Re-visiting fundamental principles of mobile cartography

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ABSTRACT
In this position paper I aim at outlining my personal view on the major research challenges regarding "User Experience Design for Mobile Cartography: Setting the Agenda". The four key research challenges are integration, design, cognition, and evaluation. To address these research challenges, in addition to adopting new technologies for mobile mapping, more fundamental research is needed.

Author Keywords
Mobile map design; data integration; map evaluation

INTRODUCTION
Mobile cartography (in the sense of mobile used digital cartography) has since its first conceptual definitions [2, 7] become ubiquitous and mainstream. The main drivers of these advancements were the large tech companies, such as Google, Apple, and Microsoft. Predominantly advances in hardware (Smartphones, high-resolution displays, GPS sensors), software (mobile operating systems, apps), and service provision (e.g., Google Maps, Apple Maps, Bing Maps) seem to have solved most problems still around at the turn of the new millennium.

What is missing
What I observe are LBS apps and mobile mapping tools featuring most recent technological advancements (e.g., 3D, VR, and AR. The underlying map designs and uses, however, have not changed much over the years. They are still quite simplistic, such as basic maps highlighting one's position or the locations of objects and/or people.

Thematically richer maps, or maps affording deeper analytics and supporting more complex decision-making, are still scarce. Similarly, the adoption of adaptive behavior and context-awareness is slow. Apart from basic filtering, context-awareness and relevance of information in current LBS apps and mobile maps is low.

My thesis is that design habits and a fixation on the ever-newest technical opportunities have hindered a profound analysis of mobile map usage contexts and its implications on mobile cartography design.

What are the next steps and research challenges?
To change this situation and to fill some of the research gaps in relation to user experience design for mobile cartography we identify following research challenges: 1) data and service integration for mobile maps 2) mobility-oriented map design; 3) cognition in mobile map usage; 4) appropriate evaluation methods for mobile map use experience. The next section elaborates on each of these research challenges.

Integration
Recent years have brought a plethora of new georeferenced data and services. Non the least, the increasing availability of all kinds of sensors, be it in the mobile devices itself or in smart environments, produce vast amounts of real-time data and data streams. Although georeferenced data visualized in mobile maps do not qualify as big data in a narrow sense, it still does have the velocity of its production and variety of its types in common.

A major challenge for a successful mobile map user experience is thus the integration of these data in mobile apps or services [4]. Such integration capability requires

- handling of various data types and data streams
- interacting with bots (machine-to-machine communication)
- processing of real-time data
- conflation of heterogeneous data of different spatial and temporal scales
- enhancement of existing integration and generalization methods for operating in real-time
- communication of data origin, its characteristics, and perhaps limitations to mobile users effectively and non-intrusively

Design
Up to now the field of mobile cartography and LBS is largely technology driven. While technology has simplified, or even enabled, how we can experience mobile maps, a too strong focus on technological advancements neglect fundamental issues of mobile cartography and map design for mobile usage. Still most mobile maps look like a miniaturized version of traditional paper maps or web maps. Not only can this lead to reading problems on mobile devices and a misfit of purpose, but also the potential of mobile maps is not fully exploited [4, 5].

While the first mobile maps were largely consumed by a public used to paper maps, the number of digital natives as

users is constantly growing. This user base comes with different "reading" behavior, comprehending mobile maps as a mainstream commodity.

To successfully design effective mobile maps that offer a positive user experience in a multitude of mobile usage contexts we need to

- find, possibly generic, map design approaches that allow for fast perception and cognition in mobile situations [9]

- improve contextualization of geographic information in mobile situations to allow for sense-making [5]

- investigate how dashboards for dynamic data can be combined with mobile map interfaces

- support efficient & effective information processing by contextually assessing the relevance of geographic information [1]

- further develop methods of context assessment and linked adaptive map behavior (e.g. change of map content, map design, map interactivity) [3]

Cognition

The last decade has seen a growing interest in cognitive issues in the larger field of cartography. Taking into account the cognitive processes involved in mobile map usage is crucial for better understanding mobile users and hence improving their experience with better fitted designs. Related to cognition we need to

- investigate how cognition can be distributed between users and mobile map services or apps

- recognize how cognitive offloading can release cognitive load in mobile usage situations, i.e. decision-making under time pressure, spatial analytics, navigation, etc.

- study, if and how metaphors are beneficial for interacting with mobile maps and how they can support sense-making

- investigate how mobile maps as a tool can mediate actions and how they fit in a more complex hierarchy of activity, actions and operations [6]

- examine how users process dynamic geographic information and how detecting changes in processes or event data may be supported by mobile map designs

- understand how users can combine and process mobile 2D/3D maps, or augmented reality maps when engaging with the physical environment

- examine how spatial analytical capacity be distributed between users, mobile apps and a backend service

- investigate how analytical tools must be designed in order to be effective on small screens and in mobile usage situations

Evaluation

To make substantial progress in the field and elicit robust knowledge about the underlying principles of mobile cartography we will have to continue the empirical evaluation of mobile map design solutions, analytical tools, and mobile map usage in the field [8].

With respect to the complexity of mobile map use experience we need a broad mix of empirical evaluation methods, addressing fundamental design principles and information processing, and mobile user experience studies in more ecologically valid field or field-like environments likewise. I strongly argue for further studies

- using stationary eye tracking (e.g. for testing visual attention guiding ability of different visual variables; change detection abilities on mobile map displays)

- using mobile eye tracking in more realistic usage situations in the field (e.g., testing referencing map representations to surroundings)

- with more controlled experiments of map usage in simulated real-world scenarios in in large scale Cave Automatic Virtual Environments (e.g., testing navigation support of a mobile map design)

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