

Using locative games to evaluate hybrid technology

Ann Morrison, Giulio Jacucci,
Peter Peltonen

Helsinki Institute for Information
Technology (HIIT)

Helsinki University of Technology
and University of Helsinki

P.O. Box 9800, 02015 HUT, Finland
firstname.lastname@hiit.fi

Antti Juustila

Department of Information
Processing Science,

University of Oulu, Finland

+359407204408

antti.juustila@oulu.fi

Gerhard Reitmayr

University of Cambridge

Trumpington Street

Cambridge, UK

+44 1223 765150

gr281@cam.ac.uk

ABSTRACT

In this paper we describe a pervasive location-based game we implement as an evaluation method in our user trials. We test the robustness and usability of a prototype digital-physical map technology called MapLens. We also seek to better understand what the technology might be most useful for. The playful tasks of the game echo real-use tasks, and include elements of social interaction—cooperation, competition and connection. We describe the first user trial, the technology itself, observations of users on the trial, and feedback. We then discuss findings, and present envisaged improvements for the second user trial. The iteration includes improvements to the technology, and to the game itself.

Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: User Interfaces-Evaluation/methodology

General Terms

Documentation, Design, Experimentation, Human Factors

Keywords

Location-based game, pervasive applications, MapLens, iterative design, digital-hybrid map, environmental awareness, evaluation, user trial, mixed reality, GameFlow.

1. INTRODUCTION AND OVERVIEW

In this paper, we discuss the implementation of a location-based game, used as the means to evaluate the usefulness of a digital-physical hybrid map technology named MapLens. The game acts as a scenario of real-use. In addition to implementing location, game and treasure hunt-type elements, which add interest to the tasks to be completed, the element of playful competitiveness between the teams is actively encouraged. In this position paper we describe the first user trial, the technology, observations of users on the trial, as well as some of the feedback. We then discuss the subsequent game, evaluation and technology developments in the lead-up to the second user trial. In the planning we improve our evaluation methods by adding a control group who complete the same

tasks using different technology (with access to the same information) and schedule two teams of participants from the first user trial to obtain comparisons on the ‘improved’ technology, comparisons on the ‘improved’ game aspect, as well as obtaining feedback from first-use participants.

We believe the game element adds roles, meaningful tasks with clear goals, feedback, social interaction [1] and time-urgency, and in so doing replicate real-life situations while using prototype technology still under development. The technology and implementation for this project is a joint effort between University of Oulu, Graz University of Technology, University of Cambridge and Helsinki Institute for Information Technology as part of IPCity, an EU funded project.

The approach of this work in using a pervasive game to evaluate a mobile augmented reality application addresses broader evaluation concerns. From its beginnings researchers have pointed to the challenges of evaluating pervasive applications in real settings. The problems include not only the complexity of setting up the environments, but also the problem of recreating realistic situations. We propose to address this by using a pervasive game that enables the recreation of a realistic situation. Recent work also shows how pervasive games more easily weave into daily life situations [2]. There is a growing interest in methodology for evaluating user experience in games, in particular pervasive ones [3]. The latest work also evaluates experience aspects beyond the game itself, namely the interface [4] or the learning [5].

Combining paper maps with mobile phones has been implemented using PDA and RFID tags [6], or using markers and dots [7]. Evaluation of these systems has concentrated on comparing the impact of the visual context in task performance [7]. Reilly et al [6] described exploratory studies that were conducted using different types of maps recruiting 10 subjects and instructing them with tasks. Task performance was evaluated and compared to a non-marked-up version of the tasks. The study showed how the effectiveness of the technique depends on the size of the map, the information tied to it, and the needs of the user. The authors observed that the tasks required little or no spatial knowledge as the experiment was conducted in one location without needing to use routes, landmarks, and navigation. Generally we find applications using mobile devices to augment a physical map have been evaluated mostly as controlled lab experiments that poorly address how people would use such systems in a more realistic situation.

By contrast, the term ‘locative media’ was coined in 2002 at a workshop at RIXC Centre for New Media Culture [8], where participants explored the impact of actual mobile, wireless, networked devices and positioning technologies on social networks and their surrounds. This field has rapidly expanded and houses two main approaches—geo-annotative and geo-

spatial. Geo-annotative works are those that augment the physical world through the superimposition of digital data onto the physical environment. Generally these works add stories about a location, encourage reflection and discovery, and allow participants to co-author. Geo-spatial work emphasizes the location of people in space using cartography and location-sensing technologies to track participants as they move around a place. Geo-spatial works encourage players to explore their surroundings, even if only in order to defeat/beat another player nearby or to pick up a virtual token for their collection [9]. The user trial game we implement falls into the geo-spatial category as players explore and find clues in their environment, gain tokens, and compete with other players to get the most tokens (figure 1).



Figure 1. Participants working collaboratively with the technology

2. MAPLENS EVALUATION

2.1 Overview of the application

MapLens is an application for Symbian OS (Nokia S60) mobile phones that accesses an image of a paper map with the phone camera, analyses and based on the features of the image, identifies the GPS coordinates of the map area visible on the phone screen. Currently we use an image analysis component developed by the Technical University of Graz (TUG), which requires black dots placed on the paper map for localization (figure 2). Based on these coordinates, the tool fetches data based on location from the HyperMedia Database (HMDB) using the phone's Internet connection. HMDB is a Database Management System with additional layers supporting easy handling of metadata with hyperlinked media such as images, videos and sound. The data is downloaded as an XML based KML [10] file generated by the HMDB, includes metadata about the place-marks in the file, and a link to the media related to the place-mark. The user is then able to view the data based on the location of the media and the other related metadata (e.g. author, description, date/time). Information set as tasks for the users and for testing the system is visualized on the phone as map overlays.

In figure 2 on the left can be seen some example overlays.



Figure 2: the technology in use with a physical map—the interface showing the additional dynamic information

In the first user trial information about battery recycling centers and air quality readings was visualized as overlays, fitting the IPCity project brief and creating the game for the users.

In figure 3 we see a typical scenario of use where a battery recycle station may be moved without notice and without signage to indicate alternate close locations. The MapLens user can go then to the nearest physical map (e.g. at a bus stop) and find out where the nearest alternative battery recycle center is located. The same information could probably be retrieved from the Internet by searching World Wide Web, but using a mobile phone's small keyboard and screen is an awkward way to search and view maps. We believe that using a mobile phone as a dynamically updating filter for real maps is a more convenient way to browse maps.

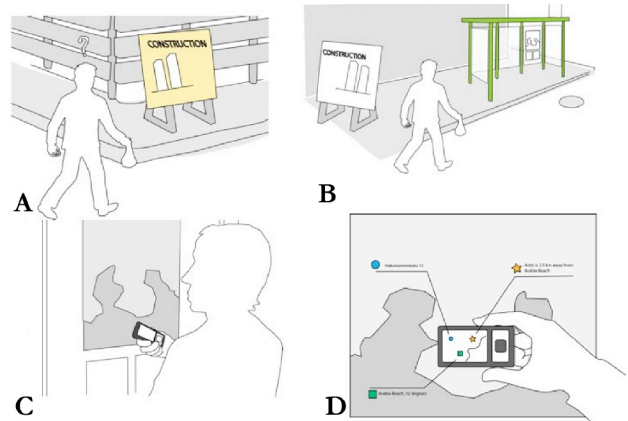


Figure 3. A: Person takes batteries to battery recycle centre. It is closed. B: Person goes to bus stop C: uses MapLens, reads from physical map D: MapLens dynamically updates and displays nearest battery recycle stations.

2.2 Organization of the first trial as a game

The first user trial was organized as a location-based treasure hunt game. Participants were required to follow clues and complete as many as possible of the given tasks within a set time frame (forty minutes in the case of this trial). Within the game social interactions highlighted dynamics of cooperation, competition and connection (both within and between the teams). An element of friendly competitiveness was established in the pre-phase game-orientation, with the promise of prizes at the end for the team with most tasks achieved in the given time.

The participants used both digital augmented map information provided by MapLens in conjunction with physical maps to locate given sites and achieve set tasks. The game in turn tested the usability and robustness of the augmented mobile technology that dynamically accessed information needed by the users to complete their tasks. The aim of the game (and ultimately that of the technology in the IPCity project) was to extend awareness of environmental issues and help users obtain more easily knowledge of how to live in an urban environment in a sustainable manner.

The simple use-scenario enacted in the first user trial asks users to dispose of batteries in a safe manner, and to take air quality readings of their environment and note the variations in these readings at different locations, which they locate by exploring the visual cues of the places (figure 3). The teams inevitably bump into each other in the relatively small mapped area where the game takes place. This encourages playful competitiveness, social interaction and a sense of joint purpose [1]. The geo-spatial nature of the game ensures players explore their immediate urban environment. As well, replicating real-life time-pressures, setting tasks with clear goals while providing immediate feedback ensures focus and non-disruption of *GameFlow* [1] to complete the game.

Pre-Phase	Fill in demographic & consent forms. Demonstration of technology. All users try technology to ensure competency.	
The Game	Task 1	Users find recycle bins and recycle used batteries they were handed.
	Task Type 2	Users locate and walk to sites recognizable as landmarks in the city centre—and record the air pollution readings at these sites (task 1 and 2 collect ‘tokens’).
	Task Type 3	Users discuss the use of the technology aloud as they complete the tasks.
Goals	Complete as many tasks as possible in the allocated period of time. Awareness of other players assists users to navigate, compete with and complete tasks faster (compete to collect most ‘tokens’).	
Post-Phase	Users are interviewed on their participation experience.	

Table 1: Game As User Trial. Sequence of events.

The first trial took place in Helsinki city centre on a wintry sunny Saturday on 29th March 2008. The five recruited users were given prepared phones, some batteries to recycle, and a large card plan featuring a map of Helsinki city centre on one side and images of recognizable Helsinki landmarks on the other (figure 4). Working as two pairs and one solo, the participants worked collaboratively (figure 1) to complete the set tasks (table 1). For example, one could hold the map while the other used the camera. A researcher followed one of the pairs with a video camera throughout the whole trial. The other teams were followed, observed and photographed while participating in the trial.



Figure 4. The dotted physical map and images of locations in Helsinki given as visual cues of locations for the users

The questions in the later interviews were open-ended and intended to generate discussion from the participants. The users were asked for example “Were you surprised by the air quality readings?” and “Can you think what you might use this technology for?” The research aims for this first trial were simple: a) to test the robustness of the technology, b) to test the usability of the technology at an early prototype stage on a small sample of users and c) to see what the technology might be useful for.

2.3 Findings from observation and interview

In our open-ended questions we found such responses as:

What was enjoyable about the experience?

“I liked the game-like aspect of the task. It was like playing a fun game, a city-wide scavenger hunt with a mobile phone and a large cardboard map”

Can you think what else such a system might be useful for?

“It would be good to index a place you see that looks interesting, and then you have it recorded, its location, so when you have time you can go back and find it easily”.

Did knowing environmental information change the way you navigated in the city?

“Well yes, but its hard to believe its so polluted, not like other places I have been with many cars.”

This last feedback was common, and found also in general conversations, and builds a case for implementing such an environmental awareness application. It is largely unknown by the general population that the real concerns in Helsinki are not with well-documented CO₂ emissions, but rather with higher than acceptable levels of Ozone (O₃) fine particles (PM_{2.5}) and Nitrogen dioxide (NO₂).

Observations and difficulties: Initial difficulties for the users included that the game took place in a small area which meant that the augmented digital information (markers) were placed very close together on top of the physical map. This made the map hard to read as multiple markers were over-lapping. As well we found that the sun in the users’ eyes, sun reflecting from the phone screen or shadows across the screen made the mobile interface hard to read. Also, users found it hard to hold the map steady which meant they constantly had to search for stable surfaces to balance the map on. Sometimes the users were too involved in trying to find things on MapLens rather than looking outwards to actually find the clues in the environment. As well, for users who did not know the city, more information was needed to enable easy navigation. As it happened, all teams had one person who knew Helsinki well.

Adaptation and problem-solving: Often the users worked out systems to deal with for example the sun problem, e.g one pair tried to find a sunny spot to look at the map with a way to have a shadow over only the phone. Another common technique employed was that one partner pointed at the place on the map with a finger, while the other looked through MapLens (the solo user marked the map with a pen achieving the same effect). Users worked well as teams or used support in the environment to steady the map (often bus stops). Some found the technology limited in its use in current state, others adapted and used the technology well after some initial problem solving, but all could see other future uses for the technology once the ‘difficulties’ were addressed. We found our users were constructive in these suggestions (see example answer to question 2 this section) reinforcing our research aims to ask ‘what the technology might be useful for?’ and to keep our research questions as openers..

3. ITERATING AUGMENTED MAPLENS AND THE GAME

3.1 A planned trial with a revised Game

We identified from the users that some aspects of the game scenarios were enjoyable but others were problematic, so in future trials we aim to expand on the former and improve or discard the later where possible. In the second trial we intend to add an expanded variety of tasks with more in-depth clues, so e.g. people who not know Helsinki can easily navigate. We also intend for our participants to be actively engaged in finding out information on their environment, so they may better comprehend the impact they can have upon it, both positive and negative. Consequently, the game sequence might now include: visits to obtain information from for example; the Natural History Museum on e.g. past means of transport; the railway station to obtain information on a train schedule, price and duration; the follow-on task then being to calculate the carbon footprint from a car, a train and a plane for the same journey from an online site that offers such comparisons.

Users will also recycle ‘waste’ to two kinds of recycling areas, as well as visiting green areas of the city. As an example for the

green visits, one task will be to walk bare-foot in the grass in a park, and upload a photo as evidence; another to gather a specific leaf (the leaf also found as a clue at the museum); and another to bring back a sample of sea water to be tested for toxicity levels. By these means our participants will be better informed about their environment, test the technology to achieve their tasks, and enjoy the nature and leisure in Helsinki.

To further emphasize the competitive element of the game, users will be required to take photos with their mobile camera phones during the trial as part of their various task completion routines. The photos will automatically upload and be visible to all users on MapLens, meaning that the players can track each others positions during the game phase—both in terms of GPS location (leaking information on where the clues lead) as well as indicating progression through the game.

The second user trial will be implemented 9th August 2008 in Helsinki city center. A scout club and their families are being recruited for a larger study where we look to involve 20 teams with 20 phones.

3.2 New Planned Features in MapLens

As MapLens is still in prototype development, we will add new features for these trials, and again enhance the functionality based on the feedback. Usability problems found in the first trials included lack of support for left-handed users and the need for manually updating media from the HMDB. This iteration of MapLens will refresh the media content periodically. Left-handed use will be supported, where the user will be able to hold the phone in a landscape position either way, and media will display correctly. Also zooming in to a smaller area of the map and included tags will be improved. Currently multiple maps are supported, but map switching is done manually.

In the second trial we will switch from using the tagged paper map tracking by the TUG to a natural feature-based tracking component developed by the University of Cambridge which does not require map instrumentation at all. In an offline stage, the system learns a statistical description of distinct features of the map image. At runtime, a fast classification approach identifies features and calculates coordinates of the visible part within the map from the known locations of these features [11]. This allows us to use existing maps already available in public places, instead of specifically enhanced maps.

In the previous implementation it was possible to view images only, but now we add sound. Moreover, image capture augmented with GPS coordinates is added to MapLens itself, in order to provide a single application to the user. We use the third party application ShoZu [12] for uploading content to the public media-sharing site Flickr.

Finally, for research purposes, we plan to enhance the logging of user activities to better study when, where and which kind of content users were generating and/or consuming and how this relates to the overall user activity with MapLens.

3.3 Revised Evaluation Approach

In the planning for the second trial we improve our evaluation methods by adding a control group who complete the same tasks via other mobile means (but with the same information to hand). They do not use the augmented MapLens technology, rather full digital maps displaying the same environmental information as MapLens. We will also include the two pairs of participants from the first user trial again in this trial, so that we can get feedback that compares both the technology and the game aspect from the first user trial with this second one. As well to this, we will add a much larger group of participants—seventeen teams of new users—who are all first-time users of

this version of the technology and the game. Combining the two pairs from the first trial, the one control pair and the new pairs there will be twenty teams with twenty phones in total for the second trial.

We posit that by adding two types of comparative control groups, a larger sample and more complex tasks run as game-type sequences, we can fulfill our aim to again test the robustness, usefulness and suitability of the technology for real-use scenarios (and gather suggestions from user for other uses), as well as add to the body of knowledge in expanding evaluation techniques useful for pervasive computing scenarios.

4. ACKNOWLEDGMENTS

We wish to acknowledge the work of Daniel Wagner (Image Analysis) TUG, Toni Räisänen (HMDB), Heikki Keränen and Juha-Pekka Kumpuniemi (MapLens) UOulu and Rodolfo Samperio, (Graphic Design) TKK. This work has been funded by the 6th Framework Research Programme of the EU, through the IPCity project <http://www.ipcity.eu> (FP-2004-IST-4-27571)

5. REFERENCES

- [1] Sweetser, P & Wyeth, P (2005) Gameflow: A Model for Evaluating Player Enjoyment in Games, *ACM Computers in Entertainment*, Vol.3, July 2005.
- [2] Bell, M., Chalmers, M., Barkhuus, L., Hall, M., Sherwood, S., Tennent, P., Brown, B., Rowland, D., Benford, S., Capra, M. and Hampshire, A. (2006) Interweaving mobile games with everyday life. *Proc. Conference on Human Factors in Computing Systems*, April 2006, Montreal, Canada.
- [3] Jegers K., (2007) Pervasive game flow: understanding player enjoyment in pervasive gaming, *Computers in Entertainment (CIE)*, Volume 5 Issue 1
- [4] Ohlenburg, J.; Lindt, I.; Pankoke-Babatz, Ghellal, S., (2007) A report on the crossmedia game epidemic menace, *Computers in Entertainment (CIE) archive*, Volume 5 Issue 1.
- [5] Costabile, M. F., De Angeli, A., Lanzilotti, R., Ardito, C., Buono, P., Pederson, T. (to appear). Explore! Possibilities and Challenges of Mobile Learning. In *Proceedings of ACM CHI 2008 Conference on Human Factors in Computing Systems*, ACM Press.
- [6] Reilly, D., Rodgers, M., Argue, R., Nunes, M., Inkpen, K., (2006) Marked-up maps: combining paper maps and electronic information resources, *Personal and Ubiquitous Computing*, v.10 n.4, p.215-226, March 2006.
- [7] Rohs, M., Schöning, J., Raubal, M., Essl, G., Krüger, A., (2007) Map Navigation with Mobile Devices: Virtual versus Physical Movement with and without Visual Context *Proceedings of the 9th International Conference on Multimodal Interfaces (ICMI)*, Nagoya, Japan, November
- [8] <http://www.rixc.lv/reader/txt/txt.php?id=186&l=en>
- [9] Mogi Mogi by Newt Games. <http://www.mogimogi.com/>
- [10] <http://code.google.com/apis/kml/>
- [11] Wagner D, Reitmayr G, Mulloni A, Drummond T, Schmalstieg D (2008) Pose Tracking from Natural Features on Mobile Phones, *IEEE International Symposium on Mixed and Augmented Reality*, September 2008.
- [12] <http://www.shozu.com/portal/>

All urls last accessed 07 June 2008

