Digital Globes Gone Mobile: LBS, VGI and their Potential Implications for Spatial Cognition and Environmental Learning

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Abstract

As technology is evolving, so too are the demands, trends and requirements of cartographic production and distribution. Compelling new ways of distributing spatial information and interacting with geographic space are being rapidly adopted in everyday activities. In this paper we explore the nature of 'digital globes,' in an era of Location-Based Services (LBS) and Volunteered Geographic Information (VGI), from the perspective of spatial cognition and environmental learning. We discuss these concepts in the context of a popular LBS application (Yelp). We identify empirical research from the literature that suggests popular LBS applications may have a negative influence on spatial cognition. We consider some of the potential negative and positive implications of using such applications. Research suggests that dividing users' attention reduces their ability to retain environmental information. We then offer recommendations for further research.

Background and Relevance

Contemporary mobile geographic computing has evolved considerably from the tools and methods available to us a decade ago. Current mobile geographic computing integrates four key technologies that were previously separate systems. Widely available mobile devices now include Global Positioning System (GPS), basic Geographic Information System (GIS) software, wireless communication, and access to the Internet - all in a handheld or tablet computer (Armstrong and Bennett, 2005). Furthermore, newer devices contain accelerometers and other sensors, enabling devices to also sense orientation, movement and acceleration in three dimensions.

These integrated mobile platforms provide incredible opportunities for people to move through space and interact with real world phenomena while simultaneously having access to information repositories in the palm of their hand. As more people gain access to ubiquitous computing devices such as smart phones, a new world of possibilities opens up – for us to interact with many types of spatially organized digital representations of geographic space – all parts of 'digital globes'.

The use of digital globes is increasingly being integrated into location-based services (LBS) and applications. Some LBS provide large quantities of varied information to users through the integration of Volunteered Geographic Information (VGI). These services paired with the use of digital globes in new spaces have considerable implications for spatial cognition and environmental learning. For us to consider possible implications we must identify, situate and describe key terms such as LBS, VGI, and digital globes. Our emphasis in this paper is to focus on spatial cognitive mechanisms that may operate during LBS and VGI use. In particular, we focus on how they may impact human development of mental models of geographic space as part of mobile and in situ environmental learning. By doing so, we aim to develop a new conceptual framework through which to encourage productive dialogue between GIScientists, Neogeographers, and broader communities of LBS and VGI researchers.

Situating our discussion: defining Digital Globes, LBS and VGI

Digital globes[1] are web-enabled digital representations of the Earth's surface. Digital globes allow us to tap into vast repositories of spatially indexed information. As a result, they are changing the way we interact with and display geographic information, and may enhance our ability to visualize geographic information (Miller, 2007; Haklay, 2008; Goodchild, 2007). These developments may have the potential to modify spatial understanding of geographic phenomena. Digital globes provide the user the ability to shift between scales swiftly and seamlessly, move quickly to any location on the globe, and view the world in two or three dimensions (Rouse *et al.,* 2007; Zhang, 2007). Digital globes often act as base maps for web-based spatially enabled applications delivering place-based information.

LBS offer information about where a mobile location-aware device user is situated (Gartner et. al., 2007 a, b; Jiang and Yao, 2006). Raper described LBS as "…distributed, componentized and dependent on a range of associated services," and as "examples of scalable ubiquitous computing applications designed for use in environments ranging from individual buildings to cities and even whole regions" (Raper, 2007). For LBS to be relevant to a wide range of users, a commensurate range of information needs to be available.

[1] Digital globes are sometimes referred to as digital earths. We prefer the term digital globe because much like a physical globe, they are a **representation** of the Earth's surface.

Goodchild (2007) introduced the term VGI to describe location-based information that people record on the web to share with others. Tulloch notes that VGI applications "…are those in which people, either individually or collectively, voluntarily collect, organize and/or disseminate geographic information and data in such a manner that the information can be used by many others" (Tulloch, 2008: 161). VGI is a unique method of collecting and recording local knowledge. The concept is broadly understood and widely used by GIScientists and Neographers, yet more work needs to be done to identify and classify various forms of VGI – including an investigation of the influence of each on geographic sense-making or distributed intelligence.

Considering the cognitive dimensions of LBS and VGI

We learn about place either by navigating the landscape freely, using a map or mobile device to give us directions. There has been much debate over the form of representations of spatial objects and relationships in the brain. Cognitive maps may be mental representations of a geographic space (Stea and Blaut, 1973), or the cognitive processes associated with encoding and retrieving the spatial knowledge (Kitchin and Blades, 2002), or feelings and attitudes associated with places (Gould and White, 1974). Unlike fixed cartographic representations of space, cognitive maps are developed in a piecemeal fashion over time (Davies *et al.,* 2010; Montello, 1992).

Spatial cognition or mental maps comprise both hard information (routes, landmarks, configuration, wayfinding, spatial distribution) as well as soft information (feelings, perceptions, attitudes, memories) – all of which are subject to variable internalization by humans. Spatial cognition is influenced by psychological factors associated with soft information (Downs and Stea, 1973) and the spatial layout of landmarks. Each individual may view and feel extremely different about the same place based on their unique experiences in that place. As people navigate through space their feelings and memories of that place are tightly intertwined with their spatial understanding of place.

These factors must surely have a powerful influence on various aspects of LBS and VGI information dissemination, and the similarly wide range of user transaction types. While objects and phenomena in geographic space may have 'hard' coordinates, the form of their internalization by user networks – mediated by information systems – may vary considerably.

Exploring these issues in a popular mobile application

There are several popular LBS applications that are populated by VGI. A recent report issued by the Pew Research Center indicated that 4% of Americans report using LBS (Zickuhr and Smith, 2010) while another study by Microsoft reported 51% of people in the United Kingdom, Germany, Japan, United States and Canada use LBS (Microsoft, 2011). These reports suggest that substantial numbers of citizens actively use LBS on a daily basis – as part of everyday behaviour. As GIScientists, we must not stop there. We feel that it is important to deconstruct one of these popular mobile applications, identify some of the possible cognitive mechanisms operating during citizen use of LBS/VGI, and discuss potential implications for geographic sense-making. We will consider Yelp -

a web-based application that has over 5 million users on both desktop and mobile applications (Yelp, 2011).

Yelp allows users to perform geographic searches by entering the name of a business or other location-based information. The application will then reveal relevant location-based results from that search. The user (Yelper) can choose from three different user interfaces (UI) to view the results from the search (map, list or mobile augmented reality view).

In the next section, we will describe connections between these LBS and VGI functions and identify some results from empirical research from the academic literature testing some of the components shared with Yelp.

Potential Implications of LBS and VGI Applications for Cognitive Maps

Combining LBS, VGI and digital globes all together in one application may be overwhelming, confusing and frustrating for a user, (especially a new user) to understand. In some cases, perhaps users are completely unaware of these components. Despite the promises held by the use of LBS and VGI applications, studies have shown that using mobile maps or mobile devices divert attention away from the task of navigating and impose other cognitive demands on users. When attention is divided, speed and accuracy of the task diminishes (Spence and Feng, 2010; Montello and Freundschuh, 2005). This may have negative implications for effective spatial cognition. Willis *et al.* (2009) found that mobile map users performed worse than static map users on route distance estimation as well as Euclidean distance (*ibid.*). These findings suggest that users do not understand the hard information associated with spatial cognition.

Some researchers (such as Ishikawa *et al.*, 2008) have conducted studies measuring the effectiveness of Google Map-like GPS-based interfaces versus paper-based maps to test users' wayfinding behaviour and spatial knowledge acquisition. These studies have found that: users of GPS devices traveled more slowly and made larger direction errors than those who used paper maps; GPS users did not have to update their position manually, and their position was updated automatically on the device much like the use of LBS on smartphones. Some researchers suggest that this could be due to the fact that "mobile map learning took place concurrently with information being delivered incrementally, so that it was never learned as a single stable schema" (Willis *et al.*2009: 109). This suggests that novel mobile device-based geographic interfaces do not necessarily result in improved geographic learning.

A new framework for approaching LBS and VGI

More needs to be done to understand the powerful role that LBS and VGI play in mediating and influencing human perception of geographic space, and the mental models that result. As a community, GIScience and Neogeography need to develop more than just detailed specifications of the technological and UI features of LBS and VGI

systems. We need to situate each and every type of work within a comprehensive conceptual framework that incorporates both the tangible and amorphous features and transactions of LBS and VGI system. These should be pursued both quantitatively and qualitatively. The results of these studies could likely influence LBS and VGI application design to enhance spatial understanding.

We propose a new conceptual architecture that may provide new inroads into understanding the mechanisms that operate in LBS and VGI. We suggest that different geographic topologies result from LBS and VGI- and from different forms and uses of them. These variations may substantially modify 'live' geographic sense-making as mediated by mobile geographic computing platforms and user behaviour. We present the first iteration of this new conceptual framework, and attempt to situate existing examples of LBS, VGI, cognitive mechanisms and empirical studies within it.

Recommendations for Future Research

New research needs to be done to reveal the effects and affects of LBS and VGI people's perceptions of place and topology in geographic space. Does reading about other peoples' experience in places you are currently visiting influence your feelings and experience in the same place? Does the act of contributing VGI differ from the act of reading others contributed VGI through LBS?

Further research is needed to investigate the synergistic relationship between LBS and VGI and the use of digital globes for mobile applications. Research in this area could reveal interesting unknowns for GIScience and pervasive computing.

Conclusion

In this paper we identify popular definitions of LBS and VGI. We situate them within the context of 'digital globes', and consider spatial cognitive mechanisms that may influence human mental models of space in freeform or structured geographic sense-making activities. We use the application Yelp to illustrate a selection of these mechanisms, and the implications they raise. We propose a new conceptual framework to distinguish different types and combinations of LBS and VGI which may mediate representations of geographic phenomena and topology in different ways. In turn, they may influence mental models that result from the use and exchanges of LBS and VGI. We offer recommendations for further research.

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