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Int. J. Human-Computer Studies 70 (2012) 66–71

International Journal of Human-Computer Studies

www.elsevier.com/locate/ijhcs

A review of locative media, mobile and embodied spatial interaction ☆

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Received 10 March 2011; received in revised form 17 March 2011; accepted 12 July 2011
Available online 24 August 2011

Keywords: Urban informatics; Locative media; Mobile spatial interaction; Embodied interaction; Mobile web 2.0; Context; Awareness; Mobile interaction

Mobile phones have become a mundane and well-established communication device in the everyday lives of many people. Their promise is to connect us to anybody, from anywhere at anytime. Mobile communication has contributed to a shift of people's role towards 'networked individuals' in urban environments (Wellman, 2001, 2002); our person-to-person relationships have become more complex affording a seamless transitioning between being physically present at a particular place and being digitally connected at all times. Mobile media support people not only to connect to distant others, but also to coordinate and initiate social interactions in their physical proximity, e.g. spontaneously organising collective actions (Rheingold, 2002).

The advent of GPS enabled phones has given rise to what today is referred to as 'locative media'. The first use of the term is traced back to Kalnins and Tuters in 2003 (de Waal, 2012; Galloway and Matthew, 2006), who selected 'locative media' as a title for an international workshop of artists and researchers (International Workshop 'Locative Media', 2003), aiming to explore how wireless and location-based networking affects people's notions of space and social organisation within space. Later, the term became a synonym for media that blurred the barrier between the physical and the virtual world, in particular mobile media that augment people's experiences in real places through relevant geo-tagged information from the Internet (Espinoza et al., 2001; Kjeldskov and Paay, 2005; Lancaster University, 1999; Proboscis, 2003).

Locative media applications have opened up new opportunities for mediated interactions with and within physical spaces (Bilandzic and Foth, 2009). A workshop at CHI 2007 focused on 'mobile spatial interaction' (MSI) and classified relevant applications in four categories (Fröhlich et al., 2007): applications that (1) facilitate navigation and wayfinding; (2) mobile augmented reality applications; and applications to (3) create; or (4) access information attached to physical places or objects. Since 2007, smart phones with touch-screen displays, QWERTY-keyboards, multimedia recording capabilities, as well as mobile high-speed Internet connectivity through 3G and WiFi networks enable users to continuously capture, create, upload and share geo-referenced content. Design principles that have shaped the Web 2.0 as a 'Social Web' (O'Reilly, 2005), in particular user participation, folksonomy and geo-tagging, have been translated for mobile interactions (Jaokar and Fish, 2006). Mobile users collectively tag, rate and recommend restaurants, cafés and other public places, crafting and nourishing a digital information layer that augments the urban physical infrastructure in real-time. The ubiquitous connectivity through mobile devices has transformed our urban environments into 'hybrid spaces,' where social interaction and communication patterns traverse through physical, digital, and a mix of both spaces (De Souza e Silva, 2006). In particular, applications that subscribe to the latter two MSI categories have triggered new socio-spatial practices and interaction patterns in urban environments, also referred to as 'net localities' (cf. Gordon and de Souza e Silva, 2011).

In contrary to Putnam's (1995) claim of declining social capital in urban environments through ICT, such community driven social services empower people to harness the collective intelligence (Anderson, 2006; Scharl and Tochtermann, 2007; Schuler, 2009; Shirky, 2008; Surowiecki, 2004) of their global

☆This article is part of the special issue 'locative media and communities' volume 69, issue 10.

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1071-5819/$ - see front matter
doi:10.1016/j.ijhcs.2011.08.004

and local community in-situ as they are traversing everyday life and activities. The probably most prominent example of this phenomenon is location-based social networking (LBSN) through mobile applications such as Dodgeball, Loopt, Foursquare or Facebook Places. They enable users to 'check-in,' i.e. digitally confirm their physical presence at a particular place. Aggregated with social network information, users can see where their friends have checked-in as well as background information of current and previous check-ins of people in their immediate proximity. Knowing where our friends hang out might reveal places that we might enjoy as well, and looking through ratings and comments from many previous navigators tells us how the majority of people perceive a specific place. People naturally navigate space by looking at what others do. Such social navigation affordances have been successfully transferred to virtual spaces (Dieberger, 1997; Dourish and Chalmers, 1994; Höök et al., 2003), and eventually to MSI applications (Bilandzic et al., 2008; Höök, 2003) enabling people to socially navigate real world environments in a way that exceeds traditional, physical barriers of space. This trend can be observed on a more general level. In early 2000, before the emergence of the Web 2.0, Erickson and Kellogg (2000) argued that visibility, awareness, and accountability, as important building blocks of our everyday social interaction in the physical space, should be transferred to support interaction in virtual spaces. They suggest that augmenting virtual spaces with such simple characteristics of the physical world would create 'social translucent systems' which would "eventually support the same sort of social innovation and diversity that can be observed in physically based cultures" (2000, p. 80). Looking back at the evolution and success of Web 2.0, we can confirm that they were right. In fact, the social translucence that we today find in Web 2.0 goes beyond what is afforded by the physical world—it bridges spatial, temporal and social barriers. The convergence of Web 2.0 as a 'social translucent system' with locative media creates a digital layer on top of the physical world affording new practices for social interaction that would not be possible otherwise; these affordances have caused a social translucence of physical space, hence transformed it into a *translucent hybrid space*.

With ideas and developments in "context-aware computing," first introduced by (Schilit et al., 1994), space becomes even more translucent. Sensor equipped devices not only detect and respond to location, but also other contextually relevant variables, such as the user's current activity, emotional state, focus of attention, identity and presence of nearby people or objects, time, temperature and so forth (Dey et al., 1999). Information gathered through ubiquitous context-sensing often overcomes the limited abilities of human perception. Such as the telescope and microscope enabled us to see things normally invisible to the naked eye, Schmidt et al. (2011) envision that sensor-equipped computing devices will ultimately reveal new insights about us and our environments—"by the middle of this century, the boundaries between direct and remote perception will become blurred" (p. 87). While it is technically possible to measure a huge variety of contextual parameters (Schmidt, 2002), and there are toolkits (Dey, 2000; Dey and Abowd, 2000a) to help with the application development of such, Dourish (2004) reminds us that context is a rather relative construct, which is not stable and cannot be defined in general (e.g. Dey and Abowd, 2000b). Context is "continually renegotiated and defined in the course of action" (Dourish, 2004, p. 29), hence the scope and set of features that describe the context of a situation is a dynamic product of the social settings, actions of and interactions between people. Therefore it is impossible for a system to fully capture a situational context and relevant context parameters in advance.

While many mobile social software applications have been explicitly designed to facilitate specific types of social encounters in particular user context scenarios, e.g. with application areas in enterprises (Eagle, 2004), dating (Wired, 1998), group finding (Kjeldskov and Paay, 2005), conferences (Eagle and Pentland, 2005) or carpooling (Hartwig, 2006), recent LBSN as outlined above do not follow such explicit goals. They augment the physicality of a place for the matter of making its invisible social properties visible. As they change our perceived physical boundaries and notions of space, they also affect our social interactions and practices within these boundaries.

Pervasive connectivity of location based people networks and accessibility to the collective intelligence that is embedded in a place brings not only the trend of 'glocalisation' (Robertson, 1995; Wellman, 2001) to a new level, but also issues around privacy and publicness, triggering tactical practices (Certeau and Rendall, 1984) that were not anticipated by the designers of such media. In her study of users of Dodgeball, one of the first commercial LBSNs, Humphreys (2010, p. 774) found that the application is not only used to facilitate, but also to avoid sociality in urban public spaces. Furthermore, while users have met new people through Dodgeball, these people tended to be demographically similar to themselves hence facilitating 'social molecularisation' (p. 776). Similarly, Crawford (2008, p. 91) argues that mobile social software "takes the chance out of chance encounters" by filtering and pre-selecting demographically compatible people for face-to-face encounters. As a consequence users tend to flock into mobile cocoons of similar people, missing the qualities and benefits of the social diversity and heterogeneity in urban environments (Wood and Landry, 2007).

Looking at the development and yet early findings about people's use and practices of locative media that have become mundane, the question is how do we go about the design and shaping of future locative media? How do we realise opportunities afforded by new technology, yet consider issues and risks that come with its use?

In order to support spatial interaction and experiences in a meaningful way (Lentini and Decortis, 2010), two things need to be considered. First, *methods* to investigate and