Integrated Project on Interaction and Presence in Urban Environments

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First Environmental Awareness prototype applications

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Abstract

In this document we begin with an overview of the conceptual and theoretical concerns, move into describing the developments with the prototypes and demonstrators, before highlighting dissemination. Two appendixes proffer an more detailed description of the design and development of CityWall and MapLens.

In this third year (M25-M36) Workpackage 7's focus was changed from large-scale events to address a new brief of environmental awareness. This meant re-design of the demonstrators to address the new brief, create a new versions of the demonstrators and carry out new rounds of field trials. The re-design has successfully moved forward the demonstrators with more articulated and substantially more developed mixed reality applications in comparison to year 1, and building from year 2. The current demonstrators follow the plan of having a mobile and permanent installation, and incorporating the mobile solution into the pervasive component. In all components substantial advancement has been made. The mobile component has moved beyond CoMedia which was already field trialed in year 1 therefore WP7 has moved forward to investigate the augmented MapLens as a new mobile component. Continued development along with field trial development and implementations has further this project to address green and environmental issues. The installation component has concretized in further development of the interaction design of CityWall, a large multi-touch urban display, with again extensive field trials. Finally, we have integrated the pervasive component into the way we manage field trials (as a pervasive location based game) for our mobile MapLens solution. The Illuminate prototype's development has been put to hold, as the it was difficult to match it to the environmental awareness brief, and focus on 2 rather than 3 projects was decided upon. Both CityWall and MapLens had ambitious targets and goals to meet, so we needed to be more realistic with what we could achieve to a high standard.

The showcase succeeded in carrying out three extensive MapLens field trials in Helsinki, and took data from the summer period with CityWall in its new location (the Cultural Office required a change of location for the installation) and now again with a huge passing public at European City of Sciences exhibiton in Paris.

Citywall still operates as a permanent installation in downtown Lasipalatsi, Helsinki and we opened a new 3D version 8th October, with press and outputting a YouTube video that grabbed more than ¼ million visits within its first two weeks. You can see the video visiting http://www.youtube.com/watch?v=IldDrCcZkZY

Citywall still continues to attract a lot of attention also in the web. Our site http://citywall.org still receives many contacts, and CityWall is referenced in a variety of important websites, papers and many blogs. We still continue to receive requests from all over the world to create similar installations.

The start-up company multitouch.fi created to commercialize the technology still has three of the researchers that worked in WP7 in the company. The company successfully obtained local Finnish funding (TEKES), has successfully negotiated IPR with the University and has sold 10 small multi-touch cells, 10 large multi-touch cells, and two projector versions. They are expanding to employ more people to deal with the extensive orders for 2009.

Intended Audience

The primary audience of this deliverable is the Project consortium and the EC.

1 Workpackage Objectives

Objectives Phase IV	The objectives of this phase are to re-define the WP7 and showcase given the large amount of results already achieved in Large-Scale Events. The WP7 will be re-directed to "Environmental Awareness" using the same demonstrator components. We will develop the initial environmental awareness prototypes.
Results Phase IV	We have created an environmentally aware location-based game as an evaluation method for our MapLens technology and held three field trials to test the application with two prototypes being developed. We are ahead of schedule with development and deployment. CityWall as a large multi-touch display is still in permanent installation in downtown Helsinki and we developed a new 3D interface to add multiple content and timelines. We worked in tandem with Ministry for the Environment on a "Nature as Nice and Nuisance" interactive work as our first prototype. We built a new portable version which we exhibited at European City of Sciences (ECS) event as our second prototype with content pertinent to Paris, Grand Palais and MRTent.We had seven conference papers accepted, and two doctoral consortium presentations. Again CityWall received a lot of media attention internationally, in particular with the opening event of its 3D interface. Mutlitouch.fi is expanding as a company, employing more people, has successfully re-applied for financial support from Finland government, and has developed a cell LCD technology with 10 large and 10 small cells being sold (as far a field as Australia) as well as 2 larger projector-based installations.
Evaluation Results Phase IV	The evaluation of the MapLens prototype has been successful: three field trials were conducted in March and August 2008 resulting in new information about presence, place-making and collaboration around digital-physical technology. In addition data was collected at CityWall in Helsinki and ECS, Paris event, yet to be analysised.
Objectives Phase V	In the next phase we will complete the analysis of Helsinki and ECS data, conduct further field trials with both technologies, refine aspects of the prototypes and write up our research, with the aim to publish extensively in high quality journals.

2 State-of-the-Art

In this state of the art we will focus on MapLens, our mobile augmented reality (AR) digital-physical map system, as this is the component of the demonstrator that has been most significantly further developed during this year, and it hasn't been discussed in the previous deliverables. The concept of *magic lens* was first introduced in 1993 [2] as a 'focus & context' technique for 2D visualisations and was later extended to 3D [14]. AR on handheld devices has been explored with different applications, including peephole applications where the background is used for positioning in virtual space [6, 16] and multi-user AR games [15]. A number of papers study target acquisition performance in magic lens pointing [4, 8, 11, 12].

Although carried out in the lab, there are two studies relevant to our work related to augmeting virtual objects over physical surfaces. Henrysson et al. [6] piloted positioning and orientation of 3D virtual objects using a mobile phone. They observed that users adopted a bi-manual strategy and sat down rather than stood up to stabilise the phone in hand. Reilly et al. [10] reported an exploratory study where 10 subjects performed pre-defined tasks on an RFID versus non-augmented PDA version. The effectiveness of the technique depended on the size of the map, information tied to it, and the needs of the user. The authors point out that the tasks required little or no spatial knowledge as the trial was conducted in a single location and involved no routes, landmarks, or navigation.

There are three critical aspects that was left to be addressed: interaction when embedded and mobile in the referred-to environment; interaction in pairs or teams; and suitability of mobile AR maps for real world use. These aspects of mobile AR map use have been in our focus for our MapLens field trials.

2.1 Pervasive games and locative media

We have chose to use a location-based game as our evaluation method for mobile AR map use. Since early days researchers have pointed to the challenges of evaluating mobile AR in real settings. Limitations of the technological solutions have constrained researchers' ability to use real tasks and outdoor conditions. There is a growing interest in pervasive games as an evaluation methodology [7]. Recent work shows how pervasive games can be interwoven into daily life situations [1] and points out that results can bring forth aspects that are telling of issues beyond the game itself; such as interface design [9] or the user's learning [5]. We see no *a priori* reason for why mobile AR maps could not be evaluated similarly. The key challenge is to create a game that is not only motivating, but also engages the users with the environment in a way that can raise interesting phenomena that would perhaps not occur in task-based evaluation. Our game was designed to encourage players to be more aware of environmental issues while exploring their surroundings in a competitive but friendly game (for similar ideas, see [3]). The game involved several aspects of real-life situations, including multitasking, coordination of team effort, role-taking, sequential tasks, clear goals, feedback, social interaction [13], and time-urgency

3 Overview

As in years 1 and 2 the demonstrator is divided into three components. In each component there have been advancements leading to the continuation of now two separate applications with their own developing and evaluation road map. The mobile component that was implemented in year one by CoMedia is this year again continued with the Augmented Map Lens. The Contact Wall of year one is again continued as a multi-touch public display CityWall. The Pervasive component is now being integrated into CityWall and MapLens applications. The third application Illuminate has been put on hold as CityWall and MapLens applications have made significant developments, and require focused attention. As well using lighting was in conflict with the altered brief of environmental awareness.

The aim of having three complementary components is to be able to address the user experience in a more comprehensive manner and to address most of the state of the art technologies for this showcase supporting the main aspects of visitors : group co-experience, engagement with an event and/ or a theme, and navigation through space.

3.1 Applications and Mixed Reality

The three complementaty component elements described here (Figure 1) are shown at various stages of development:

Component	Mobile	Public Display	Pervasive
Application	Augmented Map Lens	CityWall	Integrated into CityWall and MapLens
Features	Digital overlays on physical map addressing environmental awareness theme	Collaborative and tangible exploration and manipulation of media, contextualised display	Input by users into MapLens and CityWall
Platform	Mobile phone, Symbian S60 v.3 edition	Installation, public touch screen, rear projection, PC	Using existing data networks, MMS and SMS and image uploading
Development	Solid prototype with 3 field trials	Field re-evaluated and redeveloped prototype	Integrated into CityWall and MapLens applications
Mixed Reality	Computer vision for map tracking and overlays on video feed of map.	Multi-hand and gesture tracking, virtual objects and simulated physical behaviour with tangible interface	Representing with pervasive visual cues and text

Figure 1 - Shows the three components in development.

3.2 Presence and Experience

In this showcase we aim at supporting presence in urban environments, utilizing the work from the first two years and re-focusing on the theme towards environmental awareness. We found that the nature of CityWall lends itself naturally to event-based exposure, so we also continued to work with this and included an opening of the new interface at Lasipalatisi, the city square of downtown Helsinki, alongside Ministry for the Environment, as well as at the European City of Sciences event. Le Grand Palais, Paris. These events gather crowds (in particular European City of Sciences) so we had a large number of visitors and participants, over the duration of three days. The urban perspective includes addressing flows of visitors, and their interaction with spaces, supports visibility of mobility networks in order to interact with the works, as well as a spatial distribution of events, as with MapLens where the interactions took place via mobile networks in a large area of Helsinki.

In particular mixed reality is seen as a way to support presence for active spectatorship improving three aspects of their experience (adapted and revised from D7.2):

- Co-experience in spectator groups –supporting awareness, coordination and expressions (verbal, mediated, embodied) in a groups in both distributed and collocated interaction.
- Engagement to the event – beyond passive witnessing deeper cognitive and social processing of the event.
- Ubiquity and distribution in space. The spectator experience has to be considered beyond the limited time and space of the core of the event. Spectators navigate through and spent time in a variety of spaces during the event period. Ubiquitous media for event should support this experience pervasively.

The research includes experimenting with interactive interface layers of awareness cues about fellow players and citizens, collective media, the mobility network, environmental awareness issues and event happenings: the three above objectives

3.2.1 Measuring Presence in Mixed Reality

We have yet to make an analysis from our field trials with CityWall at European City of Sciences. However our findings from three trials with MapLens show us that:

MapLens works as a system that provides a space for “mixing realities” that can be viewed and evaluated together. *Presence* to the location, *Presence* to the game, along with competing between teams added a sense of urgency to the experience. The interaction space is enlarged, in the way in which the participants can express themselves within and experience this space. For example, one participant was so engaged in the activity of looking at *MapLens* and the paper map that he walked into a lamp-post. Participants gather around the “surface & lens” system and point to the augmented view of the world they are standing within. When they experience difficulties they raise their heads and look around and continue to point. They may need to move away, scouting, walking or running even, looking and experiencing the actual physical reality view. Then they return and add this ‘real’ information to the group-present collocated mixed reality “surface & lens” view, in order to negotiate and anticipate the next best move within the game sequence and the real environment.

3.2.2 Revised Concept Map

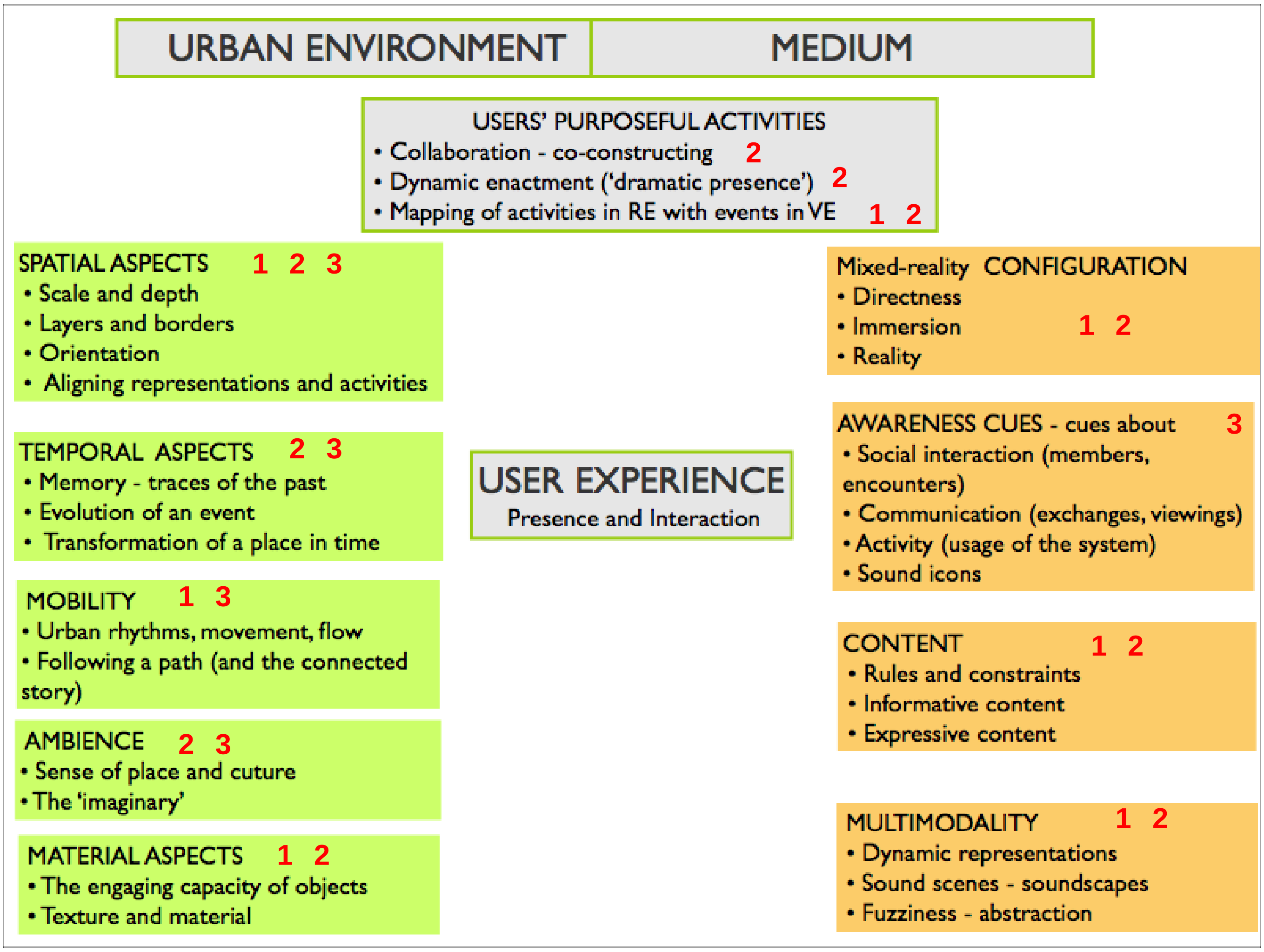


Figure 2 - Marked relation to the concept map for components 1 mobile 2 public display and 3 pervasive

We revsit the revised concept map in figure 2, and in figures 3 and 4 below we diagram the relationships between components of the concept map that are aspected by workpackage 7 in CityWall and MapLens; specifically in relation to the urban environment and the mediums used.

Figure 3. WP7 relationship between the Urban Environment and Presence

WP7 Urban Environment

Users' purposeful activities

- Collaboration: Current CityWall (CW) solution supports collaboration, we look to increase collaboration. Possibilities with new inputs (SMS, MMS and comments) and multiple timelines and contents. MapLens (ML): when compared to digital only version, ML was found to be an ideal collaboration Tool
- Dynamic enactment: CW has been shown to support performative interaction. ML users performed for each other in order to collaborate
- Mapping: Both systems dynamically upload user input from RE to VE

Spatial aspects

- Scale and depth: The new CW 3D interface allows overlaying of information, scaling and xyz axis. For ML we have measured spatial awareness with MEC-SPQ questionnaire participants scoring mostly above average
- Layers and borders: Both systems support this
- Orientation: ML users had more difficulties orientating than digital users. For CW users trials for this have not yet been analysised.
- Aligning representations and activities: ML aligns user contributed representations with actual location. CW maps activities according to time and theme.

Material aspects

Texture and material

- Physicality of a cardboard map for ML supported place-making, common ground and collaboration
- CW as a display supports touch as an input but does not support texture or haptic feedback

Temporal aspects - mobility

- Especially CW supports memory showing the traces of the past.
- ML shows the trail of its users.
- Both support and display event evolution.

Ambience

Sense of culture and place: CW is constantly reproducing its urban and cultural landscape. ML was shown to support place making as its major finding.

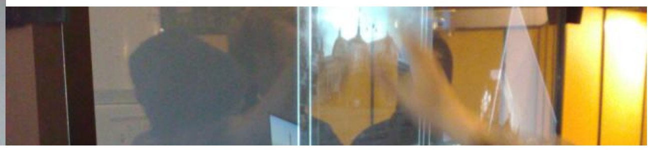
Figure 4. WP7 relationship between Mediums Used and Presence

WP7 Medium

Multimodality

- CW is constrained by the public environment of a city center which inhibits multimodality. Currently the interface is touch and sound out only.

- For ML image, sound and video were possible, but we used image and video only. Standard mobile phone buttons were used for navigation.



Awareness cues

- Both systems supported social interaction between users both in PE and VE. In ML and CW users were aware of others presence on screen and within the confines of the game.

- Users support, compete and interact with each other at both applications

- Both field trials showed active use of the system which is also logged

Content

- Informative and expressive content is deliberately initiated and facilitated at CW.

- Rules and constraints are moderated manually and online for CW.

- Informative and expressive content is facilitated with ML by providing information of locations and by users uploading expressive and playful images.

Mixed reality configuration

- Reality: ML is an mobile AR system combining the physical map with digital overlays uploaded from HMDB. CW enables a view through time of user input that is dynamically uploaded through VE. Also, comments and images in the new CW installation allow input via online, MMS or SMS-

- Immersion: CW has switching viewpoints and zooming. ML field trials reported above average scores for presence.

- Directness: CW allows direct manipulation of objects and information.

Figure 5 summarizes how the components of the demonstrator relate to the Showcase objectives and to the revised concept map of D3.4. In both cases items are ordered by priority. Figure 6 highlights differences and similarities of immersion and engagement with users of the comarative digital to augmented technology in our MapLens trial.

Component	Mobile	Public Display	Pervasive
Showcase objective	Engagement to the event coordination and Co-experience of spectator groups,	Engagement to the event, Co-experience of spectator groups	Navigating in the space
Urban Environment	SPATIAL, MATERIAL TEMPORAL ASPECTS	TEMPORAL, SOCIAL, MATERIAL ASPECTS	SPATIAL TEMPORAL MOBILITY, AMBIENCE
Activities	MAPPING of RE and VE, Collaboration, Dynamic	Collaboration, Dynamic Enactment,	
Medium	MR configuration , CONTENT, MULTIMODALITY	CONTENT, Multimodality, MR CONFIG	AWARENESS CUES

Figure 5 - Shows links between concepts and demonstrators.

Presence questionnaire

ML:MD	DM:MD	Presence Questions 17.10 Augmented
4.00	3.00	**Q1.1** The task and technology took all my attention (*)
4.00	4.00	**Q1.2** I concentrated on the tasks and technology
3.00	3.13	**Q1.3** The map systems and the game captured my senses
3.76	4.00	**Q2.1** I was able to imagine the environment and arrangement of the places presented using the map system well *
3.60	4.00	**Q2.2** I had a precise idea of the space and environment presented in the map technology
4.00	4.00	**Q2.3** I was able to make a good estimate of the size of the presented area.
4.00	4.00	**Q2.4** Even now, I still have a concrete mental image of the spatial environment.
3.00	4.00	**Q3.1** I felt like I was actually there in the mapping system environment
2.29	3.00	**Q3.2** It was as though my true location had shifted into the mapping system environment. *
3.34	5.00	**Q4.1** I felt I could be active in my surrounding environment (move, use the mobile phone and switch from task to task) (*)
3.68	4.00	**Q5.3** This mapping system activated my thinking.
4.00	4.00	**Q5.4** I thought about whether this mapping system could be of use to me.
2.76	4.00	**Q6.1** I concentrated on whether there were any inconsistencies in this mapping system (*)
2.88	4.00	**Q6.2** I didn't really pay attention to the existence of errors or inconsistencies in the mapping system
4.00	4.00	**Q7.1** I am generally interested in this topic and mapping system
2.99	3.00	**Q7.2** I have for a long time felt a strong affinity to mapping systems which are bit like this
3.00	3.39	**Q8.1** When someone shows me a floor plan, I am able to imagine the space easily.
4.00	3.00	**Q8.2** It's easy for me to imagine a space in my mind without actually being there.
4.00	4.00	**Q8.3** When I read a text, I can usually easily imagine the arrangement of the objects described.
4.00	4.00	**Q8.4** When someone describes a space to me, it's usually very easy for me to imagine it clearly.

Figure 6 - Example of Results in blue showing significant differences found between Digital and Augmented Versions.

3.2.3 Concepts and Issues for Presence Research

Stages and resources for performative interaction

CityWall supports collaborative and expressive bodily interactions and offers a stage to perform them. The gestures are large, supporting more expressive and out-going interactions. MapLens users were more socially active and shared information publicly with each other requiring more gestural and open embodied action than their digital counterpart.

Place and presence

MapLens has shown to support place-making on the fly via establishment of common ground, problem-solving via negotiation, physical and social interaction--with place-making affecting the attention to the tasks and technology rather than the surroundings. Presence ratings were above average.

For CityWall, we are looking into establish a stronger sense of place within the urban environment by encouraging user input of content (including threading discussion) relevant to daily life of the regular passers-by to CityWall. There are now ways to comment on images on screen and link related ‘photographic conversations’, I.e. photos that are posted as a response to photos already there. A local topic is the nuisances and benefits of nature where for example a single tree, can be both a useful physical shelter, an appreciated element in the urban landscape, a source for an irritating pollinosis and a danger for traffic.

The emphasis of the work is this: we are looking more towards a combination of factors to understand what works best for the experience of our participants--to improve their experience with mixed reality in urban environments.

In the future we look to add a comparative study at CityWall with simplified language to be sure the users understand the presence questions. We will continue to integrate the three styles of questionnaires within a triangulation of methods to supply a richer more in-depth form of feedback from our participants.

See D3.4 and appendix for further discussion specific to MapLens with Presence and Experience, in particular issues around embodiment, tangible objects and collaboration are aspected from this study.

4 Year 3 Prototypes and Demonstrators

4.1 CityWall

CityWall (http://www.citywall.org) is a multi-touch public display on permanent installation in a shop window at the Helsinki city centre since May 2007. The original and version of Citywall retrieves and shows Flickr images tagged with "helsinki" in its display, allowing passers-by to stop and review what has taken place in their home town. The more recent version also displays these as well as other categories of tagged images.

In Year 3 we changed the interface of CityWall (Figure), as well as the interaction paradigm with the aim to increase interaction and input from the participants. By adding 3D objects as ‚worlds' of information we looked to allow multiple content, multiple timelines as well as to expand the many ways partipants can easily input and interact with CityWall. CityWall was exhibited at downtown Helsinki , opening ist new interface with an opening event October 8th, 2008 and at European City of Sciences, Paris, 14-17 November, 2008.

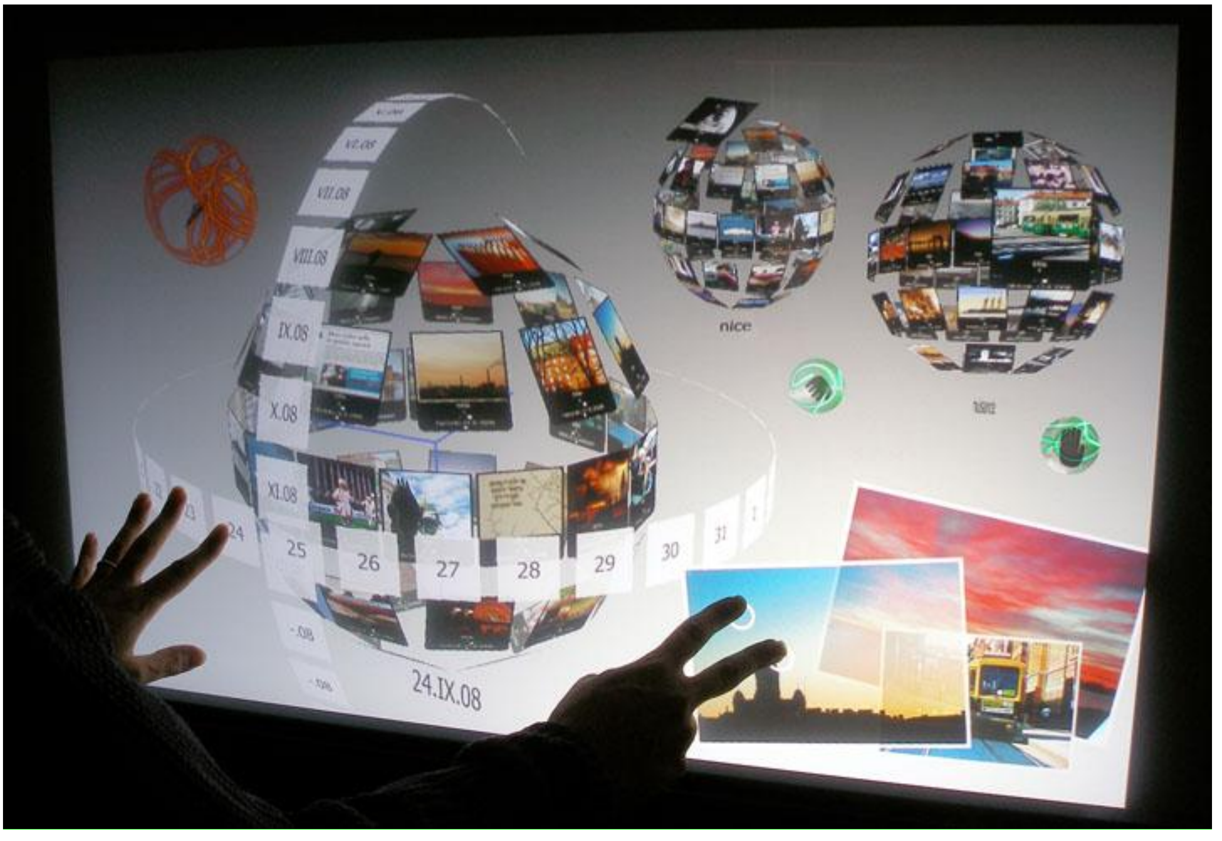


Figure 7 - CityWall's new 3D interface in the lab.

4.1.1 Description

Technical Changes

The original CityWall installation runs on the Linux platform. As such, the implementation is not easily extensible beyond photo browsing functionality, so the more complex requirements are not well supported in the existing code base. Furthermore, because the original application is quite intimately coupled with the low level Computer Vision software component developed in WP4, the adaptation process could not be directly based on the existing framework.

A widget-based multi-touch SDK was developed for Linux and OSX platforms to address this shortcoming, reusing most of the generic code of the original implementation. Although it is much more productive to work with the newly introduced widgets, it was seen that a considerable amount of time would be still invested in writing the trivial functionality. Because much of that triviality was already available in Windows platform, and because the development tools are more advanced there, the SDK was ported to Windows. The time invested into porting seems to be well spent, also when considering future extensions of the CityWall. The SDK port consists of 9 custom Dynamic Link Libraries (DLLs) and 14 third party software components, which constitutes a relatively complex solution environment. The large number of external dependencies arises from the differences in Unix- and Windows-based operating systems. To simplify the maintenance and deployment tasks, a native version of the port was devised, resulting in a solution that uses one merged custom DLL and two third party components. The enabler for the complexity reducement is .NET framework and Windows Presentation Foundation (WPF), which overlap and extend the functionality supplied by the initial port. Another benefit is in the support for further extensions, both in custom and in third party code base.

In summary, the current CityWall framework is built on the previous code base, but runs now on top of Windows .NET/WPF layers. The CityWall backend shall include also XMPP (for CityWall-CityWall connections), MMS (for mobile phones, as described in 5.4) and an optional RESTful HTTP interface, so that it will be possible to integrate components from other workpackages, if needed.

Conceptual Changes

The rationale for implementing an interface and interaction paradigm with 3D objects that are able to be manipulated on a flat screen included:

Allowing multiple objects acting as information or image or theme repositories to be viewed and manipulated on the screen by multple users. Screen real estate was divided up so that the screen was accessible predominantly by three-four users at one time.

As well multiple timelines were accessible at one time. In the previous interface we found that one timeline precluded many interactions to occur simultaneously. We were also looking to provoke more in-depth interactions.

Many displays in urban settings are developed to add life to a space and to allow reflection and serendipitous interaction between people. However, often interactions are short—too short to evoke reflection, and it is still to be shown if strangers really engage in interaction with each other.

Figure 8 - Left: CityWall user interface: the content area (A), scrollable timeline (B) and picture content (C). Right: Kids at CityWall. Participants 'working' on a singular timeline.

In the original CityWall interface, (Figure 8) images are displayed at the top of the screen (A) and they can be resized and moved around with simple touch-based gestures. The scrollable timeline (B) allows users to navigate to different days and times of interest.

From the very beginning, interactions at the wall have been recorded for research purposes. Based on our qualitative interaction analysis, the kinds of users' activities common at public displays are [19, 22, 23, 23]:

- *Trying the basic interaction techniques.* Using the timeline in the bottom of the screen and rotating, enlarging, shrinking, sliding, and throwing the images between individuals and groups.
- *Performative environment.* In a group of people, users often adopt different roles, and take turns at being in one or even all of these roles—depending on circumstances. Roles include apprentices, clowns, spectators and teachers. Teachers show others how to use CityWall and may bring their friends to the wall at a later time.

The continuous videotaping of interactions has allowed us to study the interactions also quantitatively. In one study [23] we took 8 days of video footage into a closer analysis, counting—among other metrics—the numbers of users (1199), durations of interaction, social formations (group sizes and situations with multiple user groups) and their mutual interactions (e.g., do the users from different groups talk to each other).

In this dataset, as many as 82% of use episodes (sequences of uninterrupted use) had more among the people of the same group rather than strangers, only 4.8% of all episodes having people from different groups engaged in conversation. Interpreting interaction as purely conversation is naturally a simplification. However, this was a means for gauging a conservative estimate of actual amount of social interaction between strangers.

The observed durations of interaction motivate well the problems we serve to address with shifting the interface from 2D to 3D as one of a series of measures designed to initiate more sustained engagement. The median lengths of episodes having 1, 2 or 3 users were 39, 60, and 63 seconds, respectively. Average lengths (61, 101 and 95 seconds) were a bit higher meaning that there were some, but not very many, people who spent a longer time at the display. Combined with our qualitative understanding about the nature of interaction at the display, these figures have made us reflect how to change the interaction at the display. The findings from the study suggest that most of the interaction can be described as fleeting explorations of touch-based interaction, with no clear evidence of attention paid to the actual content at the wall, neither in solo nor together with other people. Users certainly enjoy also this kind of interaction, but only a small percentage of people really engage in deeper interaction at the display.

Thus, in a nutshell, the problem is that the initial design goals—evoking reflection and supporting interaction between people—are not fully met. As a consequence our approach is to devise ways to understand and address this problem.

Difficulties in public display design

Naturally, ease of use from the very start is an essential requisite for public displays [18], as the display must be understandable from the first moments. According to our evaluation on CityWall, this goal has been achieved well, but with a cost to the following issues:

- Treating the whole display as a single interaction space means that one user's actions sometimes have effects on the actions of another user. For example, resizing an image to a very large size might overlap another user's focus of interaction, and moving the timeline (see Figure 8) means disruptions for others because all the photos in the content then start moving left or right accordingly.

- There is no memory of past interactions, no functionality to comment images on screen and no means to identify a returning user. Because of this, all the conversations and stories evoked at the wall are lost. Neither is there a way to link related ‘photographic conversations’, i.e. photos that are posted as a response to photos already there. These factors in turn decrease interest to return later to the wall.
- Images taken by other people have limited relevance to a user unless there is a personal connection to the places or activities depicted. We also found that the participants were mainly passing tourists, and not local residents. Our aim is to initiate discussions of events that directly impact the lives of the residents of Helsinki who pass by CityWall on a daily basis.

These limitations arise from having designed an intuitive interface where novice users can easily approach and ‘command’ the interaction techniques. We hypothesize that there are not enough opportunities for learning in the current version of CityWall. There is a need to extend the scope of the interactions beyond this early learning curve. As well we aim to find ways to provoke contributions of text and images—passionate discussions even—by providing initial content relevant to an urban community in an interface that entices participation.

Designing ever-increasing challenges

We look to the work of Csikszentmihalyi [17] on flow and optimal engagement to continue this discussion and develop the work. Flow is described as an auto telic state, where people lose track of time and any self-consciousness surrounding their activity, as they become so involved in an activity that nothing else matters. When people complete the kind of activity which has put them into the flow state, they feel much better about themselves, and life generally. Activities may range from e.g mountain climbing, to singing, to painting. There are a multitude of activities that the work of Csikszentmihalyi [17] has shown can produce this state in individuals. In the flow model, the requirements identified for tasks and achieving optimal engagement are that 1) the task that can be completed, 2) the person is able to concentrate on the task, 3) that concentration is possible because the task has clear goals; 4) that concentration is possible because the task provides immediate feedback; 5) that the person is able to exercise a sense of control over actions; 6) the task provides a deep but effortless involvement that removes awareness of the frustrations of everyday life; 7) that the concern for self disappears, but sense of self emerges stronger afterwards; and 8) that the sense of the duration of time is altered. The combination of these elements causes a sense of deep enjoyment so rewarding that people feel that expending a great deal of energy is worthwhile simply to be able to feel it [17].

The original eight requirements have lately been adapted to understanding flow in gaming [24, 24]. In our work, we are using a similar approach to improve user experience on large touch displays. Our aim is to ensure that the same requirements are included as core values in our design considerations, and design increasing challenges as an integral part of the interaction and content of CityWall.

In the flow model, we find that a match between both the person’s skills and the challenges associated with the task are precursors to a flow experience, with both required to be within a certain level (not too simple, not too hard). Most flow experiences occur with activities that are goal-directed, bounded by clearly defined rules, and require mental energy and appropriate skills. We ask, how can we then apply these core values to the design of interactive tasks at CityWall—providing opportunities for learning something new each time a person interacts—with a view to facilitating flow experiences for our participants?

What might these challenges be?

As a means to achieve this, we plan to extend the current interaction paradigm. For now, gesture—a bodily action—meets with a flat 2D screen. The interaction is flattened: limited, as is access to and navigation through in-depth levels of information. As a response, we designed a 3D navigation for content structure and system. In order to access the information, participants also need to learn how to navigate the system—as well as being able to learn through interacting with the content itself. Over time with continuing use participants can increase their skill levels. Their interaction can be scaffolded so that small but incremental learning steps are supported. This will allow increasingly more sophisticated interactions with ever-more complex information.

4.1.2 Addressing Environmental Awareness:

The content deals with local urban issues of environmental awareness relevant to the regular community who pass by CityWall. The navigational interface mimics the interlinked global nature of these issues. The information—in the form of text, images and videos from Finnish Environment Institute SYKE shows examples of the benefits and nuisances of urban nature. At the time of the opening (8th October, 2008), the Wall presents images, videos, descriptions and discussions on how nature in Helsinki benefits and disturbs dwellers. A single tree, for instance, can be both a useful physical shelter, an appreciated element in the urban landscape, a source for an irritating pollinosis and a danger for traffic. Many of the changes in the benefits and nuisances of nature are, at least partly, dependent on human activities. The settling of rabbits as permanent residents to Helsinki, for instance, follows partly from global warming that allows released pet rabbits to survive winters in urban green areas. Examples of *nature as nice* and *nature as nuisance* can be seen in Figure 9.

Fuel for life / Elämän ainekset

Thanks to nature, we still have fresh air, clean water and food.

Luonnon ansiosta meillä on vielä raitista ilmaa ja puhdasta vettä ja ravintoa.

Animals as neighbours / Eläimet naapureina

Sometimes animals and people disturb each other without meaning it.

Joskus eläimet ja ihmiset häiritsevät toisiaan, vaikkeivät tarkoittaisi sitä.

Figure 9 - Examples of Nature as Nice and Nature as Nuisance.

4.1.3 Facilitating Participant Input

The exhibition aims to evoke discussion e.g. on what nuisances people should just adapt themselves to, what nuisances they should fight or control, how different nuisances can be prevented and how the benefits of nature can be improved. We aim to find out what benefits and uses people contribute and how an interaction-based multitouch input display works as a type of community chat tool to enable discussion on topical environmental issues. By enabling SMS, MMS, email, tagging images on Flickr, allowing comments on Flickr (the comments are displayed on the hind-side of the commented-upon images), we are extending the ways in which the citizens can input into issues that affect them—an extended version of *Letters to the Editor*—extending the bi-directional means of input. We have seen already much discussion on for example, the rabbits issue, in the local broadsheets, and have added examples of these to the wall to invigorate discussion. In local newspapers immediacy is restricted and this electronic system allows for more ad-hoc and spontaneous inputs. We are also developing a scrabble-style alphabet with tiles that can be arranged as words and dragged onto images, so people can comment on events and images directly on the wall. It is important to note we have deliberately not included a standard keyboard as we are avoiding computer UI-type interfaces as much as possible. Our aim is to extend the interaction paradigms, not just make larger screens to do the same kind of things upon. In this infrastructure there are now ways to comment upon images on screen and eventually to link related ‘photographic conversations’, i.e. photos that are posted as a response to photos already there, as well as the comment-style conversations we see already on sites such as Flickr. The intention is that this will also integrate comments made with the alphabet, SMSs, and emails etc.

4.1.4 3D Object Worlds and Gestural Language

We use the image of a spinning globe to echo the projects evolution and research goals—in the same way as planetary, molecular or aquatic systems assist us to be able to visualise and understand the relationships between many layers of information, so too does this atomic expanded structure enable us to deal with many ‘worlds of information’ and many timelines. The field of multitouch has been developing over many years, but three-dimensional visual representations within the multitouch environment are still in early stages of development. As a research group we are looking to add to, and further the language of naturalistic gestures in multitouch environments.

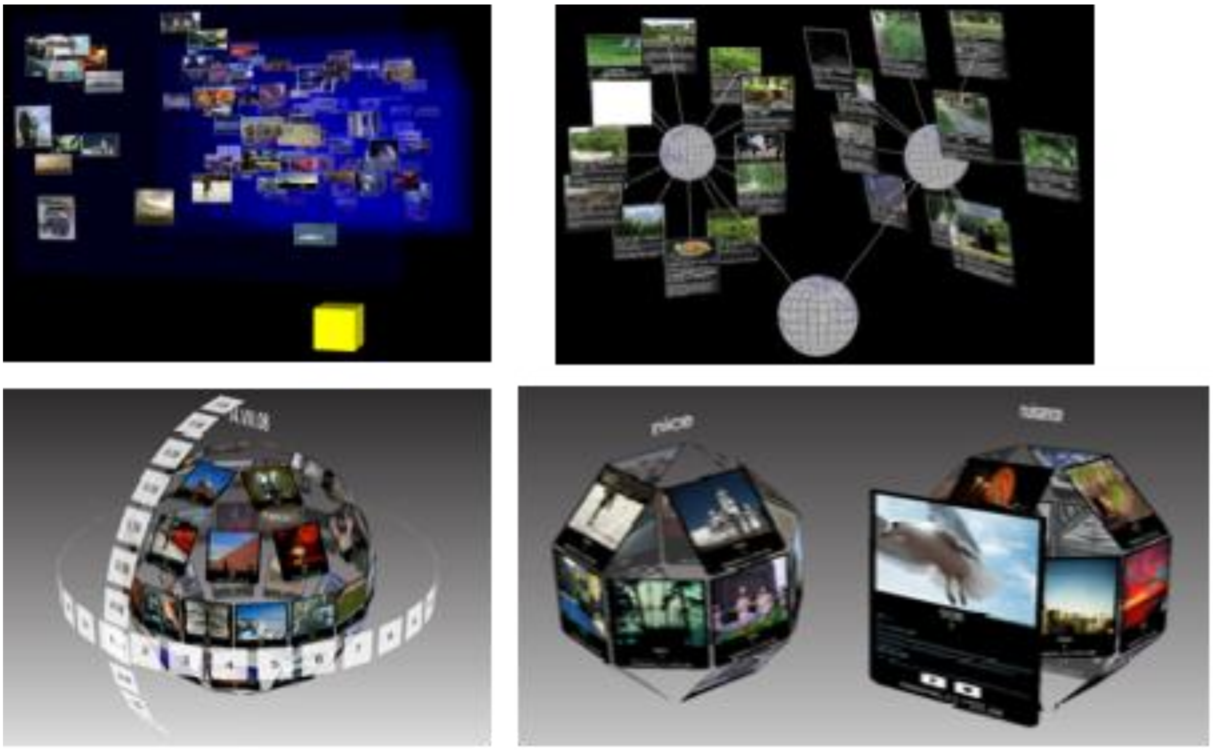


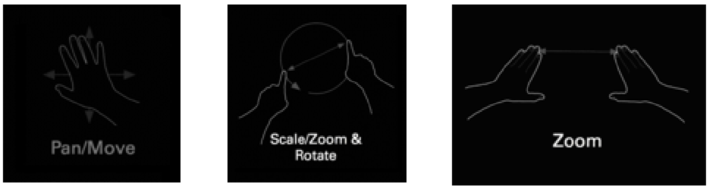
Figure 10 - Early development of the 3D interface to work out representation of content and navigation hierarchies.

The interaction model requires users input in with single tap, double tap, hold finger to the screen, use of three fingers, as well as that participants learn novel gestures to navigate content. Multiple timelines and multiple ‘worlds-of-content’ are available to many players simultaneously (see Figure 10). We are still in development phase and are currently conducting informal laboratory tests. Feedback to date suggests the current interaction schemas are less intuitive, but once learnt they are more engaging. Information on how to interact is included as part of the content and ‘play’ of the interface itself. Figure 11 shows the transition of gestures and natural languages from 2D to 3D. Figure 12 shows the new version in use, first in the lab and then in a real world setting.

At the Wall: how to use and interact:

- Spin the world fast to browse in time.
- Spinning to the right will update the pictures to the next day.
- Spinning to the left will update to the previous day.
- Hold Down on the elliptic label at the bottom of the ball to display a cross menu to find exact dates. Close in the same way.
- Holding Down on any picture will bring it to the front, then you can drag-and-drop it to the Pin Board if you wish; swiping on the information area will flip the picture so you can read and make comments.

- CityWall v1 : 2D input surface, 2D data visualization
  - 2D has 3 DOFs (translate x,y + rotate z)



- CityWall v2 : 2D input surface, 2D and 3D data visualization
  - 3D has 6 DOFs (translate x,y,z + rotate x,y,z)

DOF	semantics	gesture
trans x,y	move	drag with whole hand
trans z	focus, hilite	press / doubletap / tap (2.5D)
rotate x,y	spin	drag with 1..3 fingers
rotate z	spin	circulate
(scale)	zoom, open, close	stretch

+ higher level compound gestures

Figure 11 - Early development of the 3D interface to work out representation of content and navigation hierarchies.

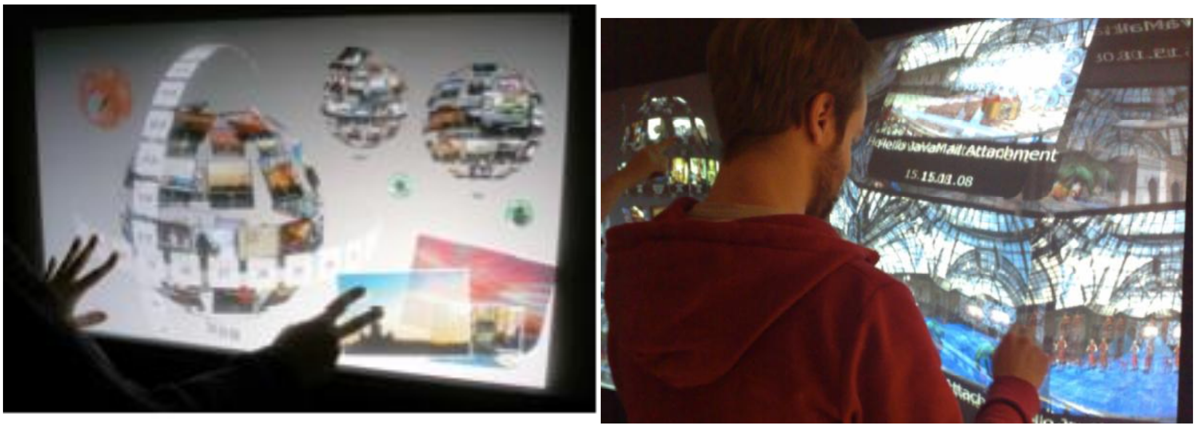


Figure 12 - CityWall, smaller version in the development lab, allows multiple timelines and multiple contents to be accessed by multiple users simultaneously.

Three-dimensional interfaces are largely recognised as being more immersive and supporting 'as if real', or 'being there' experiences; concepts found within presence research.

In field studies we included standardised presence questions to ascertain if for example, people suspend their disbelief and spatially orientate within the virtual space at the wall. We also included standardised flow questions to gauge if people for example, lose a sense of the outside world, of time, if they felt extended, it tasks were too easy or too hard. We have conducted similar questionnaires within a triangulation of methods approach with other mixed reality works and found the results very informative.

With the addition of local content and changing the interaction paradigm we are working to integrate the eight requirements of flow into our CityWall display. We believe that goals related to concentration, challenge, skills, control, clear goals, feedback, immersion and social interaction can be met, if we keep extensively iterating our design. Successful interaction will require mental energy and appropriate skills. We believe that by addressing not only how the participants can interact with the content, but also by adding in-depth and situated relevant content and ensuring tasks are not too simple, nor too difficult, we can extend the experience for our participants and engage them in a more meaningful and sustained manner for longer periods of time. We wish that the enticing interface not only entices but also prolongs and sustains engagement so that our 'players' lose their sense of time while playing and learning and becoming involved in a sense of community at CityWall. We believe the current 3D interface allows a more sustained, thoughtful interaction space, as well as allowing many users to explore multiple time lines synchronously. Our aim to is integrate flow and presence into the experience of participants with our 3D interface—and will continue to develop and discuss and reflect on the viability of applying presence and flow models to the design, content and evaluation of the use of a multitouch-public display situated in downtown Helsinki.

4.1.5 European City of Sciences Exhibition

For the European City of Sciences event we aimed to expand again the ways in which participants at the exhibition could input and make the content as valid as possible for such a large-scale event. We expanded, poked at and stretched our environmental awareness brief to include supporting a more general awareness of the surrounding urban environment itself (as we had with MapLens). We wanted participants to take note of the their surroundings, be aware of their environment and for the display to support this and encourage the users to add information' about their surrounds to the 'information' at the wall. We use 'information' loosely here, the aim was for a playful engagement with the surrounds, for people to be creative and add the elements that they as individuals responded to—not providing factual or details of information to others per se. To facilitate this we added several worlds with several ways to input information to these worlds.

The Worlds:

The world displays the day that the pictures were uploaded, in a descending spiral flow, with the oldest on the top and the newest at the bottom. There might be more than one layer in the world for the same day if there is a lot of content, then one reads the label below to determine which day one is in.

1. Helsinki FlickrWorld

Images from Helsinki and CityWall. Retrieves public files from Flicker and YouTube that use the tags "cwhki", "helsinki", "citywall". The images in this world have been uploaded to CityWall since May 2007.

2. Grand Palais and ParisWorld

Images of the Grand Palais and surrounds of Paris city, uploaded in the days prior to and during European City of Sciences week by participants at the event.

3. Multitouch World

Video examples of some of the many different types of multitouch that have been developed. Press to play.

4. Mixed Reality Tent World

Images from participants in the IPCity MRTent (next door) are continually uploaded to this world. Scenes composed on the ColorTable can be captured at any time by the participants via the barcode interface. The 25 most recent ones are displayed here In the top layer, with more below, and people can look through and see examples of their own and other's work.

5. Pin Board and Pin Board Ball

SMS, MMS, emails and texts are placed temporarily in a very frontal layer named Pin Board. After some time they are automatically moved to the Pin Board Ball, where you can browse them. You can Hold Down on items in other applications and drag a copy to the Pin Board, you can delete any item shrinking it as much as possible.

6. Help Worlds

All Help Balls wander around the screen. There are two types indicated by colour:

1) Green contain animations of the gestures you can use to interact with CityWall,

2) Blue houses a question mark, and contains brief guides of the interaction gestures, worlds, how to add content, as well as lists of credits of people and organizations.

Use Hold Down to reach the different levels of information.

See Appendix 2 for more information on means of inputting, interaction and the worlds.

4.1.6 Specification

Hardware and OS	• Data Projector, infrared filters • Camera and infrared lens • Infrared emittors • Multiple cameras and projectors are supported to handle larger screen (so far 2 FireWire cameras with 60fps and VGA resolution have been used with maximum of 4 projectors) • PC Hardware • OS: Windows XP
Software	The software uses the multi-touch display developed in WP4 and described in D4.3. Additionally the following components: • CityWall application, that provides the user interface with 3D objects • ContentManager application handling the content downloads from social media services
Core Features	• Multiple point touch-screen supporting interaction with two hands and several people at once allowing for group interactions. • Browsing and organizing of media (pictures, sound and movies) in 3D worlds • Interfaces for receiving input via SMS, MMS and email • ContentManager downloads automatically media files from Internet media services like Flickr
Status	Technological prototype. First prototype Helsinki opening 8 October, 2008. Second prototype European City of Sciences exhibition 14-17 November, 2008.
Intended users	The number of simultaneous users at the screen is limited by the physical size of the screen and how many people can physically touch it at once. We have observed the groups of users to range from passers by wanting to simply look at media, to people interested in engaging in the various areas of activity over several days which the wall provides for such as sending your own media to the display and coming to see your own pictures at the wall from time to time.

4.1.7 Evaluation of CityWall usage in an exhibition space

At European City of Sciences we built a new portable version where we showed our demonstration of multiple timelines and content. In repsonse to the 'portable' version from the IPDeiuchland tour where the project was implemented successfully, but the need for a lighter and more easily transportable installation package was recognized, we built a version from scratch that is much more lightweight and compact. For content we add flickr images from Helsinki since May 2007, Images of Paris and Grand Palais, videos of other state of the art multitouch systems, images from participants in MRTent, a pinboard of SMS, MMS, and emails sent to CityWall, as well as a world of help animations. We made initial video footage of one week interaction of a passing public in down-town Helsinki in the new location, with the first interface over a similar time-period as that of the summer 2007 study. We made video footage of 3 days interaction at the screen, observations of participants in-situ and enlisted presence, flow and IMI questionnaires at European City of Sciences (ECS) exhibition. After ECS we are in post-production, setting up new CityWall at HIIT as a demonstrator to our visitors and passing public, improving and updating the Lassipalatsi version and getting ready press releases etc. We notice from ECS a difference in use with an experienced public who come specifically to an event on science and technology, and those who are passing public in an urban environment. The responses to the questionnaires were all very enthusiatic, We will follow up with more in-depth field study observations of people interacting with the new interface in down-town Helsinki in summer, 2009 and will write up our research from this extensive collection of material over 2009

4.2 Illuminate

Illuminate technology is now a working prototype that was demonstrated in the Barcelona review 2008. The concept behind the technology is to track the movement of people through distributed event spaces that function as the staging area for social interactions that occur outside a given users peer group. The interactions create a flow of movement where people's paths cross invisibly. Visualizing these flows and social interactions visible enriches a spectator's presence at and awareness of an event.

In the early months of year 3, we continued development with Illuminate technology and concepts, but after much discussion Illuminate has been placed on hold for a large part of the third year as WP7 changed its focus from large-scale events to address environmental issues (for more detailed plans for months 24-42, see D1.9) and the focus on lighting was in conflict with this. The focus of WP7 will be environmental issues for the rest of the project, so no further development for this technology is to be expected to happen within IPCity. However, as the prototype is open-source it is envisaged the project may anyway be exhibited in the future. With this in mind, we will now discuss the further development of the prototype to date.

4.2.1 Description

Illuminate was implemented to as means to visualize and support flows of people in space and the ongoing social interaction in this space. The technology illuminates the space and the people in it with colored lights. Small wirelessly connected PC called Nodes illuminate physical spaces with ambient lighting and people in this space are provided with illuminated Badges. The color of ones badge or the color of a space is affected by physical interactions between the people wearing the Badges in the space. Illuminate allows also users to set the lightning of a place interactively, thus modifying also actively their immediate environment lightning, using their mobile phones.

Behind the Illuminate technology is a network of Nodes each equipped with Bluetooth™ sensors and a wireless Internet connection. Atelier Infrastructure, a Java and XML based distributed framework, is used to establish the communication between the nodes. To control ambient lighting within the space the Nodes are installed in, an Arduino board is used. The wearable electronic badge is prototyped by using mobile phones which include a Bluetooth™ sensor and a light source react to communicate with the Node network.

To overcome the problem with long Bluetooth™ device discovery times with multiple nearby devices, the implementation caches the found badges (mobile phones) in the Nodes to minimize the need for device discovery. The other Nodes further away also to find the Badges more quickly this way, since the Nodes share the cached, found devices over the Atelier Infrastructure. The cached Bluetooth™ device addresses are used by the Nodes to attempt direct connections to again minimize the time-consuming device discovery phase.

For security reasons, it is required that the Bluetooth™ devices have to be paired before data can be transferred between the Nodes at the event site and the Badges (participants' mobile phones). This pairing between Nodes and the Badges however is impossible, because physical proximity is required for it. To resolve this issue, Bluetooth Service IDs are used as the means to pass color information between the Nodes and the Badges. This enables the devices to use service discover to get the colof or the Badge, by just querying the service attributes of the Badge service. The original Illuminate system architecture can be seen in Figure 13.

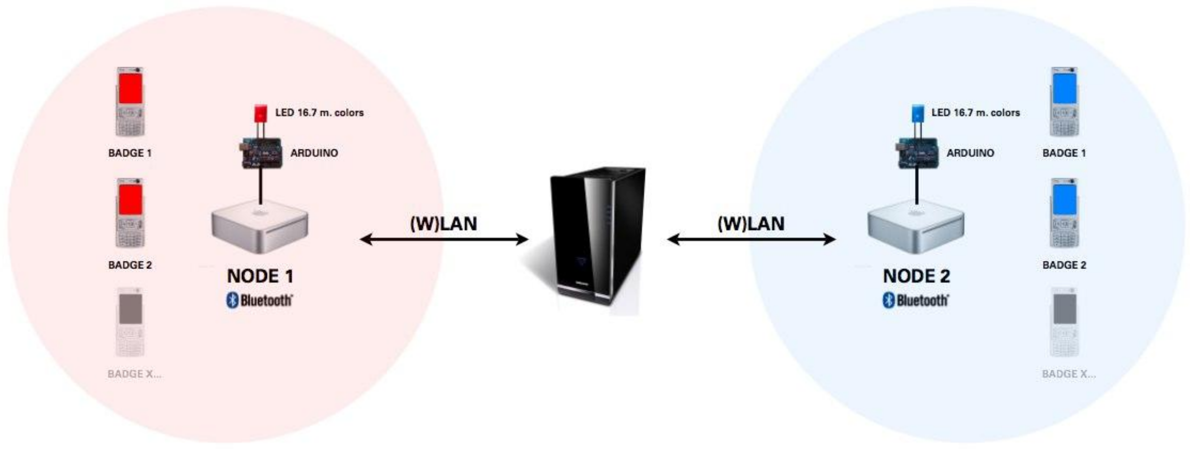


Figure 13 - Original Illuminate system architecture.

A re-design to implement a larger scale installation view was scoped in the early months of 2008. The new idea was to allow for the users direct access to the independent Nodes (e.g Mac Minis), placed in different locations controlling the space's lighting systems via Arduino board (see Figure 14).

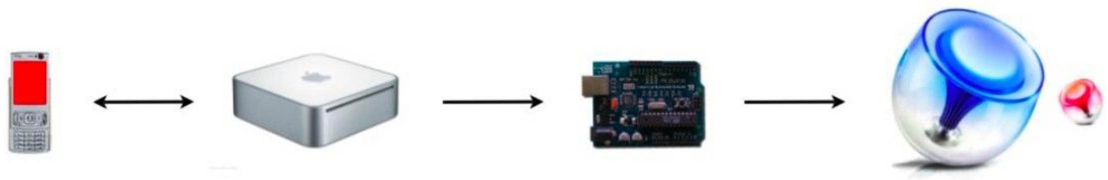


Figure 14 – Re-deisgn of simple system using lighting via arduino boards and indepndent mac minis.

With the envisaged re-designed system the user would be able to browse colour scheme with the navigate buttons of her mobile phone and lock a colour on or off with the select (see Figure 15). When the color of the Illuminate node is changed, either manually or by the internal logic component, all registered light control components are notified. In the current version three different components are implemented. The Bluetooth™ light control dynamically updates the light color information (stored as a hexadecimal string) in the Bluetooth™ service attributes, which can in turn be queried by other bluetooth devices to discover the color of the Illuminate node. The Arduino light control transmits the color information to the Arduino board. In the current version, it controls three LEDs, one for each color component. It simply sends the values (0-255) of each of the color components, together with a color identifier. These identifiers correspond to the numbers of the analog pins on the Arduino board, in which the LEDs are inserted. The GUI for manually changing the color is itself also registered as a lightcontroller, and shows the current state of the node's lighting on screen.

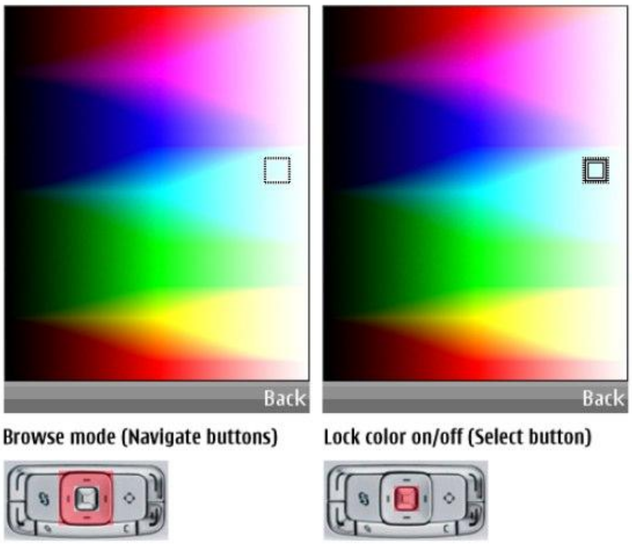


Figure 1 - The selection for colour could occur through the standard phone navigation buttons.

4.2.2 Specification

Hardware and OS	PC hardware, Linux, MacOS X, Arduino board for controlling lightning. J2ME 2.0 enabled mobile phones (with necessary JSRs) as Badges.
Software	• Modified Avetana open source Bluetooth™ OBEX implementation • BlueZ Bluetooth™ stack • Component implemented in Java, using the Atelier Infrastructure as a platform for distribution.
Core Features	• Enables control of lightning in a space, as well as controlling the color of the Badges carried by the event participants, in a wireless environment. In new version, active control of the lightning in a space.
Status	• Beta prototype
Intended users	• Any number of users
Showcases	• WP7, others
Relevance beyond project	• Can be used outside the project in similar purposes; uses open source and freely available software and hardware.

4.2.3 Testing / Evaluation

The Illuminate has been previously tested in a laboratory environment using four Nodes, one Arduino board (other nodes using flat displays to simulate lights) and eight mobile phones. Considering the limitations of the Bluetooth™ discovery and the fact that the open source Bluetooth™ stack used had to be hacked (in order to enable the usage of the service attributes in conveying the devices' colors between the Nodes and the Badges), the system performed well.

The new implementation having mobile phones controlling the Nodes directly through the color picker application developed (see Figure 15) was also tested in laboratory settings.

The final work was seen as a public space with a prevasive and all encompassing installation atmosphere, where passers-by could affect and adapt their environment (Figure 16), but as stated before, due to the shift of focus from large-scale events to environmental awareness, the development of Illuminate was put on hold and testing in a real-life urban setting has not been conducted.

Figure 16 - As envisaged implemented in an urban environment.

4.3 MapLens

4.3.1 Description

MapLens is an application for Symbian OS S60 Nokia mobile phones with camera and GPS. When a markerless paper map is viewed through the phone camera, the system analyses and identifies the GPS coordinates of the map area visible on the phone screen. Based on these coordinates, location based media (photos and their metadata) is fetched from HyperMedia Database (HMDB). Markers to access the media by clicking the selected marker showing the thumbnail of the photo are then provided on top of the map image on the phone screen (Figure 17).

Figure 17 - MapLens in use with a paper map.

To help out selection in situations when there are multiple markers cluttered close together, a freeze function is provided: if there is more than one marker visible on the screen after the selection, the view is frozen with the markers being decluttered (pulled away from each other) so, that the user can more easily select the correct marker/thumbnail.

MapLens also functions as a camera for taking pictures that are uploaded in the background to HMDB. The user presses the * key to enter camera mode, 0 to capture a photo, and * again to return to MapLens. Photos are available for all within five minutes. By pressing 1 one is then able to see photos taken by other users. Pressing 1 again turns the feature off.

MapLens uses predetermined map data files to identify the paper map and associate its visible area to geographical coordinates. Using this information, MapLens is able to position the media icons also on the edge of the paper map accurately. To accurately overlay information of the image of the map in the mobile phone's display, the 3D pose—translation and rotation—of the phone's camera with respect to the map must be known. To track an image, we select distinct feature points in a representative template image and try to find these feature points again in the live image produced by the phone's camera. Because we do not modify the template image and do not require special fiducial markers to be applied, this is a so-called *natural feature tracking method*. Recent work in computer vision has given rise to a number of methods to accomplish this. However, our solution is among the first ones optimised to perform well on platforms with limited processing power.

The method implemented here was optimised to operate on the N95 phone. In general the system operates at between 5 and 12 FPS, depending on the speed of motion of the camera allowing for interactive use. For this study a template image was used that allows operation from about 15 to 40 cm distance between the printed map and the camera. Tilt between the map and the camera is tolerated up to about 30 degrees, while in plane rotation is handled over the full range of rotations.

4.3.2 Specification

Hardware and OS	Nokia N95, Symbian OS v 9, S60 UI 3rd Edition
Software	C++
Core Features	Grabs mobile phone camera image, extracts features from the image, showing a map. Defines the area of the map visible on screen, gets location based media from remote database and displays media, icons on top of map.
Status	Implementation ongoing, first prototype ready by March 2008. Second prototype August, 2008.
Intended users	Users interested in location based media, events.
Showcases	WP7, others.
Relevance beyond project	Would be usable and extensible over many usage scenarios.

4.3.3 Testing / Evaluation

One field trial was held in March 2008 in Helsinki with 5 users and a series of three field trials took place in August 2008 in Helsinki with a total of 37 users. In our trials we enlisted a mix of 37 early-adopters, environmental researchers, scouts and their families to use MapLens, to play an environmental awareness-raising location-based game. A comparative trial was run with a non-AR digital system called DigiMap which echoes Google Maps for mobile phones (Figure 18). No physical map was required, but we used the same map, red markers, and updated data to be switched on and off across both systems. We used standardised joystick phone navigation for *scrolling* across the map, using two buttons to control *zoom* in and out.

Figure 2 - DigiMap.

Analyses of videos, field notes, interviews, questionnaires and user-created content expose phenomena that arise uniquely when using AR maps in the wild. We noted on how augmentation affects the way participants use their body and hands, manipulate the mobile device in tandem with the physical map, walk while using, and collaborate. We found that the MapLens solution facilitates place-making by its constant need for referencing to the physical, and in that it also allows for ease of bodily configurations for the group, encourages establishment of common ground (Figure 19), and thereby invites discussion, negotiation and public problem-solving. Its main potential lays not so much in use for navigation but in use as a collaborative tool. The field trials are presented in more detail in

Appendix 1: Field Evaluation of MapLens Prototype. For results relating to presence, see section 3.2.3 and D3.4 for a more extensive discussion.

Figure 19 - MapLens field trial users.

5 Dissemination

CityWall has continued running as a permanent installation at Lasipalatsi, in the city centre of Helsinki. From Helsinki's Cultural Office's request the installation was moved from the street side of Lasipalatsi to the inner courtyard side of Lasipalatsi, which is not as busy spot with passing by pedestrians like the old place. Although the new location is not as visible as the old one, it still has cafes and people spending time there. The new 3D version was opened there 8th October, with press and outputting a YouTube video that grabbed more than ¼ million visits within its first two weeks. http://www.youtube.com/watch?v=IldDrCcZkZY

The biggest event for CityWall was not in Helsinki, but in Paris: CityWall was exhibited with WP6 Mixed Reality Tent in the European City of Sciences exhibition at Grand Palais. The event was very popular among Parisians, attracting over 50 000 visitors in a few days.

For MapLens, several field trials were conducted. In Figure is a summary table of dissemination events and field trials and and users regarding both CityWall and MapLens. .

Prototype	Period	Event	URL	Users
CityWall	Jan-Dec 2008	City installation in cooperation with Cultural Office	http://citywall.org	Estimate: 500 per week (general public)
MapLens	Mar 2008	Field trial with first prototype	-	5 users
CityWall	May 2008	Dissemination at UC Berkely, Stanford and Nokia NRC Palo Alto	-	Estimate: audience of 100 people
MapLens	Aug 2008	Three field trials with 2nd prototype	-	37 users
CityWalll	Oct 2008	3D version opening at Helsinki City Centre	http://citywall.org	50 invited guests, including press
CityWall	Nov 2008	European City of Sciences	http://www.villeeuropeennedessciences.fr/uk/index.htm	Over 50 000 visitors

Figure 20 - Dissemination and field trials in 2008.

5.1 Sites and Blogs reporting on CityWall

Besides appearing in the Finnish and French written media, CityWall has been quite visible in the Internet. Here is a list of selected sites and blogs and a viral marketing site (see Figure 21) reporting on CityWall. Publications are listed in Figure 22.

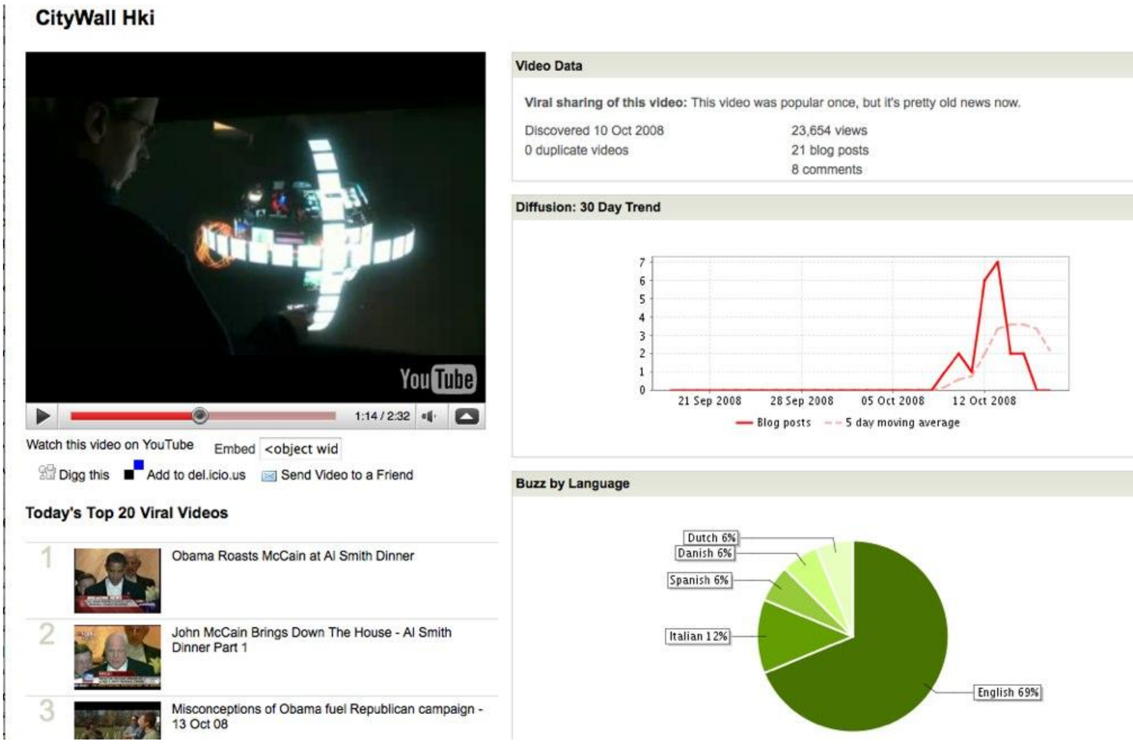


Figure 21 http://www.viralvideochart.com/youtube/citywall_hki?id=IldDrCcZkZY

http://www.youtube.com/watch?v=IldDrCcZkZY This YouTube video received ¼ million hits in the first two weeks from opening at downtown Helsinki October 8th, 2008 with a new 3D interface that caught the attention of the global multitouch and IT community, The video was advertised as a highlight on for several days on the front page of YouTube most popular sites.

The WAVE Report on Digital Media 3D, Media Creation, Shared Space, Published by 4th Wave, Inc., Issue #0814 11/4/08 http://www.wave-report.com/

http://museiteknik.blogsome.com/2008/10/27/citywall-tryckkanslig-lcd/http://www.wave-report.com/conference_reports/2008/CityWall.htm

http://www.cultureevenement.com/2008/07/les-surfaces-multi-touch-desormais-disponibles-pourevenementiel/http://www.gizmodo.com.au/2008/10/citywall_interactive_multitouch_display_now_has_a_glorious_3d_interface-2.html

http://www.tietokone.fi/uutta/uutinen.asp?news_id=35243&tyyppi=1

http://www.tietokone.fi/uutta/uutinen.asp?news_id=35243

http://www.unidademultipla.com/2008/10/citywall-display-multi-toach.asp

http://www.slashgear.com/citywall-multitouch-interactive-display-1018961/

http://heightz.blogspot.com/2008/10/city-wall-multi-touch-display.html

http://elanso.com/ArticleModule/HGTgNiSsSiHlQcSESYRRJ2Ii.html

http://officesearchtoronto.com/2008/10/09/citywall-interactive-multitouch-display-now-has-a-glorious-3d-interface/

http://www.helsinkitravelguide.com/latest-blog-posts/city-wall-multitouch-display-now-has-3d-interface.html

http://news.cnet.com/crave/?keyword=%22CityWall%22

http://www.mediauser.de/

http://charliemartinez.wordpress.com/

http://touchscreenyear.blogspot.com/

http://oh-so-fresh.blogspot.com/

http://www.nelson-wong.com/blog/

http://selected-few.blogspot.com/

http://rockstarsociety.blogspot.com/

http://ima80sbaby.blogspot.com/

http://thejournalofawesome.blogspot.com/

http://allthingsmusik.blogspot.com/

http://ashleytan.wordpress.com/

http://solidspace2.blogspot.com/

http://www.gadgetzone.ro/

http://www.aboutprojectors.com/news/

http://freedesign-artedisegnovideomusica.blogspot.com/

http://ravlik.com/

http://www.elhuequito.com/

http://foodshub.com/

http://onzetoekomst.blogspot.com/

http://lifebook98.blogspot.com/

http://playgroundtop.blogspot.com/

http://news.cnet.com/crave/

http://www.google.com/reader/view/

http://tech.slashdot.org/article.pl?sid=07/05/31/1928251&from=rss

http://www.tietokone.fi/uutta/uutinen.asp?news_id=35243&tyyppi=1

http://news.cnet.com/crave/

http://cooler-online.com/

http://www.impactlab.com/2008/10/11/city-wall-multitouch-display-now-has-3d-interface/

5.2 Commercialisation

Mutlitouch.fi is expanding as a company, employing more people, has successfully re-applied for financial support from Finland government, and has developed a cell LCD technology with 10 large and 10 small cells being sold (as far a field as Australia) as well as 2 larger projector-based installations. In 2009 the company will expand further, employing more people again, to deal with increasing demand..

5.3 Publications and presentation

Conference/journal, date or timeframe	Title or topic	Responsible person and additional authors	Status (published, submitted, under preparation, planned, presented)
CHI 2008	"It's mine, don't touch": Interactions at a large multitouch display in a city Center.	Peter Peltonen, Esko Kurvinen, Antti Salovaara, Giulio Jacucci, Tommi Ilmonen, John Evans, Antti Oulasvirta, Petri Saarikko	Presented as full paper
AVI 2008: Public and Private Displays workshop (PPD 08)	CityWall: Limitations of a Multi-Touch Environment	Morrison, Ann, Jacucci, Giulio, Peltonen. Peter.	Accepted and presented as workshop paper
ACM Multimedia 2008, HCC Workshop, ACM publication	Evoking Gesture in Interactive Art	Ann Morrison, Peta Mitchell, Stephen Viller	Accepted and presented as full paper
British HCI workshop: Using locative games to evaluate hybrid technology, Liverpool, September 1-5, 2008.	Using locative games to evaluate hybrid technology	Morrison, A., Jacucci, G, Peltonen, P., Juustila, A., & Reitmayr, G.	Accepted and presented as workshop paper
British HCI workshop: Critical Issues in Interaction Design, Liverpool, September 1-5, 2008.	Speaking with many voices: Intertwining within and between inter-disciplines	Morrison, A	Accepted and presented as workshop abstract
ShareIT -Shareable Interfaces for Learning Workshop 2008, 11-12 September, Sussex 2008.	Sustaining Engagement at Public Shared Interfaces,	Morrison, A and Salovaara, A	Accepted and presented as workshop paper
CHI 2009	"Like Bees Around the Hive" Interaction In the Wild with a Mobile AR Map	Morrison, A, Oulasvirta, A, Peltonen, P, Jacucci, G, Lemella, S, Juustila, A., & Reitmayr, G.	Accepted as full paper
OZCHI 2008	Proposal to Doctorial Symposium run by Margot Brereton, Paul Dourish and Wally Smith	Peter Peltonen Ann Morrison	Accepted and presented as symposium presentations
OZCHI 2008	Situated Engagement at a Public Urban Display	Morrison, A and Salovaara, A	Accepted and presented as workshop paper

Figure 22 - WP7 publications 2008.

6 Conclusion

Both applications have made major breakthroughs in this third year. There has been a first field trial with MapLens in March, followed by a series of three field trials, with the prototype further developed, as well as the innovative evaluation methods. CityWall has been re-built as a system, and the hardware and portable version have had major rennovations. As well the approach to what and how people might interact here has been under intense scrutiny and re-design. We have two field trial video recordings of the wall in use; one in the new Helsinki location and another at European City of Sciences. The focus fort his third year, has been largely on the re-design and the re-development, while targeting the new theme of environmental awareness. As a result new aliances have been forged with local environmental and other organisations, which we look to continue with our further work. We published as we progressed to ensure we maintain profile with our break-throughs.

Moving into year four, for CityWall there is further refinement and optimisation work to be completed, as well as a further field trial in Summer 2009. This will be followed by analysis of what will then amount to three video-documented recordings of activity at CityWall. We will target one highly ranked conference and one highly ranked journal for dissemination of our research here, using a grounded theory approach that allows the data to reveal the findings. As a permanent installation, there are constant enquiries about, and interaction with, this popular work.

For MapLens there has heightened interest and collaboration with other consortium partners, which will continue to expand over year four. We have emerging research that reveals the differences in use between digital only and digital-physical systems, which potentially houses follow-on consequences for how and for what purposes these technologies might be developed. Further refinement of the technolgy, and a further planned game as evaluation method for late Summer, 2009 is well-underway in it’s planning stages. In year four we are writing a journal article, and will target further journals after more analysis of our data, as well as location-based and game aspects of the study.

In year four, a book chapter on ubiquitous media is underway from TKK, that discusses MapLens and CityWall as it’s case studies.

7 Appendix 1: Field Evaluation of MapLens Prototype

In this appendix we will present the detailed findings of our three MapLens field trials done in August 2008.

7.1 Overview and timeline

In order to replicate a real-life scenario, we aimed to include real elements and tasks to imitate the kinds of circumstances that might usually be found around the use of this kind of technology. In order to achieve this, we designed a location-based game that required the users operate the systems and complete their tasks in a situated environment, that required they manage multiple levels simultaneously—with constant interruptions and shifts in focus, as well as conflicting distractions and divergent goals.

Three trials were held over three Sundays, in down town Helsinki, Summer, 2008. Prior, we piloted the game logic, timing, task difficulty, and interaction. Each trial was of an incrementally larger size. We had run a previous trial with an earlier prototype in Spring 2008. We included one team from this Spring trial in the first and third Summer trials to give comparative feedback on improvements. As well, five teams in the third trial tested DigiMap and the other five teams tested MapLens.

7.2 The participants

The first two Summer trials were comprised of largely professionals working in related fields, early-adopters, and researchers working with environmental issues. The third was comprised of scouts and their friends and families. Over these three trials we enlisted a total of 37 people with ages ranging from 7 years to 50 years, 20 females and 17 males. 21 had owned five or more mobile phones, with 22 owning or using regularly Nokia brand, and only one not familiar with or not owning a mobile phone. All phone owners used their phones for at least SMS and phone calls. Other self-reported information can be found in Figure 22.

	MapLens group 26	**DigiMap group 11**
Females + Males	19 + 7	1 + 10
Education	6 primary, 7 secondary, 13 tertiary	7 school, 3 secondary, 1 tertiary
ICT Knowledge	12 basic, 7 average, 7 expert	3 basic, 7 average, 1 expert
Hours of Technology Use week	6 > ten hours, 7 ten - 39 hours, 13 < 39 hours	4 > ten hours, 7 ten t- 39 hours
Know Helsinki	8 no, 4 average, 14 yes	2 no, 2 average, 6 yes
Aware of Environmental Issues	9 average, 17 yes	3 no, 2 average, 6 yes
Navigation Skill	7 no, 19 yes	4 no, 7 yes
Used GPS	21 no, 5 yes	9 no, 2 yes

Figure 22 - Self-reported information from the participants.

7.3 The location-based environmental awareness game

The trials were run as location-based treasure hunt-type games. The game was designed to raise users awareness of their local environment. With the assistance of the technology the players followed clues and completed the given tasks within a 90 minute period, and in so-doing learnt about specific environmental concerns. We included three different prizes aimed at encouraging a variety of approaches to the game. One prize was for speed and accuracy—a more traditional approach to a game—another for the best photography, and one more for designing the best environmental task. An element of friendly competitiveness was established in the pre-phase game-orientation, and encouraged by promising prizes on return. Our intention was to focus and motivate our participants, as well as instigate time-pressure while they managed a broad range of multiple and divergent tasks simultaneously. Some tasks were more or less complex than others.

1. Pre-Phase. Fill in demographic & consent forms. Demo of technology and game. All familiarised themselves with devices.
2. Instructed Goal. "Complete as many tasks as possible in the allocated period." Awareness of other players assists users to navigate, compete with others for prizes.
3. The Game. The participants had four types of tasks to go through: *Inside the museum.* Task Type 1) Find clues and complete tasks. Task Type 2) Take photos of whole group. *Outside the museum.* Task Type 3) Find a recycle bin using software. Task Type 4) Locate and walk to sites and complete tasks such as water testing, sunlight photos. Record completion of tasks.
4. Post-Phase. Questionnaires and interviews.

Figure 23 - Overview of the trial procedure

The trial began at the Natural History Museum where players completed indoor tasks, two of which included follow-on components outside the museum (Figure 23). We wanted the players to solve a variety of kinds of tasks (12 in all), some of which were sequential problem chains. For example, one museum task required information on an endangered Baltic seal; the follow-on task was to find the seals' home and calculate the carbon footprint by car, train and plane from an online site offering such comparisons.

The trial began at the Natural History Museum where players completed indoor tasks, two of which included follow-on components outside the museum. We wanted the players to solve a variety of kinds of tasks (12 in all), some of which were complex sequential problem chains. The game required players visit green areas in the city. One task was for the whole group to walk bare-foot in the grass, and upload a photo as evidence; another to gather a specific leaf (the leaf also found as a museum clue) and then take a sunlight photograph with a kit supplied, using water to develop the photo; another was to test a sample of sea water and a sample of pond water with a supplied kit for readings on Chlorine, alkalinity and pH balance. We added the task of taking a photo of the whole group to many tasks to encourage physical proximity and team bonding. Provision for 20 minutes at an Internet café was included. How tasks were completed was up to players. As well there was no compulsory order for tasks to be completed in. Some tasks could be completed in several places, whereas others required visiting places in a certain order. After the more physical tasks, in particular with the lifting of a 27.4 kilo 'salmon' in the museum—where teams needed to either contort to fit the whole team into the photo (including the held 'salmon')—or outwardly engage other teams or strangers, to take the photo—the players noticeably settled into a more relaxed game mode. We sought to include specifically physical activities in order to force the players to continually reorient their relationship to themselves as physical beings (and objects) within a world consisting of other physical beings and objects [20]; essentially a confrontation with the self as both an entity in the world, as well as an object amongst other objects in the world. One's progress through the game is represented virtually as a trail of activity, where all the players are continually co-present to each other. This co-*Presence* keeps the game meaningful, where competition, keeping to the tasks and time frame are continually 'thrown up' for the players, in turn heightening the intensity of their experience.

The game required players visit green areas in the city. One task was for the whole group to walk bare-foot in the grass, and upload a photo as evidence; another to gather a specific leaf (the leaf also found as a museum clue) and then take a sunlight photograph with a kit supplied, using water to develop the photo; another was to test a sample of sea water and a sample of pond water with a supplied kit for readings on Chlorine, alkalinity and pH balance. We added the 'taking-photo-of-whole group' component to many tasks to encourage physical proximity and team bonding.

Each team was handed a *kit* which contained seven objects in all (see Figure 24). By design, these objects required some coordination between team members to manage well. The large physical maps, expanding clue booklets, manipulating the phone over the map, writing in the clue book, the bag, meant that the participants needed to organise themselves into some kind of system of use. There were no ready-made solutions, in-situ creative problem-solving was required, and solutions varied according to the immediate environment—for example, a tree, a team mate or a near-by bench might be used as a steadying, leaning or resting prop.

Figure 24 - Kitbags contained 7 items that needed to be managed: sunlight photographs, map, phone, water testing kits, voucher for internet use, clue booklet and pen.

Tasks were designed with a view to promote: internal and external group activities and awareness; negotiation of tasks and artifacts; 'noticing' and awareness of the environment; higher level task management; and awareness of physicality, proximity, embodiment and physical configurations around artifacts. There was particular emphasis on the mix of digital, and augmented with real and overtly tangible. These tasks were designed to facilitate proximate bodily configuration, to 'jolt' users away from small-screen absorption, and to remind the participants of their own corporeal selves [21].

For all trials, we ran thorough briefing sessions, to ensure all participants were familiar with game tasks and devices. When the teams left the briefing room each individual understood the immediate tasks and how to proceed.

7.4 Data collection

In the study we gathered data with a triangulation of quantitative and qualitative methods. Methods included collecting demographic data (Figure 2) and ascertaining perceived experience with: technology, phones, use of maps, as well as knowledge of environmental issues and Helsinki center. Each team was accompanied through-out by one researcher taking notes, photographs and/or videos. On return from the game, participants completed a three-page questionnaire from Flow, Presence, and Intrinsic Motivation research to gauge reactions to the technology and the game [7, 19, 21]. This activity also focused participants on their experience in the trial, familiarising them with an extended vocabulary to better articulate those experiences. Each participant then described their experience, highlighting aspects that had caught their attention in semi-structured one-to-one recorded interviews.

Throughout the trial participants took photos as evidence of completing tasks. These images were synchronously uploaded from the phones, and assisted researchers to build an overview of activities undertaken during the trial.

7.5 Observations

Before moving on to the main subsections dealing with embodied interaction and collaboration, we briefly explain the general strategies of game play that we observed.

After the briefing session in the museum, the players headed for the clues—some even running—with many covering the same ground twice. Scout teams tended to ask museum guides or look for maps of the museum. Some teams split up while hunting, others stayed as a pack and were more systematic in their approach. Deciding a way to proceed, and more or less strategic game-plans unraveled in these early stages, varying between teams. Some teams, particularly those who knew each other well, divided the tasks with seemingly little effort or overt communication

Across the trials, we found that expert users' teams were more impartial in their turn-taking and role changing, whereas family members or friends tended to stay within their 'habitual' roles. For example, the youngest son in a family of four, automatically used the internet and where difficulties occurred was handed the phone, while the father and oldest daughter managed task order.

Photographing the environment

During the trials, the participants took a total of 184 photos. The DigiMap users were more eager to take photos as the average photos per team was 21.5 in comparison to 9.8 for MapLens teams. 36% of the photos taken by the DigiMap teams were task-related, with 45% by MapLens teams. Photos that do not count as task-related contained for example, photos of streets (7.6%), of parks (7.1%), of buildings (3.8%) and statues (3.2%). The DigiMap teams were somewhat more oriented to photograph the environment.

7.5.1 Embodied interaction

Comparing MapLens to DigiMap exposes several ways in which the systems both resource and constrain embodied interaction. By embodied interaction we refer here to the use of hands and body to position oneself, and the technology, in the context of other people and the environment.

We ask the reader to note that the figures presented from here on have been labeled with M when referring to MapLens and with D when referring to DigiMap.

Doing tasks with physical map versus the mobile map

In order to use MapLens, teams needed to use both the physical map and the device in tandem. For DigiMap teams, the use of the physical map was of course optional. Most MapLens teams used the physical-digital combination for identification of target location, but also for route planning (see Figure 25 left). As an exception to this a few groups unfamiliar with the surroundings used MapLens in two stages: first to identify the target destination and then the physical map alone to agree on the route to take (Figure 25 right). Three DigiMap teams did not use the paper map at all, or if they used it at the beginning, once it was put away in the bag, despite it having been useful, did not bring it out again. By contrast, MapLens teams were required to constantly negotiate this physical artifact to function in the game. They developed an expertise around handling the map, which in turn had a carry-on effect in the way they managed all the physical artifacts generally.

Figure 25 - Most teams used MapLens (M) for both identifying the target and selecting the route. An exception is on right, a team that used the paper map having identified the target.

Holding the device

MapLens users typically held the device stretching out their arms because the camera needed to be held within the operating range of 15 to 40 cm away from the paper map. Moreover, the best light to view by was with sunlight on the map and the lens in shade. Importantly, by placing the device in this way, stretching one's arm, others could see what part of the map was being examined and at times contents on the display. We return to this issue, which we believe is central for encouraging collaboration on and around the map.

DigiMap users typically kept the device lower and closer to their body—a natural posture for holding a phone. However, this posture renders the phone more private (see Figure 26 right) and others cannot directly see the contents or reference points as with MapLens.

Figure 26 - MapLens (M) was held in a way that it could be shared in the group, whereas DigiMap (D) users held the device more privately.

Use of two hands

The use of MapLens with the paper map often required two hands. The device was typically held in the dominant hand and the map in the other. Players also often used two hands to stabilise the phone, with another user holding the physical map (Figure 26 left). The players using MapLens had various items to carry with them and they often ended up gesturing with the device in the gesturing hand. While gesturing or organising their items, some players dropped the device on the ground (Figure 27 left). We observed this happening several times, but only with MapLens users.

The DigiMap players could use the device single-handedly, consequently they tended to have their non-dominant hand free, which allowed them to switch objects between their hands more flexibly (Figure 27 right).

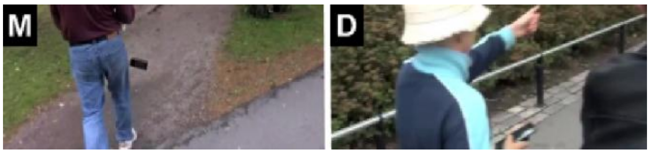


Figure 27 - Use of hands with was different with MapLens (M). On left a MapLens user's drops his phone . By contrast, when using DigiMap (D), one hand is typically free.

Stabilising the map and lens

The players using MapLens had to stabilise the physical map and the device to be able to focus the lens properly. They often favored places where they were able to place the map on a table or bench. They also often laid the map on the ground or held the map for their group members (See Figure 28). This was a strategy to solve the problem of hand-tremble, which some MapLens users reported.

Figure 28 - Stabilizing map surface for MapLens (left), then holding the device in two hands to mimimise tremble (right).

Turning and tilting the objects in hands

The paper map and the lens can be held in various orientations and alignments with the surrounding environment. When holding the paper map, MapLens typically kept the map aligned to north facing-up, and did not rotate the map around to align it with their orientation in the environment. As the map was somewhat cumbersome, rotating the map was more common when the map was supported by other players or surfaces, or when the map was on the ground.

The players using DigiMap occasionally turned the device—typically 90 degrees—for aligning the map with the environment. This may have been partly due to the smaller size of

DigiMap setup that is easier to turn in hands. Another reason could be that the players struggled with establishing understanding of the map through the small screen size. Interestingly, about half of the players using MapLens kept the device horizontally, while the orientation of text and photos on the screen suggested vertical use.

Body posture

While the players using MapLens had to be relatively stable when using the system, DigiMap players were able to look at the map while moving around. Due to this we saw DigiMap users more often turning their body or glancing around while using the system (see Figure 29).

Figure 29 - Turning to gaze the environment was more natural with DigiMap (D) that does not block view and constrain upper body movement as much as MapLens.

Walking while using

Seven of the eleven teams tried to use MapLens when walking, but all faced difficulties. In a typical scenario the team tried to use MapLens when walking but stopped doing so as the technology required steadiness to focus. There were two kinds of difficulties faced. First, even a very light trembling of the device makes MapLens difficult to use. Second, the participants' possibility to be aware of their immediate environment was challenged when using MapLens. One of our players was so engaged in looking at MapLens and the paper map that he walked into a lamp-post. These incidents indicate that MapLens does not support 'playing by moving,' but demands effort, forethought, and planning. Indicative of this, some teams used MapLens while waiting at traffic lights. In this way, they used their time well and it was possible to focus on using the technology without losing too much control over their immediate environment.

By contrast, difficulties of these kinds were not common in the DigiMap teams. Three of these teams used the system while walking, and one of the teams even ran while watching a map. However we did see a few cases of using MapLens while walking. A team of three young girls usually stopped to use 'MapLens & map', but as they began to run out of time, one of them walked more slowly behind the other two, who prevented her from running into anything (Figure 30 left). When she noticed something on the map, she called them to stop and look. As a group though, they did not use the technology when walking. Two other teams used MapLens while walking to watch the changing interplay as markers were picked up from the environment.

For MapLens players time spent walking was mainly used to get from one task to another, and to converse, or to discuss the last or the next task. Conversely for DigiMap teams walking was also an efficient time in the game, as it was inseparable from watching the map, and working out the next steps, so was less used for discussion.

Figure 30 - Walking while using and bodily configurations. Left: Girls walk in front while one tries to read off MapLens (M). Center: MapLens (M) team negotiate where next. Right: One DigiMap (D) user reads the system while the other navigates.

7.5.2 Collaborative use

The previous section establishes salient differences in the manual and bodily operation of the two systems. We here turn to look at their implications on joint efforts. We start with analysis of handing over the phone as a physical object, then look at bodily configurations around MapLens, establishing common ground and place-making, and finally how conflicts were resolved.

Handing over phone

The handing over of the phone occurred more in the MapLens groups than in the DigiMap groups. As an example, in one instance with a MapLens expert-user group, we saw the one with the phone made an error about a place-name, and the next player while verbally corrected this error at the same time made a gesture of holding out her hand, and the phone was passed over. With a mother-son team where there was a constant struggle on which way to proceed. The boy retained DigiMap perhaps as a means to re-address the power imbalance. With a MapLens aunt and niece team, the only chance the niece had to use the 'MapLens & map' combination was when it was placed on the ground at the pool. She was the more competent user, but did not take it from her aunt, even though this meant they were less efficient in the game. The holder of the phone had the most agency in the team at that moment in time.

Bodily configuration

We observed teams negotiating together at all parts of the trial. The discussions did not only concern the task at hand and what the team should do next (and by which route) but also how to use the technology itself, as in Figure 30 (center), MapLens users in many instances gathered together around the physical map to use MapLens. The group members who did not have the phone gave instructions to the one holding MapLens on where to look. The need to hold the map stable did not give participants the freedom to do the navigation tasks while on the move (Figure 30 center), as it did for DigiMap where often one person was the "navigator" of the group searching things from the mobile, while others observed the environment and lead the way (Figure 30 right). This made DigiMap use more private and non-collaborative. Regardless participants using both systems found traffic lights a good place to negotiate where to go next and to find information from the maps or discuss clues.

Figure 31 - The physical map as a common ground, established by showing with the lens (M) and pointing with finger.

Establishing common ground

Given that the typical way of using MapLens involved a team gathered around the map and the main user gesturing on the map with the lens, establishing common ground was made easier for MapLens groups. By this term, we refer to shared understanding about the objects that are the focus of co-conversants' attention [5]. The location of MapLens on the paper map, and the contents that are revealed to others on its display, help others understand what the discussion is about without explicitly asking or negotiating. In Figure 31 a young woman browses the map by using MapLens. After finding an interesting place she suggests it to her father by pointing to it with her finger. The father proposes a nearby location instead and points to it by using the corner of a clue booklet.

The groups using DigiMap were not able to share the map that fluently. In Figure 32 a young boy is trying to identify a place by pointing to a relevant location on a screen and glancing around. After this he gestures towards the direction he suspects to be correct and hands the device over to his uncle, who then assesses the situation.

Figure 32 - DigiMap (D) Attempting to share the map as common ground.

The physical paper map supported the players better in establishing a common understanding of the area and referring to different locations. Some players though found it challenging to identify the current location on the map with the focus of the lens, especially while it was being used by another player. The players using DigiMap often referred more directly by pointing at their surroundings.

The combination of the lens and the physical map provided the group a means to be collaborative in a more physical way. For example it was possible to pinpoint locations from the physical map either with a finger or a pen so that the participant using MapLens could easily target that point on the map (see Figure 33 left). As DigiMap use did not require using the physical map and the mobile phone screen is rather small in size, negotiations in DigiMap groups less often occurred with both trying to look at the mobile phone screen. Within a team of 2 close friends we observed constant pointing at the mobile screen, establishing common ground, others looked at the screen behind the “navigator’s” shoulder (see Figure 33 right), but most often this was not done at all. Two DigiMap groups chose to use the physical map in addition to the digital map. For example, in one group a son searched for locations using DigiMap and either spoke aloud the options to his mother or pointed at them on the screen. The mother then used the physical map for a more detailed view of the surroundings.

Figure 33 - Referring to objects by pinpointing. Left: Pointing with a pen while using MapLens (M). Right: pointing with finger from DigiMap (D) screen.

Place-making

The act of stopping walking, raising up the paper map and the lens, and gathering around for a while creates an ephemeral opportunity, isolated from the surroundings with the physical map and the bodies, to momentarily focus on a problem as a team. The phenomenon of place-making has been raised previously in the literature looking at mobile use of technology [11], and we encounter here a special multi-user form of it. Here, the physical map as a tangible artifact acts as a meeting point, a place where joint understandings can be more-readily reached by means of participants being able to see and manipulate and demonstrate and then agree upon action. The teams in pausing for discussion created a series of temporary spaces, places for collaboration. For example, they put bags down, swapped or rearranged objects they were carrying, and also stabilised the map and re-looked through MapLens to be sure they were on the right path. At this rapidly-made ‘place’ the tasks became again shared, negotiation and switching of roles often occurred and we witnessed a different kind of social usage in this temporary place. Other pedestrians walked around these ‘places.’

Conversely the DigiMap teams only needed to stop at places that the tasks themselves dictated, the rest of the action and decisions and way-finding were mainly done while on the move.

Collaboration and Presence

The collaboration described above however came at a cost. While “forcing” users to create a common ground and engage in place-making, users had to adjust their interactions to cope with several problems in operation. While the non-augmented digital counterpart of *MapLens*, DigiMap, is also susceptible to direct sunlight, it is much easier to cover such a small object with the palm of one’s hand. Secondly, the use of *MapLens*, but not of DigiMap, effectively requires two hands, because either one has to steady the surface (the map) or use two hands to stabilise the phone in hand. For these reasons, use while walking is not possible, whereas DigiMap was often used while on the go. Moreover, the need for careful operation and focus on the “surface & lens” restricted their attention to the surroundings. Users echo this description, describing interaction with *MapLens* as difficult and unstable.

MapLens turns AR mediated cues into resources for collaborative action, but this came at a cost. In VR related tele*Presence* we can exclusively focus on how a person feels in another place or connected to remote people. Conversely, *MapLens* forces us to look at how several persons co-experience and act with an AR mediated device. *MapLens* works as a system that provides a space for “mixing realities” that can be viewed and evaluated together. *Presence* to the location, *Presence* to the game, along with competing between teams added a sense of urgency to the experience. The interaction space is enlarged, in the way in which the participants can express themselves within and experience this space. For example, one participant was so engaged in the activity of looking at *MapLens* and the paper map that he walked into a lamp-post. Participants gather around the “surface & lens” system and point to the augmented view of the world they are standing within. When they experience difficulties they raise their heads and look around and continue to point. They may need to move away, scouting, walking or running even, looking and experiencing the actual physical reality view. Then they return and add this ‘real’ information to the group-present collocated mixed reality “surface & lens” view, in order to negotiate and anticipate the next best move within the game sequence and the real environment.

Resolving conflicts

Even though the tasks required much group work, conflicts rarely occurred. Most problems were encountered while trying to locate things from maps. A failure to locate ended up usually in handing out the phone to some other group member who then tried to achieve the same task. This happened more often in MapLens groups as swapping the phone from one subject to another was easier as the augmentation usually happened while the group was standing still and close to each other. In DigiMap groups the ‘navigator’ less frequently handed out the phone to others, but it happened in some occasions, especially in groups of two composed of a parent and a child. These groups were also the ones that had most arguments on how the group should proceed in the game. For example, in one DigiMap group the mother did not allow her son to explore the environment, as she wanted their team to go as fast as possible.

7.6 Questionnaires and interviews

7.6.1 Questionnaires

The participants filled in three questionnaires: a shortened version of MEC Spatial Presence Questionnaire (MEC-SPQ) [21], a GameFlow questionnaire based on [19] and an Intrinsic Motivation Inventory (IMI) questionnaire [7]. As Likert (ordinal) scale was used as a measure and Shapiro-Wilk’s test revealed our data is not normally distributed, the Mann-Whitney U-test was selected to test differences between MapLens and DigiMap teams.

When comparing total Presence, Flow and Motivation score medians between MapLens and DigiMap participants, no significant differences were found. However, both groups scored above average on most items indicating that motivation, being present to the game and/or map system, and experiencing a sense of concentrated engagement was activated for users of both systems. When comparing individual Presence, Flow and Motivation items, significant differences were found. This may be due to questions addressing whether the system related to map system use, the game played or both (see Figure 34).

Item and Mann-Whitney U-test Significance: Presence 1-5 scale, Flow and Motivation 1-7 scale	**System with higher median**	**System with lower median**
*Items related only to **map system** use*		
Presence: I was able to imagine the environment and arrangement of the places presented using the map system well (*)	DigiMap MD=4.00	MapLens MD=3.76
Presence: It was as though my true location had shifted into the mapping system environment (*)	DigiMap MD=3.18	MapLens MD=2.29
Presence: I concentrated on whether there were any inconsistencies in this mapping system (*)	MapLens MD=5.00	DigiMap MD=4.00
*Items related to **both map system use and the game***		
Presence: The task and technology took all my attention (*)	MapLens MD=4.00	DigiMap MD=3.00
Presence: I felt I could be active in my surrounding environment (move, use the mobile phone and switch from task to task) (*)	DigiMap MD=5.00	MapLens MD=3.34
Flow: How to play the game and how to work the technology was easy (**)	DigiMap MD=6.00	MapLens MD=5.00
Flow: My skill level increased as I progressed (**)	DigiMap MD=7.00	MapLens MD=5.00
IMI: While I was working on the tasks I was thinking about how much I enjoyed it (*)	DigiMap MD=6.00	MapLens MD=5.48
IMI: I think I am pretty good at these tasks. (**)	DigiMap MD=6.00	MapLens MD=5.00
IMI: I found the tasks very interesting (*)	DigiMap MD=6.00	MapLens MD=5.00
*Items related only to the **game***		
Flow: The difficulty level got easier as the game progressed (**)	DigiMap MD=7.00	MapLens MD=4.31
Flow: I knew how I was progressing in the game as I was proceeding (*)	DigiMap MD=6.00	MapLens MD=5.35
Flow: I helped other players in other groups (**)	MapLens MD=2.08	DigiMap MD=1.00

Note: (*) = $p<.05$ and (**) = $p<.01$.

Figure 34. Questionnaire items having significant differences

As a general conclusion it can be stated that while the MapLens users felt confident using the technology and enjoyed the experience, the DigiMap users did so even more. The technology also enabled the DigiMap users to perceive their surroundings better than users of the MapLens system, who concentrated more on the technology as such, as well as being more focused on the game as a whole. Also MapLens users were socially active and more helpful of others. MapLens users were more focused and both groups scored high on sense of control, understanding requirements, interest and enjoyment.

7.6.2 Interviews: common participant descriptors

From the oral interviews we searched for recurrent descriptors (adjectives) in the participants' descriptions of their experiences. We found that MapLens users made 11 mentions of the word *stability* (compared to 0 with DigiMap). For example, "You need to be quite accurate; you need to be *stable* and you need to get the camera into the right position." Six MapLens users described the trial as *easy* compared to twenty-five instances of the word *easy* being used with DigiMap players. Here too, we find MapLens teams were more challenged by the technology: “At first it was difficult to find these dots. Maybe it was because we were not able to keep our hands stable enough. But after that we were able to find the dots, catch the red dots by using the square.” The DigiMap technology was perceived as much *easier*, with zero problems with *stability*.

8 Appendix 2: Inputting to CityWall

8.1 Adding content to CityWall

There are several ways to add text, videos and images into CityWall. Some are immediate, like SMS, others might happen at a later time or from a different location. (see Figure 35 for an overall picture of input)

8.1.1 Inputs

SMS

Write to 0033 (0) 64 51 24 76 and your messages will be displayed immediately for 15 minutes on CityWall. After that time you can locate your message in Pin Board Ball (see beside), where you can drag them out into the Pin Board again.

MMS

Send to "citywall-email@hiit.fi", to be displayed on the Pin Board.

Email

Upload images attached to emails sent to:

"citywall-paris@hiit.fi" for Grand Palais and ParisWorld(subject lines will be used as titles)

"citywall-flickr@hiit.fi" for Helsinki FlickrWorld (subject lines will be used as titles)

"citywall-email@hiit.fi" for Pin Board (subject lines will be used as titles)

Online: pictures through Flickr

Images tagged with "cwprs" and "cwgrpalais", go to Grand Palais and ParisWorld

Images tagged with "cwhki", "helsinki" and "citywall" go to Helsinki FlickrWorld

Online: videos through YouTube

Videos tagged with "cwprs", "cwgrpalais", go to Grand Palais and ParisWorld and videos tagged with "helsinki", "citywall" and "cwhki" go to Helsinki FlickrWorld.

These are the same tags as for the images.

Text (future)

You can create small messages directly on CityWall using the "Alphabet World". Your messages will be displayed immediately for 15 minutes; after that time you can find them in the Pin Board Ball, where you can drag them out into the Pin Board again.

8.2 At the Wall: how to use and interact:

- Spin the world fast to browse in time.
- Spinning to the right will update the pictures to the next day.

- Spinning to the left will update to the previous day.
- Hold Down on the elliptic label at the bottom of the ball to display a cross menu to find exact dates. Close in the same way.
- Holding Down on any picture will bring it to the front, then you can drag-and-drop it to the Pin Board if you wish; swiping on the information area will flip the picture so you can read and make comments.

8.3 The Worlds:

The world displays the day that the pictures were uploaded, in a descending spiral flow, with the oldest on the top and the newest at the bottom. There might be more than one layer in the world for the same day if there is a lot of content, read the label below to determine which day you are in.

Helsinki FlickrWorld

- Images from Helsinki and CityWall. Retrieves public files from Flicker and YouTube that use the tags “cwhki”, “helsinki”, “citywall”. The images in this world have been uploaded to CityWall since May 2007.

Grand Palais and ParisWorld

- Images of the Grand Palais and surrounds of Paris city, uploaded in the days prior to and during European City of Sciences week by participants at the event.

Multitouch World

- Video examples of some of the many different types of multitouch that have been developed. Press to play.

Mixed Reality Tent World

- Images from participants in the IPCity MRTent (next door) are continually uploaded to this world. Scenes composed on the ColorTable can be captured at any time by the participants via the barcode interface. The 25 most recent ones are displayed here and people can look through and see examples of their own and other’s work.

Pin Board and Pin Board Ball

- SMS, MMS, emails and texts are placed temporarily in a very frontal layer named Pin Board. After some time they are automatically moved to the Pin Board Ball, where you can browse them. You can Hold Down on items in other applications and drag a copy to the Pin Board, you can delete any item shrinking it as much as possible.

Help Balls

- All Help Balls wander around the screen. There are two types indicated by colour:
- Green contain animations of the gestures you can use to interact with CityWall,
- Blue houses a question mark, and contains brief guides of the interaction gestures, worlds, how to add content, as well as lists of credits of people and organizations.

- Use Hold Down to reach the different levels of information.

The Nuances of Nature World

- A project about living within the benefits and nuisances of nature in the urban environment of Helsinki. Produced in cooperation with the Finnish Environment Institute (SYKE). Retrieves public files from Flicker and YouTube tagged with “cwnicehki” (for Nice ball), “cwnuishki” (for Nuisance ball).

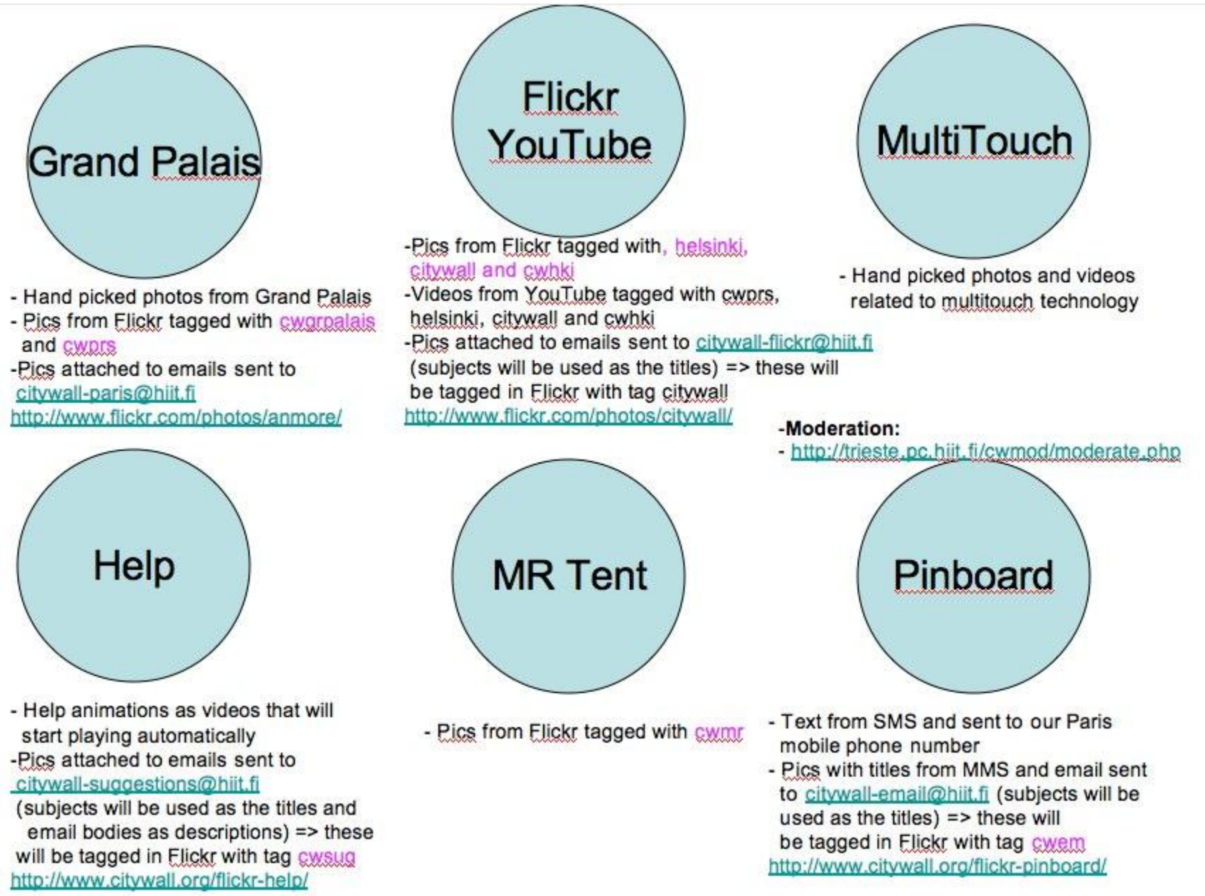


Figure 35. Inputting into CityWall worlds at European City of Sicences Event, Paris November, 2008.

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