

Wayfinding Cognition & Mobile Maps for Indoor Settings

Christoph Hölscher
University of Freiburg,
Center for Cognitive Science
Friedrichstr. 50, 79098
Freiburg, Germany
hoelsch@cognition.
uni-freiburg.de

Daniel R. Montello
University of California, Santa
Barbara
Department of Geography
UCSB
Santa Barbara, CA 93106
USA
montello@geog.ucsb.edu

Verena Schnitzler
University of Freiburg,
Center for Cognitive Science
Friedrichstr. 50, 79098
Freiburg, Germany
verena.schnitzler@cognition.
uni-freiburg.de

ABSTRACT

We describe our current research on HCI aspects of digital indoor navigation systems. We focus not only on traditional concerns of usability, but on basic behavioral and cognitive questions concerning spatial learning, reasoning strategies, and individual differences among users. We also stress the importance of analyzing the physical setting of wayfinding.

Author Keywords

Wayfinding; Mobile Maps; Indoor Positioning; Individual Differences; Space Syntax; Spatial Cognition

ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

General Terms

Human Factors; Design; Measurement.

INTRODUCTION

In recent years, navigating through outdoor environments (on streets and highways) has been largely augmented by the arrival of digital, often GPS-enabled, maps on smartphones and other devices, for use indoors. Only very recently has similar technology become available to the general public for navigating indoors, in the form of Indoor Maps for Google Maps on the Android platform. In 2012, our research team begun initial studies into issues of user experience, behavioral strategies, and spatial learning with digital indoor maps.

Finding your way in a large public building can be a challenging task, and people frequently report frustration and failure not unlike that triggered by the poor user interfaces of some digital systems. Ultimately, human-computer interaction is a type of human-artifact interaction, and HCI research is characterized by analyzing human

behavior, cognitive processes, and task structures. Buildings can also be understood as artifacts, and humans interact with these artifacts in numerous ways. Both geographers and psychologists have studied human navigation, map use, and spatial learning since the 1970s or earlier, and especially in the last two decades, they have focused their interest on navigating with computational technologies [4, 5]. Wayfinding in the built environment shares a number of properties with traditional human-computer interaction, although the metaphorical space of computer systems and databases is quite different than the real space of the earth surface. Identifying a reasonable route to a destination can be characterized as a planning and problem-solving task, involving general (background) knowledge about urban and building structures, specific memories about particular locations (spatial memory), as well as heuristics and strategies for turning spatial information into movement plans and action. Researchers [e.g. 1, 7] have identified building features like visual access, architectural differentiation, layout complexity, and signage as key triggers of navigation success or failure. These can be seen as the interface elements that determine how a building is ‘read’ or understood, and how people make movement decisions. Over the past 10 years, our research group has conducted a range of behavioral studies in real and VR-simulated buildings to untie the relationship between building features and user behavior; we have identified “usability hotspots” in building design with respect to orientation and navigation [1, 3]. Adding a digital device to the navigation process may or may not be beneficial for wayfinding performance and/or spatial learning, but it clearly makes the applicability of a HCI perspective on human navigation even more evident.

In planning our own research on digital indoor maps we have identified a number of issues at the interface of HCI, psychology, and geographic information science that are relevant for other geographic HCI research and design projects, and thus can inform a discussion on the emerging field of geographic HCI (GeoHCI). First, we distinguish between analyzing a digital device with respect to its direct usability and interface on one hand, and the underlying task model and its impact on other core cognitive tasks on the

other hand. For digital indoor maps, the latter is addressed by looking at the impact of using a device on how people choose routes and learn about the environment. These are captured by established, partly standardized experimental procedures from behavioral science. This is an addition to more qualitative observation of how people interact with the device and specific user-interface features. In this context, behavioral experiments can reveal underlying task structures, behavioral strategies, and learning components that constitute basic research findings in their own right. At the same time, they can inform the future design of digital systems and serve as benchmarks for assessing new systems.

Key for GeoHCI is that the human cognitive apparatus includes specific mechanisms for handling spatial information. The spatial-cognition community has spent several decades investigating these phenomena, from which the GeoHCI community can benefit. For example, psychologists have developed a range of standardized and validated psychometric measures (performance measures as well as self-report scales) to capture individual differences in basic spatial processes like mental rotation, and higher-level composite skills like wayfinding competence. Individual differences have a particularly strong impact on wayfinding tasks, with respect to both actual performance and subjective competence and enjoyment. There may also be cultural differences in spatial processing. Therefore, our project aims to compare device use between U.S. and European participants who may differ, e.g., in their reliance on cardinal-directions vs. egocentric navigation strategies.

Determining the usability of any device routinely requires one take into account tasks as well as characteristics of intended user group(s). In the case of wayfinding, the physical environment becomes a crucial factor in itself and must be taken into account. For example, asking users about their experience (or measuring their performance) with a specific device, for a specific task (such as finding the shortest route between locations) will be confounded with characteristics of the building(s) in question; separating out the relative impact of each factor becomes non-trivial. For user-experience questionnaires, this means developing separate items for aspects of the environment and device. And to compare results across environments, it is important to characterize environmental complexity. For wayfinding, whether outdoor or indoor, the environmental characteristics presented above provide a basis for this analysis, and analytic techniques like space syntax [3] can help measure behaviorally relevant properties.

When investigating GeoHCI in a complex setting, it is highly desirable to collect several streams of data to support methodological triangulation and provide a rich basis for reconstructing user interaction with the environment and digital device. Devices like smart phones can produce logfiles of spatial positions as well as screen videos of interactions with the interface. Our group has developed the

PeopleWatcher App [2], which allows real-time coding of events such as sign and map interaction, asking for help, etc. Human observations can be used to validate the spatial accuracy of the device's logfiles (and vice versa).

Another relevant issue is the impact of shortcomings of digital devices. From a research perspective, comparing traditional static maps to digital indoor maps is most promising when the digital device provides consistent and highly accurate self-localization and heading information to the user. On publicly available systems without specific instrumentation for each building – like Google Indoor Maps – reliability in this respect is quite variable. By itself, this triggers new HCI-oriented research questions, like how do people react to such irregularities? At the same time, this illustrates that different versions of a technology may be required for different research questions.

While challenges for research and design will vary depending on the type of task or tool, GeoHCI needs to take a cognitive as well as technical perspective, and user characteristics and environmental properties must be appropriately modeled to capture phenomena of interest [6].

ACKNOWLEDGMENTS

We thank Google Inc. for the Google Award as well as Jens Riegelsberger and his GeoUX team for supporting our current research project.

REFERENCES

1. Carlson, L.A., Hölscher, C., Shipley, T.F., and Dalton, R.C. Getting lost in buildings. *Current Directions in Psychological Science* 19, 5 (2010), 284–289.
2. Dalton, N., Dalton, R., Hölscher, C., and KuhnMünch, G. An iPad app for recording movement paths and associated spatial behaviors. *Proc. Intern. Conf. Spatial Cognition (SC2012)*, (2012), pp. 431-450.
3. Hölscher, C., Brösamle, M., and Vrachliotis, G. Challenges in multilevel wayfinding: A case study with the space syntax technique. *Environment and Planning B: Planning and Design* 39, 1 (2012), 63–82.
4. Montello, D.R. Navigation. In P. Shah and A. Miyake (Eds.), *The Cambridge Handbook of Visuospatial Thinking* (2005), pp. 257–294. Cambridge: Cambridge University Press.
5. Montello, D.R. Cognitive research in GIScience: Recent achievements and future prospects. *Geography Compass* 3, 5 (2009), 1824–1840.
6. Montello, D.R. and Sas, C. Human factors of wayfinding in navigation. In W. Karwowski (Ed.), *International Encyclopedia of Ergonomics and Human Factors*, 2nd ed. (2006), pp. 2003–2008. London: CRC Press/Taylor & Francis, Ltd.
7. Weisman, J. Evaluating architectural legibility: Wayfinding in the built environment. *Environment and Behavior* 13, 2 (1981), 189–204.