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# Leveraging urban digital footprints with social navigation and seamful design

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**Abstract**

The widespread deployment of mobile and wireless technologies increases the amount of recorded interactions between humans and the urban environment. The accumulation of these digital footprints provides new opportunities to reveal human behaviors in space. Beyond their utility to improve the quantity and quality of mobility data already available to urban planners and local authorities, this information can be returned to residents and visitors to enhance their perception of the space and inform their discussions and decision making. In this paper, we argue that digital footprints, when properly revealed, can act as social navigation cues to support the exploration of the city.

**Keywords**

Urban computing, social navigation, seamful design.

**ACM Classification Keywords**

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

**Introduction**

The rise of wireless and mobile computing devices has brought new forms of interactions in the urban space with digital means. As a side effect, it provokes a

massive increase in the volume of records of where people have been and when they were there. Indeed, in our every day activities we leave behind footprints from our interaction with the urban environment and its digital infrastructures (e.g. taking and sharing photos, communicating through wireless networks, withdrawing money). They add up to the other signals people leave in urban environments such as crowds, stickers, footsteps or graffiti. From these cues, other persons can draw a large range of inferences: others were here, this was popular, where I can find something, or where I should not go. While the collection of these implicit digital footprints poses serious privacy issues [8], it also opens up unprecedented opportunities to reveal the dynamics in urban environments.

Inspired by the recent projects that collect and visualize spatio-temporal (i.e. space and time referenced) data, we present, in this paper, our approach that leverages these types of digital footprints to support urban awareness and exploration. In addition, we raise some of the opportunities and challenges inherent to the rendering of spatio-temporal data in mobile and urban environments.

### **Revealing urban activities and traces**

Pioneer projects showcased the mapping and graphical representation of cell phone usage to represent the urban activities and their evolution through space and time [9]. They brought urban planners with additional perspectives on the social dynamics in urban environments. Similar data are employed to identify and map consequences of human activities. For instance, they can reveal real-time traffic congestion, pollution phenomenon or the emotional arousal in conjunction with geographical location.

The accumulated spatio-temporal records can also benefit their creator by improving the delivery of timely location and user sensitive information [7] or infer a destination [5].

These projects strongly suggest the analysis of the spatio-temporal data can derive valuable high-level human behavior information in realms of urban planning, mobility, social interactions or consumer behaviors. However, little work has been done to understand how these data could help raise awareness of the overall dynamic of the urban space and affect the discussion and decision-making of residents and visitors. The remainder of this paper describes our endeavor in that direction.

### **Social navigation and seamful design**

In a previous work we showed the potential of collecting and analyzing the history of physical presence of tourists from the photos they explicitly make available on the world-wide web [4]. Based on the time, explicit location and people's description of the photos, we reveal some aspects of the tourist activity and flows in space and time. The correlation and aggregation with other layers of spatio-temporal data such as mobile network usage and museum survey provide new understandings of the visitor's behaviors to local authorities. We now explore how these accumulated and real-time data can be made locally available in a way that tourists and residents can act upon. In consequence, we singled out two main areas of investigation for the design of location-based services that can leverage digital footprints: social navigation and seamful design.

### *Social navigation*

Location-aware application have thus far tended to concentrate on using a mobile carrier's immediate geographic location in isolation but there is a merit in using a position history to tailor results from requests for information further [7]. Indeed, humans as social beings often rely on other's implicit or explicit recommendations to solve their problem. Dourish and Chalmers coined the term "social navigation" that refers to the navigation towards a cluster of people or navigation because other people have looked at something [3]. For instance, the number of cars parked in front of a restaurant, as well as the waiting line before a theatre indicate the places popularity. The cues of the past and real-time consumption of the space revealed by digital footprints could play a similar support to social navigation. In other words, people's past interactions with the urban environment and infrastructure become recommendations and impact the perception of the space. They can be used as a socially-enhanced map showing what places are the most looked-at at what time.

Current scenarios for the application of these real-time and on the spot visualizations mainly aim at facilitating a quick search or decision making such as determining a jogging path that corresponds to a combined query, or pedestrians turning to interactive maps to catch a bus. However, supporting mobility is not necessarily about solving problems, but also about raising opportunities for the diversity of "mobilities" as suggested by Dourish et al. [2]. Revealing the traces relevant to geographic location of specific socio-cultural groups and matching behaviors could help create an informed decision on what and when to visit. For instance, a mobile tourist guide or urban furniture could

provide a map revealing nearby points of activities and obscuring others according to a profile based on past behaviors and preferences other the social behaviors (e.g. people who visited that the Sagrada Familia massively went to museum Picasso, or reveal the areas of interest with less tourist and more genuine resident activity).

### *Seamful design*

However, delivering a clear mirror of the reality from sensed and explicitly disclosed data might be hard to reach. In many cases a meaning emerges from incomplete and patchy data revamped by data mining, filtering and visualization algorithms. The lack of quality in the data and the choice of algorithms distort reality and potentially modifying the behavior and decision making [6]. In consequence, instead of hiding the imperfection of the data and mislead the user, a proper design would be to reveal the uncertainty in the data and their lack of timeliness. Indeed, revealing the imperfection of the sensed data, referred in the literature as "seamful design" [1], can be a positive and empowering design option. It puts the user in a situation to better appreciate the reality and its distorted representation. Tourists need to know the dynamics of the city according to their cultural views of mobility. With social navigation and seamful design they could exploit the activity of other people as indicator of this information. For instance, a service that highlights the flow of visitors who have been strolling Barcelona's Gothic quarter should also reveal the area arbitrarily defined by the system and the accuracy of the data collected in that space (e.g. street level, neighborhood level).

Moreover, the recording and analysis of digital footprints could be used to inform on the design and deployment of location-based services to enhance the tourist experience. We have our own perception of the space that often does not match with technologically set ties between information a place. Therefore, understanding the nuances in the granularity employed to communicate or retrieve location information could improve the relevance of a location-based service. For instance, capturing where, when and the granularity photographers reference geographically their photos could improve the relevance of a location-based service aimed at tourists.

### Conclusion

The widespread deployment of mobile and wireless technologies is having a significant impact on urban life. Their usage generates new types activity data or digital footprints collected and analyzed through visualization techniques. They present an opportunity not only for urban planners and local authorities, but also to the residents and tourists the ability to look down on the city and view the activities and their consequences. When this information is fed back to the community, it can inform the decision-making and change the behaviors through social navigation. However, providing a proper mirror on the urban and tourist activity raises several challenges. First a vital element of such system will be the protection of contributors' privacy. Second, the many sources of error and imprecision in the sensed data impact the quality and timeliness of location information. The design of a social navigation service should take into consideration this uncertainty and in some cases, inspired by seamful design techniques, reveal it to improve the appropriation.

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