

# Chapter 29

## Empirical Evaluation of Smartphone Augmented Reality Browsers in an Urban Tourism Destination Context

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### ABSTRACT

*Today, exposure to new and unfamiliar environments is a necessary part of daily life. Effective communication of location-based information through location-based services has become a key concern for cartographers, geographers, human-computer interaction and professional designers alike. Recently, much attention was directed towards Augmented Reality (AR) interfaces. Current research, however, focuses primarily on computer vision and tracking, or investigates the needs of urban residents, already familiar with their environment. Adopting a user-centred design approach, this paper reports findings from an empirical mobile study investigating how tourists acquire knowledge about an unfamiliar urban environment through AR browsers. Qualitative and quantitative data was used in the development of a framework that shifts the perspective towards a more thorough understanding of the overall design space for such interfaces. The authors analysis provides a frame of reference for the design and evaluation of mobile AR interfaces. The authors demonstrate the application of the framework with respect to optimization of current design of AR.*

### MOTIVATION

As tourists we are often exposed to unfamiliar environments where the fast retrieval of information is fundamental for our decision-making. Access to

relevant content through location-based services not only facilitates this process but also changes the way we perceive destinations, creating more memorable and unique experiences (Tussyadiah & Zach, 2011). Recently, a lot of attention was di-

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rected towards Augmented Reality (AR) interfaces as a suitable visualization paradigm, especially within the domain of travel and tourism (Wither et al., 2009; Yovcheva et al., 2013a). AR browsers deliver (geo)spatial and attribute information about physical objects through spatially registered virtual annotations (Wither et al., 2009). Such interfaces reduce the need to translate abstract information (for example, encoded in maps), or switch gaze between information and physical space, as is the case with guidebooks and list-based mobile interfaces. This scenario is particularly beneficial for time-pressured visitors to unfamiliar locations.

A number of requirements for the design of virtual annotations have been proposed within the domains of AR (e.g. Bell et al., 2001), Information Rich Virtual Environments (IRVEs) (e.g. Chen & Bowman, 2004), Information Visualization and Cartography (e.g. Hartmann et al., 2005):

1. **Readability:** The labels should be readable at all times and should not overlap;
2. **Unambiguous association:** The labels should clearly refer to their target objects;
3. **Aesthetics:** The labels should be placed in a way that prevents visual clutter;
4. **Frame-coherency:** The system should provide a seamless transition of content among frames.

Design recommendations and principles already exist which suggest how to satisfy each of these requirements. The study by Jankowski et al. (2010) concluded that the billboard style of AR annotations is most suitable for ensuring legibility in heterogeneous environments (Jankowski et al., 2010). Studies investigating ambiguous association problems draw heavily on classical theories and design principles within cartography (e.g. Azuma & Furmanski, 2003), multimedia illustrations and computer graphics (e.g. Hartmann et al., 2005). Early experiments with AR interfaces provided convincing evidence that the imprecise

position of an annotation can lead to confusion, higher task times and cognitive overload (Azuma & Furmanski, 2005). To date, this remains the most prominent research topic within the area and significant progress has been made within academia (e.g. Grasset et al., 2012) and industry (e.g. Metaio's 3D AR engine). However, most AR experiments dealing with placement of annotations are still carried out with head-mounted displays (HMDs) and simplified reference objects (e.g. dials on a control board) (e.g. Azuma & Furmanski, 2003). There is very scant evidence of studies which investigate how the variation of the position of annotations, their layout and, most importantly, their content, impacts the user experience in more complex environments. Research addressing hand-held devices is also very scarce. It is therefore challenging to generalize the results to a more irregular urban environment where it might be difficult to differentiate individual features or view the terrain in its entirety (Levine, 1982). In this study we strived to optimize the design of AR annotations for visitors (tourists) to an unfamiliar urban environment. Considering the domain of travel and tourism, the design of AR browsers becomes even more challenging, because:

- In any urban destination, many objects can be augmented with information.
- Each object can be a source of a substantial amount of information.
- The incoming video feed might be visually heterogeneous and dynamic.
- The target user group is in an unfamiliar environment.
- Tourists have information needs which differ from those of urban residents.

Therefore, the key objectives of our research were to investigate, empirically, the problems tourists experience with AR annotations and to propose meaningful ways to improve their design.

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