Bridging the Social-Technical Gap in Location-Aware Computing

Fabien Girardin
Interactive Technologies Group
Pompeu Fabra University
Passeig de Circumval·ació, 8
08003 Barcelona, Spain
Fabien.Girardin@upf.edu

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Abstract
Building ubiquitous applications that exploit location requires integrating underlying infrastructure for linking sensors with high-level representation of the measure space to support human activities. However, the real-world constraints limit the efficiency of location technologies. The inherent spatial uncertainty embedded in mobile and location systems constantly challenges the coexistence of digital and physical spaces. Consequently, the technical mechanisms fail to match the highly flexible, nuanced, and contextual human spatial activities. These discrepancies generate a social-technical gap between what should be socially supported and what can be technically achieved. My research aims at exploring, and hopefully reducing this gap in the context of location-aware computing.

Keywords
HCI, CSCW, Location-Aware Computing, Ubiquitous Computing, Uncertainty.

ACM Classification Keywords
H5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Problem Statement and Research Question

Location-aware systems emerged from the recent evolution of mobile computing, location sensing and wireless networking. They play a central role in ubiquitous computing to sense and react to real-world context. However, physical, technological, organizational or economical constraints limit their use in the real world. Each location and wireless enabling technology carries its own set of limitations and problems in terms of service coverage, stability, connectivity, mobility, cost, privacy and accuracy. Therefore, the advantage of location information can be easily obscured by these difficulties, with an impact on the usability and adoption of ubiquitous systems. As investigated in several field studies on mutual location-awareness [3,4,6], users struggle with the spatial uncertainty emerging from uneven location sensing and fluctuating wireless networks. These observations reveal a social-technical gap [1] that exposes the need to handle inadequate location information without undermining the benefits of location-aware systems.

My research focuses on bridging this social-technological gap. I propose that defining the granularity of location information relevant for the users and supporting strategies for users to manage the spatial uncertainty inherent to location-aware systems can help reduce this gap significantly. More specifically, I plan to address the following research questions:

- Highly precise location information may not always be necessary to support mutual location-awareness. In consequence, how certain does location information have to be in order to be useful and relevant?
- Currently, there is no comprehensive understanding of the usability of uncertainty presentation methods. Therefore, what parameters influence successful uncertainty visualization in a ubiquitous location-aware system?
- What is a balance between implicit and explicit forms of human interaction with a location-aware system that communicates the inherent uncertainty of its location information?

Answers to these questions are highly relevant too in new approaches to HCI.

Approach and Methodology

My research approach matches the growing need in ubiquitous computing research to deploy more real-world experiments to mature the practice of HCI evaluation. I use a mix of case and field studies to observe (and analyze) the authentic human use of location-aware and ubiquitous technologies.

A first step of my research has been accomplished in exploring and analyzing spatial uncertainty inherent to ubiquitous technologies from a field study based on a pervasive game [6]. Here we deal both with individual and collaborative aspects. Currently, I am undertaking a case study on the sharing of geotagged information to identify the users behaviors when making use of location information granularity. This gives social perspectives. Another case study aims at analyzing the main issues embedded in the interaction of mobile workers with location information that fails to match a relevant quality. This will provide individually related aspects.

Based on the general lessons of these first three studies, I plan a more comprehensive field study to evaluate the design of a city-scale location-aware system. Here we should be able to analyze the integration of location information granularity in the design of the application, to evaluate strategies to manage spatial uncertainty emerging from the discrepancies between the sensed physical world (i.e. location quality and timeliness) and its virtual representation (i.e. location presentation). Experimental design should enable us to get both qualitative and quantitative data.

Related Work

So far, studies in ubiquitous location-aware computing have strongly focused on optimizing the accuracy of location sensing and tracking information from a technology-driven perspective. In contrast, few user-centered field studies have been performed that would discuss (and perhaps challenge) the need of fine-grained location information to support human spatial activities.

Similarly, few user-centered studies have been done to understand how to design applications that take into account the lack of maturity, the underlying imperfections and inherent uncertainties of location technologies.

Benford et al. [3] suggest that designers should use different main strategies to deal with uncertainty: remove it, hide it, manage it, reveal it, and exploit it. In this perspective, Chalmers and Galani [4] advocate that designers may consider selectively revealing differences and limitations of systems, in ways that support social interaction. Similarly, Antifakos et al. [2] base their proposal to display uncertainty on the fact that users are actually used to and highly successful in dealing with uncertain information throughout their daily lives. Their experiments show that human performance in a memory task is increased by explicitly displaying uncertainty information. In contradiction, [8] proves that the user needs slightly more time and produces slightly more errors when the confidence of the system is visualized.

These contradictory results might be due to considering uncertainty and context as a whole and failing to focus on location information and their inherent uncertainty. The review of the methods to visualize geospatial information uncertainty, [7] notes that there is no comprehensive understanding of the parameters that influence successful uncertainty visualization.

Preliminary Results

I started this research with a main observation that the quality of the location information impacts the usability of location-aware systems. In a preliminary field study [5] based on qualitative data collected from both field observations and post-experiment questionnaires, I could define categories of user behaviors towards spatial uncertainty. Likewise, I was able to define a taxonomy with three layers of sources of spatial uncertainty (i.e. location quality, location timeliness, and location presentation). Moreover, I remarked the lack of user-centered perspectives on the granularity of location information in the literature.

Conclusion and Future Steps

My research is inspired by William Buxton’s aphorism “Let's do smart things with stupid technology today, rather than wait and do stupid things with smart

technology tomorrow"[1]. Indeed, the recent emergence of location-aware computing enables us to benefit from systems that sense and react to a physical context. Yet, the limitations and constraints related to the underlying technologies create a technical-social gap in the use of such systems. Therefore, to reduce this gap, I suggest gaining a comprehensive understanding of the human individual and collective use of location information. Similarly, there is a need for a more systematic approach to understand the usability of uncertainty representation methods and interaction supporting the use of those representations.

The next steps in my research are based on the investigation of the current use of location information granularity and of the interaction with uncertain spatial information through two case studies.

In addition, I will build a city-scale system to evaluate design strategies to manage spatial uncertainty in order to match a user-expected granularity in the location information. Beyond examining the usability (Does it work for the user?), and the contextual impact on usability (Where does it work?) I aim at exploring and comparing various design strategies impact on usability (When and compared to what does it work?) and, as a result, derive guidelines that can be applied to other designs

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