitate the observation of alternative solutions.

Approach

The spatio-temporal planning problem can be treated as a partially unformalized constraint problem (PUCP) (Schlieder & Hagen, 2000). The principle of PUCPs is based on separation of the hard constraints like spatial assignments and temporal order of planned activities from soft constraints like personal preferences, moods or even emotions. The assistance system provides users with alternative solutions, which fulfil the underspecified hard constraints. In order to obtain a “good” solution, users have to examine the generated alternative solutions and specify additional, or relax existing constraints according to user’s personal preferences. To facilitate the mental coprocessing during the interactive search process, assistance system should be adapted to human reasoning strategies about geographic large-scale environments.

Methods

To define the structure of the spatio-temporal problem domain I’m going to utilize the state of the art representations of spatial knowledge in artificial spatial systems (e.g., Chown, 2000; Kuipers, 2000; Leiser & Zilberschatz, 1989) as well as the cognitive phenomena for structuring large scale environments – (1) *regionalization* (Montello, 2003) and reasoning about spatial relations – (2) *region connectivity* (Wiener, 2004).

Contributions

The thesis aims at bringing mental reasoning strategies and computational power of an artificial constraint solver together. The resulting representation structure should provide a possibility to deal with a computational complexity of such types of problems allowing a user to guide the search process interactively.

The representation structure is going to be prototypically implemented using the constraint programming language PROLOG. The resulting spatio-temporal assistance system should operate on a Tablet-PC and provide a graphical web-based user interface with JAVA backend.

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