What the Quest for Tactile Maps Can Teach Us about Making Interactive Maps

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***Abstract*—For those people who are visually impaired or blind there are tactile maps that can be read by touch. Like in visual maps, the tactual entities representing geographical features have to be carefully selected and placed on the map with respect to technical and sensory considerations, i.e. abstraction. A *schematic map* is abstracted beyond technical needs. It can support map-readers to better grasp the essential spatial concepts represented in the schematic map. This short paper first collects the constraints for constructing schematic tactile orientation maps that can be easily understood and used. It discusses how the knowledge about schematization principles found for tactile orientation maps and the lessons learned during the quest for those maps can benefit the construction of visual interactive maps. The aim of the transfer is that (certain types of) visual maps can be abstracted in novel ways such that the whole map then would be easier to understand.**

Keywords*— spatial cognition, tactile map, interactive map, schematization

I. Introduction

Diagrammatic representations, such as maps, have proven to be successful aids in navigation [1], i.e. to gain some geographical knowledge about the world. In the age of GPS assisted wayfinding systems, why should we deal with other forms of assistance? It has been argued that turn-by-turn instructions outperform maps in terms of navigation success [2]. However, it was argued that technology focused on conveying routes has no positive effects in acquiring spatial knowledge about the environment traveled [3]. The more complex is the information communicated by the assistance, the richer could be the understanding of the environment, the better would be the orientation and wayfinding performance within. A good understanding of a map will allow wayfinders to navigate the environment as freely from assistance as possible. But often maps are regarded as complicated as they 'hide' the information needed for a certain task. One approach is to abstract maps following cognitively grounded principles such that the whole map then would be easier to understand.

II. Maps for the Blind

Maps can be brought into existence in different sensory channels (for example, visual maps, auditory maps, tactile maps) accustomed for differently enabled users. In the case of visually impaired people, tactile maps have become an option to supply geographical knowledge [4]. Supporting the role of tactile maps, it was pointed out that they "have a clear advantage in facilitating the development of cognitive maps by providing a global perspective on the surrounding geography"[1] [5, p. 259]. By exploring tactile maps in map scale a person could acquire abstract survey knowledge of some area that might be helpful for navigation in geographic scale. There is strong evidence that tactile maps are a promising aid to convey geographical knowledge to visually impaired persons [6].

Due to the low resolution tactile maps are very sparsely populated with cartographic entities to ensure that the reader may distinguish every single one. Entities must have very different tactile characteristics to differentiate them, for example, in terms of pattern/texture, width, elevation etc. Overlapping or connected entities are often omitted to gain a clear separation and to avoid introducing ambiguities.

Recent technological developments have made the fast production of tactile maps become an option. There are first digital devices that can be used to present tactile maps as dynamic physical artifact, for example, the Hyperbraille display [7]. New tactile printers that are capable of processing line graphics—which many Braille printers cannot—have become available, for example the TIGER Emprint [8]. The tactile print-outs are one viable option for production of tactile artifacts in terms of availability and low production cost. Even if only the tactile displays allow for interactive usage, both technologies offer an individual, on-demand, and nearly effortless access to tactile graphics. And as both technologies produce graphical representations that are non-continuous, i.e. they are composed from discrete single tactile entities (much like the pixels in visual graphics but with a resolution of about 20dpi), challenges and solutions for one technology could apply for the other to realize cognitively-adequate and usable tactile maps (see [9]).

III. Schematic Maps

Due to the low resolution in the tactile modality, tactile maps cannot be populated heavily (tactile entities are rather large compared to graphical entities and they need a larger gaps to be recognized as separate entities). Selecting map entities has to be limited heavily to the relevant ones by letting out geographic detail by choosing only relevant features. After selection, relevant features have to be abstracted and their map representations placed in such way that they can be easily

1 The exact nature of the representation is not of importance for this work as long as one assumes functional equivalence.

discriminated perceptually[2]. The intentional distortion of a representation beyond technical needs to achieve cognitive adequacy was called *schematization* [10]. Schematization aims for facilitating map comprehension through deliberately introducing abstraction and distortions that support the cognitive processing of the information displayed. Research in spatial cognition has shown that humans form abstract knowledge about their geographic environments when learning maps to ease spatial tasks such as way-finding. Those *schematic maps* are intentionally simplified representation aiming at cognitive adequacy. Through a cognitively motivated schematization at the time of map-construction the map-maker can help the map-user in comprehending the map when reading it. Several investigations showed that using (visual) schematic maps holds advantages compared to maps that were not schematized [11].

IV. Schematization in Tactile Maps and It's Transfer to Interactive Maps

I have previously proposed other schematization principles for tactile maps, for example to shorten segments where no activity is needed or to provide static relations to main landmarks [12]. The thorough investigation of schematization principles for tactile survey maps brought about three areas of enhancements through schematization [9]. *First*, distortions of track networks can be used to emphasize certain spatial concepts, for example, how streets intersect or connect. The shortening of segments, the simplification of the geometry of the segments, and the schematization of intersections decreases the sensory complexity of the map, could decrease cognitive processing and could prevent misconception of the underlying track network. Subsequent problems in matching the remembered structure with the environment are prevented (e.g. when the navigator engages in a path following task once in the geographical environment) if the main characteristics are preserved. For interactive maps, this schematization approach could be well suited as visual attention is focused on the important conceptual details. *Second*, comprehension of the map can be facilitated by preventing clutter in the map. This could be achieved through using not only the map space but the map margin to hint for relevant relations and entities, for example by using indicators that are place in the margin of the map instead of placing everything into the map space [13]. In this way, important entities or positions can be foregrounded such that map-users find them faster compared to searching the whole map-space. Relations to adjacent maps can be made clear by placing indicators about the direction and distance of global landmarks, such that the embedding of the current map in the greater surrounding becomes clear. In interactive maps, when entities dynamically change positions, including indicators at the margin of the frame could ease tracking of otherwise volatile entities. *Third*, a Bell curve like distribution of map entities seems to characterize the conceptualization of the content of tactile maps. The central part of the tested tactile maps were conceptualized well, but the space towards the frame of the map was only remembered in low details even if the need for knowing about connections to other parts of the environment was stressed. For interactive maps an approach with different density of map entities could result in having full details in the center and low details in parts that are far away, i.e. by applying a non-uniform abstraction.

The investigated schematizations may contribute to different levels of map understanding. Some contribute to a better understanding of the content of the map itself, for example the distortion of the track network or the non-uniform abstraction. Others contribute to a better understanding of the existence and relations of important landmarks, for example by employing indicators. And those indicators seem to help (in the case of tactile maps) to understand the embedding of the map into the greater surrounding, which is a third quality. The investigation of these qualities and their relations to the proposed model of factors of map-understanding (e.g. [14]) could guide the systematic investigation of interaction with maps, regardless whether it is a tactile or a visual map.

2 In cartography the whole process from geographic data to map representation is called ‘generalization’.

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