

# A Cooperative Spatial Planning System

Inessa Seifert  
DFKI GmbH  
Alt-Moabit 91C, 10559 Berlin, Germany  
inessa.seifert@dfki.de

## ABSTRACT

This paper describes a cooperative spatial planning system that shares a complex tour planning task between a person and an artificial assistance system. The planning process is represented as an interaction cycle which allows the user to define activity constraints together with spatial assignments at different levels of granularity and contribute with spatial planning strategies and tactics.

## Author Keywords

ubiquitous spatial planning assistance, navigation systems

## INTRODUCTION

Planning activities in an unfamiliar environment is a complex spatial task people have to deal with when preparing a journey to a foreign city or a country. Journeys are usually constrained in time. A travel route has to fit into a pre-defined temporal scope and encompass different activities that take place in various locations. Travelers' requirements for activity types and possible destinations are often under-specified: concrete places or a temporal order of activities may be left open, or may be defined only at a coarse level of granularity.

On one hand, determining all possible spatio-temporal combinations is a computationally demanding task that results in a huge number of alternative tours. On the other hand, such a large solution space inhibits finding an appropriate tour that fulfills traveler's individual preferences.

The proposed cooperative tour planning system enables a person and an assistance system to share this complex and computationally demanding task. The user specifies activity types and spatial constraints at different levels of granularity (as locations or regions) and contributes with a spatial strategy and tactics. The spatial strategy involves the definition of a coarse route that allows for constraining the search space at the coarse level of granularity. The spatial tactics involve modifications of tours proposed by the assistance system at the detailed level of granularity. The system employs a user-defined or automatically produced coarse route to guide the search procedure at the detailed level of granularity. In doing so, it efficiently generates a limited number of solutions that can be easily communicated to the user.

## COOPERATIVE SPATIAL PLANNING SYSTEM

The Cooperative Spatial Planning System is structured into the following functional components: *specification compo-*

*nent, navigation component, and tour generation component.* These operate on the data structures: *user-defined plan, knowledge base, and solution space.* The navigation

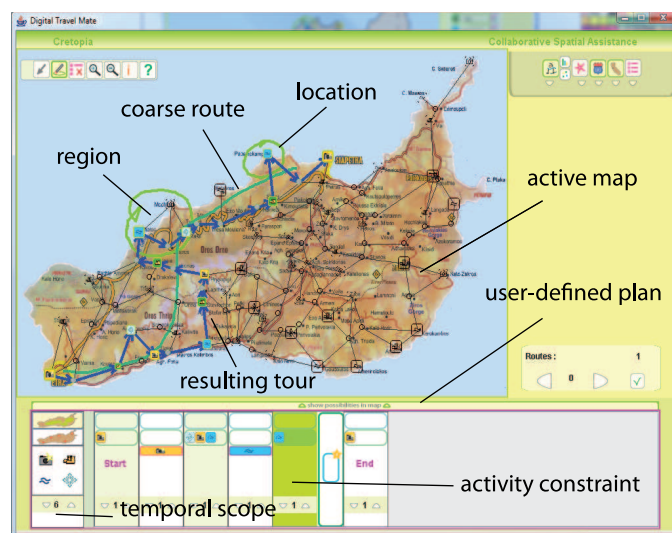


Figure 1. User Interface

component retrieves information about the environment from the knowledge base and presents it to the user on the active map (see Fig. 1). It enables the user to filter different aspects of information, e. g., landscapes, street network, or sight-seeing attractions. The specification component provides the user with interactive operations for modifications of a user-defined plan that encompasses a collection of activity constraints and a temporal scope. Each activity constraint includes the attributes: duration (e.g. 1 day), activity type (e.g. hiking), and spatial assignment (a location or a region). The assistance system operates on a hierarchical knowledge base that includes locations and high-level regions [2]. The solution space contains tours produced by the tour generation component.

## Cooperative Interaction Cycle

The cooperative interaction cycle encompasses problem solving states and state transitions which allow the user and the assistance system to work together towards a solution. The states encompass two different problem models, the definition of a coarse route, and the examining a solution space. The first problem model reflects the trajectory-based [3] spatial planning strategy. It involves the definition of a coarse

route that represents the main course of a journey and considers activity constraints of a variable temporal order. The second problem model reflects human spatial tactics at the detailed level of granularity according to the *closest next* principle [1]. It implies a fixed order of activities included in a user-defined plan. The cooperative problem space offers

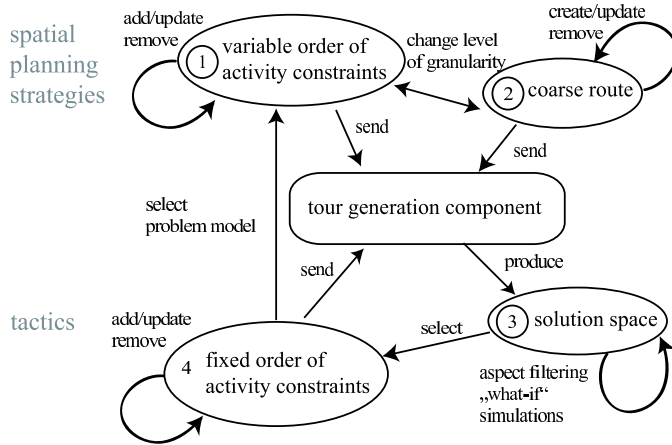


Figure 2. User Interface

three different entry points into the planning process (see Fig. 2). The problem solving states are illustrated as circles and corresponding state transitions as arrows. Each entry point is annotated with a number surrounded by a circle.

1. The first state and entry point represents the definition of a variable order of activity constraints. Possible transitions from this state are: sending a set of the specified activity constraints to the tour generation component, or applying the spatial planning strategy, i.e., the specification of a coarse route.
2. The user can also begin by specifying a coarse route as an entry point before defining activity constraints. Possible transitions are: sending the specified coarse route and set of activity constraints to the tour generation component, or continue the definition of activity constraints in the first state.
3. In the third state, the user can interactively examine the solutions space by focusing on specific aspects of the solution space, or observing it using "what-if" simulations. The solution space can also act as an entry point for starting the planning process by retrieving an example solution. Possible transitions from this state are: returning to the first or the second state via the entry points, or selecting a solution to modify it under consideration of a fixed order of activity constraints.
4. In the fourth state, the user can relax or specify additional activity types, durations, or spatial assignments by removing or modifying the activity constraints in the selected solution. Such local modifications keep the cooperative spatial planning system in balance, as long as the number of tours, which have to be considered by both problem solving partners, is within a specific bound (for example,

less than a hundred solutions). Possible transitions from this state are: sending the relaxed solution space to the tour generation component, or relaxing the order of activity constraints by moving to the first state, in case the problem space becomes too large.

The cooperative spatial planning system runs through the introduced problem solving states until the user finds an acceptable solution that fulfills his/her personal solution quality criteria. The assistance system produces solutions or reports conflicts if spatial assignments specified in the activity constraints are outside a user-defined coarse route or violate the temporal scope of a journey.

## CONCLUSION

This contribution presents an approach for assistance with difficult spatial tasks that goes beyond traditional navigation and wayfinding assistance systems. The user interface has been implemented as a JAVA-based application that runs on a mobile touch screen device (e. g., a notebook with a touchpad). The concepts underlying the introduced cooperative spatio-temporal planning system open new perspectives for the new generation of digital traveling guides and navigation systems. Videos demonstrating the interaction with the assistance system can be found:

<http://www.digitaltravelmate.net/>

## ACKNOWLEDGEMENTS

This work has been done in the scope of the project R1-[ImageSpace] funded by the German Research Foundation (DFG) in the framework of SFB TR/8 Spatial Cognition, University of Bremen.

## REFERENCES

1. B. Hayes-Roth and F. Hayes-Roth. A cognitive model of planning. *Cognitive Science*, 3:275–310, 1979.
2. I. Seifert, T. Barkowsky, and C. Freksa. Region-based representation for assistance with spatio-temporal planning in unfamiliar environments. In *In LBS and TeleCartography*, 2007.
3. T. Tenbrink and J. Wiener. The verbalization of multiple strategies in a variant of the traveling salesperson problem. *Cognitive Processing*, in press.