# Driving Map Construction by a Process-Oriented Context Model

**Kai-Florian Richer, Falko Schmid**

**Transregional Collaborative Research Center SFB/TR 8 Spatial Cognition**

**FB 03, Universität Bremen, PO Box 330 440, Bremen, Germany**

**{richter,schmid}@sfbtr8.uni-bremen.de**

In this paper, we outline an approach to the automatic generation of task-specific maps that uses a process-oriented context model to drive map construction. We introduce this context model, and schematization and schematic maps as our approach of providing task-specific assistance. We then explain how instantiating the constituents of the context model results in scripts determining the automatic construction of task-specific maps.

## A Process-Oriented View on Context

In mobile applications, context plays an important role. One of the main advantages claimed for assisting tasks with mobile devices is the possibility to adapt assistance to the current situation (Dix et al., 2000). The importance of context is also present in map-based mobile assistance; questions of context-awareness and adaptation to context play an important role here (e.g., Reichenbacher, 2001; Sarjakoski & Nivala, 2005). In most approaches context is supposed to emerge from parametrizing a (non-exhaustive) list of factors that may play a role in the current situation, for example, the location of a user, their age and stress level, lighting conditions, mode of transportation, display size of the mobile device, etc. These lists nearly inevitably have the stain of incompleteness.

Thus, other than more traditional approaches to context handling (for an overview, see Chen & Kotz, 2000), we take a process-oriented view on context (Freksa et al., 2007). The basic constituents defining context are the environment at hand *E* (e.g., an office building, a campus, or a city), the environment's representation *R* (e.g., a map or an agent's internal knowledge of an environment), and an agent *A* that uses the representation to interact in and with the environment (e.g., a human or a software agent). Between the three constituents, processes determine the interactions going on. These processes, in turn, are determined by the task at hand (*T*). Figure 1 provides a diagrammatic view on this context model. Context emerges from the consequences determined by the interplay of (a small set of) processes, instead of listing a large number of attributes and their possible values.

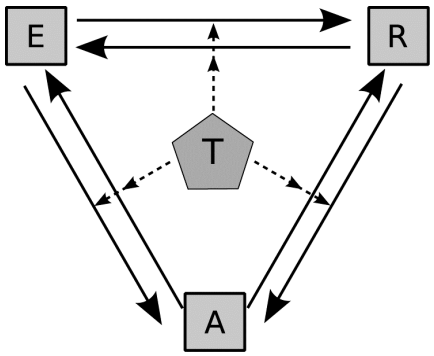


Figure 1: The process-oriented context model (from Freksa et al., 2007; modified) with the basic constituents *E, R, A,* and *T*.

## Schematization and Schematic Maps

We define schematization to be the process of simplifying a spatial representation beyond technical necessity in order to achieve cognitive adequacy (Klippel et al., 2005). The resulting spatial depictions are termed schematic maps. Schematization captures the abstraction pertinent in human perception and cognition of space in order to focus on the relevant information for a given task (Freksa, 1999). The abstraction captured by schematization processes may alter spatial information along several dimensions affecting map reading on a perceptual or cognitive level, or both (Peters & Richter, 2008).

We have developed principles for achieving different schematization effects that support map reading. They are brought together in a map generation toolbox (Richter et al., 2008). The toolbox consists of a collection of functionality and methods for generating schematic maps, covering all steps from setting up basic data structures to graphical and geometric manipulation of spatial objects (features represented as points, lines, or polygons).

## Context-Driven Map Generation

Currently, the operations stored in the toolbox can mostly be used independently of each other, i.e., in the way the toolbox is organized there is no predefined order of execution. However, clearly some execution orders do not result in sensible maps or simply render execution of further methods impossible. Therefore, we are currently setting up a control module for the toolbox that is based on the presented context model.

A process-oriented context model is an ideal basis for controlling the execution order. We use the toolbox to create task-specific maps; these maps specifically support those processes required for mastering the given task (Freksa, 1999). When constructing such maps, next to the task typically the environment and (type of) user, i.e., the agent, are known. Thus, by specifying task, environment, and user, we can determine what kind of map is needed and, consequently,

which operations need to be executed in which order. To this end, we define operation sequences, which can be thought of as scripts that are stored in a script repository and get called by the control module for specific constellations of the mentioned parameters T, E, and A (see Fig. 1).

The advantage of this approach is an increased reusability of toolbox functionality and an easier access of developers of wayfinding assistance services to this functionality. We expect a limited number of states we have to define and interlink. This way, we can automatically construct maps for different purposes. For example, if the task is navigation in a subway network, the environment at hand a city and the agent a human, we need to construct a map that illustrates how subway stations are connected. To this end, the corresponding construction script first selects from the geographic database all subway stations and their connecting lines. Since for this kind of task, the prime information is topology (the order of stations and places where to change lines), the script then calls line simplification functions that reduce the original geometric configuration of the connecting lines to straight-line connections between stations (see Barkowsky et al., 2000). Likewise, we can define scripts for constructing maps to support humans in navigating in urban environments or to support human-robot interaction in indoor settings.

The control module also allows for a flexible adaptation of external representations (R) when the context changes. For example, the representation used can be adapted to cues available in the current environment, may change depending on the type of robot currently handled in human-robot interaction, or may be changed when a human moves from known to unknown parts of an environment and vice versa (cf. Schmid, 2008). It is also possible to define scripts for other parameter combinations, for example, if the agent or environment is unknown. Keeping the task undefined will result in a non-schematized map since in this case it is unknown which information is most relevant. A base (topographic) map is displayed instead. Since the context model allows for different representations, the control module may also be extended to decide whether a verbal or graphical presentation of information is more suitable in a given situation. It, thus, also lends its way to developing multi-modal assistance systems.

## Summary

Using a process-oriented view on context allows for straightforwardly focusing on the relevant aspects in context-specific map construction without the need to specify arbitrary lists of environmental, device, or user parameters. Setting three of the four context model's constituents, environment (E), representation (R), agent (A), and task (T), fully determines the kind of emerging assistance. It also results in scripts that determine how this assistance is to be generated, which will be stored in a script repository for future re-use. The definition and execution of scripts—instead of calling methods of the schematization toolbox in the right order

manually–will ease the development of assistance systems as they provide an important abstraction level to the individual functions' inner workings. Implementing and testing the proposed control module is work in progress.

## References


Barkowsky, T., Latecki, L.J., & Richter, K.-F. 2000. Schematizing maps: Simplification of geographic shape by discrete curve evolution. In C. Freksa, W. Brauer, C. Habel, & K.F. Wender, eds. *Spatial Cognition II*. Berlin: Springer, pp. 41-53.

Chen, G. & Kotz, D. 2000. *A survey of context-aware mobile computing research*. Dartmouth Computer Science Technical Report TR2000-81. Hanover, NH: Department of Computer Science, Dartmouth College.

Dix, A., Rodden, T., Davies, N, Trevor, J., Friday, A., & Palfreyman, K. 2000. Exploiting space and location as a design framework for interactive mobile systems. *ACM Transactions on Computer-Human Interaction* vol. 7, no. 3, pp. 285-321.

Freksa, C. 1999. Spatial aspects of task-specific wayfinding maps—a representation-theoretic perspective. In J.S. Gero & B. Tversky, eds. *Visual and spatial reasoning in design*. University of Sidney: Key Centre of Design Computing and Cognition, pp. 15-32.

Freksa, C., Klippel, A. & Winter, S. 2007. A cognitive perspective on spatial context. In A.G. Cohn, C. Freksa & B. Nebel, eds. *Spatial cognition: Specialization and integration*. Dagstuhl: Dagstuhl Seminar Proceedings. No. 05491.

Klippel, A., Richter, K.-F., Barkowsky, T. & Freksa, C. 2005. The cognitive reality of schematic maps. In L. Meng, A. Zipf & T. Reichenbacher, eds. *Map-based mobile services.* Berlin: Springer, pp. 57-74.

Peters, D. & Richter, K.-F. 2008. Taking off to the third dimension — schematization of virtual environments. *International Journal of Spatial Data Infrastructures Research* vol. 3, pp. 20-37.

Reichenbacher, T. 2001. The world in your pocket—towards a mobile cartography. In *Proceedings of the 20th international cartographic conference*. Beijing, China.

Richter, K.-F., Peters, D., Kuhnmünch, G. & Schmid, F. 2008. What do focus maps focus on? In C. Freksa, N. Newcombe, P. Gärdernfors & S. Wölfl, eds. *Spatial cognition VI*. Berlin: Springer, pp. 154-170.

Sarjakoski, L.T. & Nivala, A.M. 2005. Adaptation to context—a way to improve the usability of topographic mobile maps. In L. Meng, A. Zipf & T. Reichenbacher, eds. *Map-based mobile services—theories, methods and implementations*. Berlin: Springer, pp. 107-123.

Schmid, F. 2008. Knowledge based wayfinding maps for small display cartography. *Journal of Location Based Systems*, vol 2, no. 1, pp. 57-83.