Spatial Information in Tactile Orientation Maps – The Users' Requirements

Christian GRAF
University of Bremen, FB3 – Informatics, Cognitive Systems

Abstract. Tactile orientation maps for conveying survey knowledge of a previously unknown area hold a lot less detail in terms of quantity of displayed representations and in terms of quality of the represented spatial concepts. When constructing such maps, the selection of spatial entities could be driven by a hierarchy of spatial concepts. This paper reports an interview with blind users to determine a hierarchy of spatial information regarded as necessary in tactile orientation maps. The underlying spatial concepts are identified, discussed and ranked. In the end, Future work to come foster a hierarchy of spatial concepts for tactile orientation maps is proposed.

Keywords. Survey representation, tactile map, user requirements, spatial concepts

1. Introduction

It was suggested that different spatial knowledge sources are differently suited for geographical environments of different size, for example that campus locations were learned better through a mediated experience with small-scale models [1]. Such models are, for example, maps. At least two types can be differentiated: route maps and survey maps. A route map specifies one route from a indicated location A to some other location B. It affords to follow one linear succession of turning points connected by route segments while discarding most of the geographic information that has no relation to neither of the elements. Survey maps are used to gain an overview of geographic environments. From a holistic view they show where landmarks are positioned and how the street network is structured. As they show the whole environment, re-orientation at multiple locations is afforded and multiple routes can be determined when needed from the map or from the mental model acquired with it. It depends on the task the navigator wants to solve with the map at hand, but survey maps are believed to be more generic in usage in comparison to route maps. In this article, I will present some users' requirements for orientation maps of previously unknown environments that are made to be read by touch, i.e. Tactile Orientation Maps (TOM). I will reason about how a deliberate choice what to display in such a map and what to leave out could be obtained.

Tactile realisation of cartographic representations have been in the focus of the map-making profession for some time, be it as tool for conveying and communicating geographic knowledge [2-6]. In times of GPS driven, mobile navigation systems that are especially customized to guide blind people there seem to be no need for bulky, tactile maps. But it was argued that approaches focusing on conveying routes have no positive effects on learning spatial knowledge about the environment travelled [7, 8].

As one suggestion, TOM could be used to become independent from route guidance systems by learning the structure of some unknown environment before starting the locomotion.

The challenge in building a TOM is that the tactual realisations of different spatial aspects compete for limited map space. Not all concepts that would be present in a visual map can be represented in a tactile map to allow for the tactual realisation of the most important ones[1]. To guide the relaxation of aspects whose correct depiction is assumed to be of lesser importance for map interpretation, a *depictional precedence hierarchy* of spatial concepts was proposed for some other type of map [9]. Such a hierarchy of spatial concepts for TOM would allow for making an well-informed decision at construction time about which concepts might not be depicted in the map without loosing essential geographic information. The aim of this paper is to report about a short study to identify whether there is a set of spatial concepts that potential map-users regard as essential to be represented in TOM and which items belong to that set.

2. Users' Requirements For Tactile Orientation Maps

Following a user-centred design methodology [10] potential future users of TOM were incorporated in that requirements the artefacts are discussed first. Three visually-impaired, late blind persons took part in a structured group interview. First, they were asked about their experience with tasks of navigation. Then, we discussed the types of spatial concepts that they would expect to be represented in a TOM such that an unknown urban environment could be learned for later locomotion in the physical environment. In the end, the participants were asked to rank the spatial concepts for a TOM.

During the first phase of the interviews, the participants characterised their information need during tactile map reading as being focused on acquiring distal, abstract and rather coarse information. They reported that in the preparation phase they built a survey-like mental model based on allocentric directions and relations, for example, remembering what landmark is in the north/south/west/east on the map.

During the second phase of the interview about which details the readers of a TOM would certainly expect, the following were recalled without cueing.

- **Cardinal directions**. Using cardinal directions in learning the position of some spatial entity (for example, a landmark) in relation to the displayed area and other landmarks offers the opportunity to roughly know the layout of the environment.
- **Landmarks**. The interviewees regarded point-like landmarks more important that line-like landmarks or area-like landmarks as they identify distinct positions in space most precisely.
  - Most important: Persistent, unique objects that could be asked for, for example historical buildings, monuments, churches, fountains, bridges, sightseeing spots, railway stations, stops for public transport
  - Important: Public squares, major roads and side streets, pedestrian

[1] The challenge to represent spatial information on tactile maps was compared to the challenge displaying visual maps on small display devices [11].

pathways and intersections, open areas that can be sensed by sound or by smell, for example parks or soccer fields, and water bodies such as streams or lakes

- **Scale & Topology.** The interviewees equivocally reported that representing the topology (how streets and intersections are connected) was important, especially if the scale of the map is not constant such that the map-users cannot rely on distances read from the map. Then, labelling approximate distances should be considered in a TOM.
- **Acoustic Characteristics along Streets.** For walking in an unknown environment it was regarded as helpful to know what acoustic characteristics to expect along potential walkways. Especially changes of echo were reported as important as they allow for estimating how far someone has already progressed. To benefit form the map the traveller should – at best – be able to anticipate the sound characteristics beforehand. The TOM must provide necessary information such that the map-reader might relate the learned spatial sound characteristics with the factual ones in the geographic environment.
- **Structural Characteristics at Intersections**. It was reported important to know about undetectable, more structural aids. For example, at a pedestrian crossing it is usually not clear to the blind pedestrians whether there is an island in the middle of the street where people could stop to be save from traffic. The existence of such structural aid cannot be detected in other ways and should be represented in a TOM.

Concerning what to display in a TOM the interviewees pointed out that it is important how well a blind pedestrian already knows the environment in question. If one assumes that someone is completely new to an environment then it might not be a good idea to fill the map with too much detail. Then the existence of tactile walking indicators and the characteristics of the ground should possible not be displayed as they could overwhelm the map reader. In the preparation phase information about ground properties such as inclination or material, information about local support means such as groove plates and attention fields do not provide substantial help to blind pedestrians who want to build up an abstract, rather coarse mental model of the environment.

When asked for a ranking the participants equivocally voted for the topology as being the most important information. Valued second most important were natural, static landmarks in the environment such as parks and water bodies. Artificial landmarks such as salient buildings and monuments were ranked third. Distance and cardinal directions were ranked to be of lower importance. Features like acoustic characteristics that mainly support safe locomotion in the terrain were regarded as to be of almost no relevance for getting an overview in an formerly unknown environment. The interviewees stressed that, in addition to the information in the map, information about the general context of the map should be given, for example, whether the map shows a rather flat or rather hilly area, whether the depicted urban environment is a small town or a big city.

3. Conclusion

An interview with a group of visually impaired but mobile pedestrians brought up. some interesting opinions about what information are useful in tactile orientation maps. Equivocal was the statement that for usable tactile orientation maps the concepts topology and landmarks (especially the point-like ones) are important. Tactile orientation maps do not need to be metrically veridical, i.e. having a unique scale, as long as their topological structure is maintained, i.e. intersections and their neighbourhood relations are maintained.

To come up with a proposal for a *precedence hierarchy of spatial concepts for tactile orientation maps* comparable to that for visual route maps [12] or the hierarchy of primitives of spatial knowledge [13] more investigation need to be made. A promising approach could be to combine the user-centered design approach with results from the cognitive sciences regarding spatial orientation. User-centered design includes the users as active part in solving the problem, for example, through ethnographic interviews and prototyping. The results form cognitive science could motivate some decisions that cannot be obtained by user-centered design as users do not always have an idea what could be better for them than the already known. The quest for better tactile orientation maps could result in rendering TOM users "free and self-dependent", as one interviewee expressed his hope.

References

1. Bilge, A. R., & Taylor, H. A. (2010). Where is “Here” in Nested Environments? Location Accessibility from Different Sources. *Spatial Cognition & Computation*, *10*(2), 157–183.
2. Blades, M., Ungar, S., & Spencer, C. (1999). Map Use by Adults with Visual Impairments. *The Professional Geographer*, *51*(4), 539-553. DOI:10.1111/0033-0124.00191
3. Espinosa, M. A., & Ochaita, E. (1998). Using Tactile Maps To Improve the Practical Spatial Knowledge of Adults Who Are Blind. *Journal of Visual Impairment & Blindness*, *92*(5), 338–45.
4. Sherman, J. C. (1975). The Challenge of Maps for the Visually Handicapped. *Auto-carto 2: Proceedings of the International Symposium on Computer-Assisted Cartography* (Vol. 1, pp. 91-98). Reston, Virginia: U.S. Bureau of the Census and American Congress on Surveying and Mapping.
5. Spencer, Christopher, & Travis, J. (1985). Learning a new area with and without the use of tactile maps: a comparative study. *British Journal of Visual Impairment*, *3*(1), 5-7. DOI:10.1177/026461968500300103
6. Ungar, S., Espinosa, A., Blades, M., Ochaíta, E., & Spencer, C. (1998). Blind and Visually Impaired People Using Tactile Maps. *Cartographic Perspectives*, *28*, 4–12.
7. Parush, A., Ahuvia, S., & Erev, I. (2007). Degradation in Spatial Knowledge Acquisition When Using Automatic Navigation Systems. In S. Winter, M. Duckham, L. Kulik, & B. Kuipers (Hrsg.), *Proceedings of the 8th International Conference on Spatial Information Theory (COSIT 2007)*, Lecture Notes in Computer Science (Vol. 4736, pp. 238-254). Berlin /

Heidelberg: Springer-Verlag. DOI: 10.1007/978-3-540-74788-8_15

8. Burnett, G. E., & Lee, K. (2005). The effect of vehicle navigation systems on the formation of cognitive maps. In G. Underwood (Hrsg.), *Traffic and transport psychology - Theory and Application* (pp. 407-418). Amsterdam: Elsevier.
9. Barkowsky, T., & Freksa, C. (1997). Cognitive requirements on making and interpreting maps. In S. C. Hirtle & A. U. Frank (eds.), *Spatial information theory: A theoretical basis for GIS*, LNCS (Vol. 1329, pp. 347-361). Berlin, Heidelberg: Springer. DOI: 10.1007/3-540-63623-4_60
10. Dix, A., Finlay, J., Adowd, G.D. and Beale, R. (2004). *Human-computer interaction* (Third Edition). Harlow : Pearson Education.
11. Graf, C., & Schmid, F. (2010). From Visual Schematic to Tactile Schematic Maps. In S. C. Hirtle, A. Klippel, & F. Schmid (eds.), *Workshop You Are Here 2: 2nd Workshop on Spatial Awareness and Geographic Knowledge Acquisition with Small Mobile Devices, Proceedings* (pp. 15-28). Mt. Hood / Portland, Oregon.
12. Agrawala, M., & Stolte, C. (2001). Rendering effective route maps: improving usability through generalization. *Proceedings of the 28th annual conference on Computer graphics and interactive techniques* (pp. 241-249). International Conference on Computer graphics and interactive techniques, New York, NY, USA: ACM. DOI:10.1145/383259.383286
13. Golledge, R. G. (1995). Primitives of Spatial Knowledge. In T. L. Nyerges, D. M. Mark, R. Laurini, & M. J. Egenhofer (Hrsg.), *Cognitive aspects of human-computer interaction for geographic information systems*, NATO ASI series : Series D, Behavioural and social sciences (Vol. 83, pp. 29-44). Dordrecht, Netherlands: Kluwer Academic Publishers.