Integrated Project on Interaction and Presence in Urban Environments

FP6-2004-IST-4-27571

ipcity.eu

First Prototype of TimeWarp Applications

Deliverable D8.2

Doc-Id:	**D 8.2**
Version:	**1.0**
Author(s):	**Iris Herbst, Anne-Kathrin Braun, Rod McCall**
Date:	**2008-02-07**
Status:	**Draft**
Availability:	**Public**
Distribution:	**Project Partners / EC / Web**

Table of Content

Abstract

This document describes the second year of research within the TimeWarp subproject of IPCity. TimeWarp concentrates on mixed reality game experience in an urban context. The aim of the project is to develop an edutainment game that makes use of state-of-the-art AR technology and implements variious presence concepts such as the use of sound or virtual characters.

The specific objectives for TimeWarp are:

- To develop and evaluate concepts and tools for:
  - Cross-media mixed reality user interfaces and applications
  - Orchestration and authoring interfaces for a broad range of people to shape the edutainment application.
- Further advancing research into the subject of presence in mixed realities in an edutainment context by:
  - Exploring the use of cues for creating a sense of temporal and spatial presence, in particular with respect to travelling between different time periods

Examining engagement and augmentation issues that are designed to support a sense of presence**.**

Intended Audience

This document is intended to all partners of the project, the EC, and to the reviewers for the second project's phase.

1 Workpackage Objectives

Objectives Phase II	During phase II we have: • implemented TimeWarp as a single-user game according to the concept developed in Phase I • implemented two game-front end – the mobile AR system and the mobile information terminal • developed and tested evaluation techniques • conducted tests exploring issues related to game play and presence
Results Phase II	In this phase the initial concept for the TimeWarp game developed in Phase I was implemented and evaluated. A cross-media mixed-reality user interface based on state-of-the-art mixed reality technology provided by WP5 was realized. Also, an authoring to shape the TimeWarp application was realized using and extending tools provided by WP4. In a couple of test runs data were gathered to check precence concepts developed within WP3. We have used video observations and interviews, and adapted MEC.
Evaluation Results Phase II	• Developed an early questionnaire for assessing sense of place and presence in mobile MR games. • Completed a study of the TimeWarp systems, resulting in some guidelines how to shape city MR games. • TimeWarp study also pointed to the need to consider the nature and types of locations chosen and the effect this will have on place and presence.
Objectives Phase III	During phase III we will: ▪ redesign TimeWarp according to the findings of Phase II ▪ conduct tests exploring issues related to game play and presence

2 State-of-the-Art

A pioneering work in mobile AR gaming and social computer game research is ARQuake [10] and Pirates! [2]. In *ARQuake,* which is an AR version of the famous ego-shooter Quake, the player runs around in the physical world and shoot virtual monsters and collect items. Therefor, the player is equipped with a differential GPS receiver and a camera for marker-based computer vision tracking for positioning and a digital compass for orientation.

A successor of *ARQuake* for multiplayer mode is *Game–City* [5]. The players are equipped with a wearable computer as well. The aim of the game is to find and pick up real objects to interact with the game space physically. The reality may be augmented with virtual objects.

Pirates! is a multi-player game on PDA. Since it is played indoor, the positionig can't be determined by an absolute positioning system such as GPS, but uses a relative positioning system like a radio frequency (RF) based sensor. The PDAs are connected to a WiFi network. In the game, the events are triggered by the position of the players.

A handheld based outdoor game is *REXplorer* [13]. In *REXplorer,* the player explores the city by unleash and interact with virtual magical spirits and treasures, which are locked in two landmark buildings. The interaction is realized by specific movements and gestures, which are recognized by the camera of a mobile phone. The position is detected using a GPS reciever. Augmentations are only provided in acoustical form

Interaction techniques for temporal augmentations allowing to browse through several time periods are explained in Güven et al. [8]. As AR system a backpacked PC with a wireless trackball as interaction device is used. The virtual 3D objects in the worls are distinguished between location-independent and location-dependent representations. Clicking on an object, a related image or 3D model is displayed. To choose the age of each model or image, two different timelines exists, one timeline for the location-independent and one for the location-dependent augmentation. The latter one uses markerless computer vision tracking for a correct registration with the real world.

The effectiveness of location-based services in urban environments is examined in the LOCUS project [9]. Especially the usage of MR interfaces for navigation and way-finding compared with the current map- and text-based approaches are investigated. Since the real world is augemented with text and arrows, the tracking needn't to be so accurate. The position is determined with marker-based computer vision tracking or alternativley GPS.

The usage of Mixed Reality and mobile technologies in urban environments from the presence point of view is explored in the *CitiTag* game [12]. The question how the players deal with the public and how the public reacts on the players is a main issue within this game project. It showed that the players didn't feel embarrassed to play the game in public space. They even tried to use it to their advantage. The passerbies were partly curious about what is going on as they were watching many people running around with technical devices.

Regarding the technique, the players were frustrated due to the bad GPS signal and the loss of WiFi. Because of the resulting inaccurate registration, the game did not correspond to the immediate environment. Furthermore a correlation between enjoyment and usefulness of sound was found out.

Another game where the usefulness of sound was shown is *Riot!1831* [11]. This outdoor game was played with 700 people. Using audio augmentation, a historical story came alive. The disadvantage was that only audio information was available. The players began to shut their eyes to get immersed.

3 Overview and Concept Map

In addition to the definitions and types of presence in urban environments it is also important to review the elements of presence which are relevant to the design of mixed reality city games. Although there is much debate on what constitutes presence a cursory examination of the literature would suggest it is related to aspects such as: engagement, immersion and affordances. Engagement is when someone is focused on a particular activity within an environment. Immersion is the feeling of being completely inside an experience and affordances, where the environment affords certain actions. It is important to note however that immersion is not presence, for example it is entirely possible to be immersed in a virtual environment and not be feel physically present in the experience. Likewise in mixed reality it is perhaps true that people are always immersed in the chosen location, but are not present in the overall mixed reality experience. Affordances are related to what the user can carry out in the environment, for example picking up objects and interacting with them, it is also related to more classic HCI issues such as the naturalness of the interactions. Providing the users with a sense of immersion in the TimeWarp challenges is one of the key requirements. Laura Ermi and Frans Mäyrä [7] give the following overview on player immersion within games which provides a set of issues which, when combined with higher level presence issues should be considered when developing the TimeWarp application.

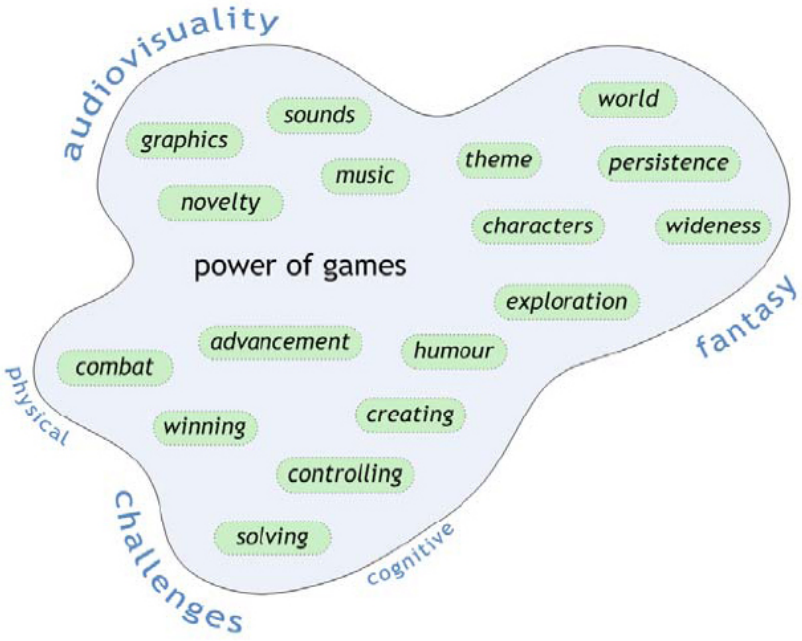
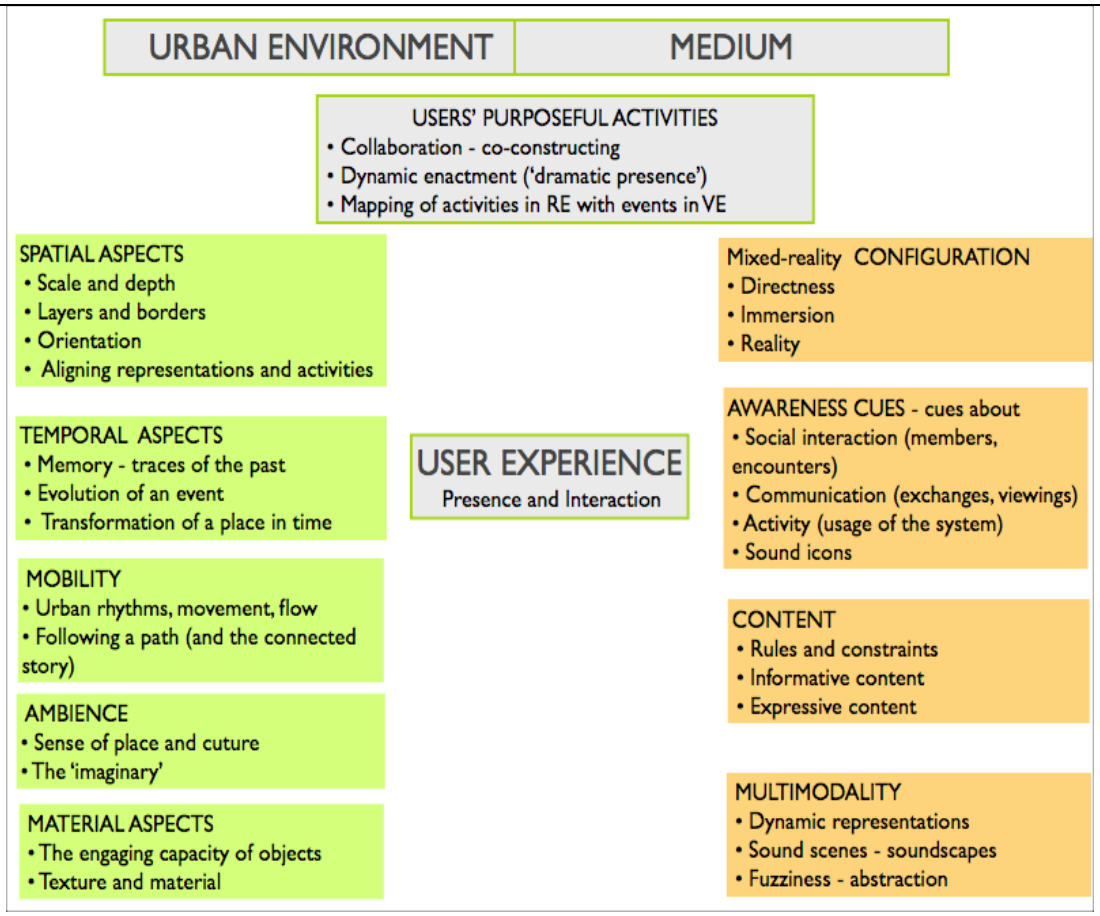


Figure 1 Player Immersion from "Fundamental Components of the Gameplay Experience: Analysing Immersion

3.1 Relationship to IPCity's Conceptual Map

The intention is to evaluate TimeWarp from a range of perspectives as outlined in the presence concept map in WP3. The underlying interest is to explore how the mixed-reality aspects of TimeWarp influence user perception and behaviour within the environment – an initial set of research questions for the first prototype are outlined and answered below.

WP3 Presence Concept Map	Based on the concept map outlined in WP3 TimeWarp focuses on the following presence research:



In addition to this issues, TimeWarp will analyse following topics based on the game play experience (ref):

Fantasy (~ Urban Environment): theme, characters, exploration

Challenges (~ Activities): controlling, solving, winning

Audio-visual (~ Medium): graphics, sound, music (= multi-modal content)

Urban Environment:

Spatial Aspects:

- Which elements of the real city do the players make use of? For example routes, buildings or other real elements which they interact with during the game.
  As players are free to explore the city on their own and TimeWarp doesn't have a pre-defined route, players do not take a common root. It is obvious, that players expose different behaviors when running towards a challenge location and being at a challenge location. In the first case, they act very determined, whereas in the second case their behavior is altered by the technology (insufficient stable tracking). Furthermore, real elements are not integrated into the game play.

Temporal Aspects:

- Does a player feel present in a certain time period during the game play?
  No, due to lack of content.

Social Aspects:

- Do the users interact with other users or other people while playing the game?
  No, because the sun visor of the HMD hides the player; he feels incognito.

Theme: Do the users find the main themes in Timewarp relevant?
Yes

Characters: How do the users interact with the characters? Do the users feel interacting with

	the characters enhanced their sense of place and presence? *The players reported that they didn't feel that the characters responded to them. We addressed this with pre-recorded voice, so that the Heinzelmännchen explain the task.* **Exploration:** Does the use of the main Timewarp elements (e.g. characters and challenges) encourge the user to explore more or different areas of the city*?* *A better understanding of how user will explore a city will be part of the next evaluation cycle.*
Medium:	TimeWarp makes use of almost all aspects of the **Medium** to generate a unique user's experience. *Sound has been a major aid in using the mobile AR system.* The design of TimeWarp supports all three **MR Configuration** dimension: • Does the chosen hardware enhance the users sense of immersion and/or presence? *There was more attention and focus on the virtual game elements, however sense of presence was more connected to the real than virtual space. There was however little feeling of traveling in time.* • Does the location-aware technology used in Timewarp enhance the users feeling of immersion and presence? *The problems with location aware tracking detracted from the overall experience and hence sense of presence.* TimeWarp presents multimodal **content**, implementing spatial audio in the second prototype. *The participants who used the last version of the system in the trials noted the following points:* • *The sparse content reduced the feeling of traveling between time periods.* • *Their attention and related feeling were more drawn to the virtual elements* • *They felt stimulated by the experience and part of he action* • *Opinions were divided to the ability to interact with real and virtual objects* • *The players did not feel as if the virtual characters were real and hence did not feel present with them* Different **awareness cues** (geo-localized icons and sensory information) are used to inform the player about the game world, game status but also about urban aspects (see above). • Do the audio cues speed up finding the challenge location? *Audio cues was used to provide information on type of location (i.e. time portal, market or challenge) or bind to activation/deactivation of interaction tools (i.e. viewpointer). Players said that the sound icons were helpful, but that they didn't like all, e.g. the sheep baa to mark a market.* The **UI** variations (speech, game pad, head up menu, 3D tools) have an effect on the experience on presence because they allow for different forms of user control. • Which user interface is less disturbing/interruptive?
Activities:	The performance and co-construction aspects of Timewarp will be evaluated using the theories of immersion in games

3.2 Evaluation plan

The evaluation plan will use a variety of qualitative and quantitative techniques ranging from questionnaires through to interviews and video analysis. The intention is to select specific techniques which will allow us to identify trends that exist within the variety of data sources. For example video observation of certain user behaviours may indicate they experienced

problems with the technology and corroborating evidence from the log files may also point to this. Moreover, results from the interviews may also indicate that this problem resulted in them feeling less immersed within the experience. Therefore, where possible this particular problem should be fixed as quickly as possible, certainly when compared to other problems which perhaps had no effect on the users sense of immersion or presence.

Evaluation Preparatory Work:	**Selecting participants – diverse groups,** a group of 24 people took part in the studies. These ranged from other research scientists and students through to city tour guides. **Evaluate game scenario (including content) with test users** Before we can fix the detailed schedule of field tests (duration, number of used systems), we have to evaluate the game scenario with test. **Define observation techniques and criteria**.
Evaluation Methods:	**Video observation** During the game play, we will video tape some of the players, mainly at the challenge sites where interaction takes place. We may also take notes while observing the users. **Direct Observation.** Where possible an additional evaluator took part and noted down any interesting observations. **Presence questionnaire.** Prior to conducting the study we examined a number of techniques, in particular questionnaires from existing presence research. These were adapted to fit our needs. For example the MEC (ref) questionnaire had sections pertaining to assessing where people felt in the mixed reality experience as well as social presence issues drawn from the work by Bailenson et. al [1]. To this we also added elements of the place probe to catch more qualitative descriptions. **Semi-structured interviews** Based on the data obtained from the questionnaires direct and video observation we will conduct semi-structured interviews with selected participants.

4 Year 2 Demonstrators

4.1 Overview

TimeWarp is an outdoor edutainment game that allows for exploring the history of a city using AR and mobile devices. The background is a tale of small elves called H*einzelmännchen* which helped the citizens of Cologne during the night, although they were never actually seen. Then suddenly they disappeared when one evening a tailor's wife tried to have a peep on them. *TimeWarp* extends this legend by spreading the rumour that the elves never left Cologne but fell into time holes and are still in the city, but trapped in different time periods. The goal of the game is to find the elves in the city and within specific time periods by the means of time travel; having done so the players have to rescue them by solving small challenges. Therefore, each player is equipped with a "magical technical" system, which enables him to see the elves and to travel to different epochs – roman, medieval, new age and even to the future. The player's system is composed of two mobile systems: a mobile AR system (see 4.3) that augments the real environment with graphics and sound, and a handheld information terminal (see 4.4) that provides an overview on the game area and status.

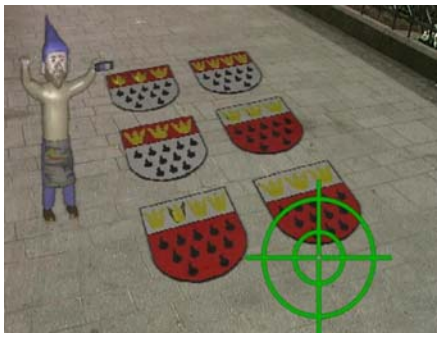


Figure 2 shows an example from the perspective of the player. In this case, the player have to rescue the small elve selecting the right coat of arms of Cologne.

TimeWarp is implemented as a distributed system (see Figure 3): the game server retains game resources the players compete for, whereas the player system is a thick client. In single player mode, it is also possible to play *TimeWarp* without connection to the server (as for Year 2 demonstrators). Synchronization of game status is only necessary if game play changes available resources like tools or solved challenges, which might only be the case at game-relevant locations (see 4.2), whereas a permanent connection to a server cannot be guaranteed. Therefore, this software architecture is most appropriate. Furthermore the mixed reality experience will be extended to a web application that provides travel journals for the players.

In Year 2 of the IPCity project, the thick client (i.e. *Local Control Logic*) and the two front-ends were implemented and evaluated. Figure 3 shows three different views on *TimeWarp*: the development architecture depicts the major software components, the physical architecture depicts the distribution of these software components on hardware (without the not yet implemented components), and the logical architecture depicts the functionality of these components, whereas the functionality of beige components is provided by work packages 4 and/or 5.

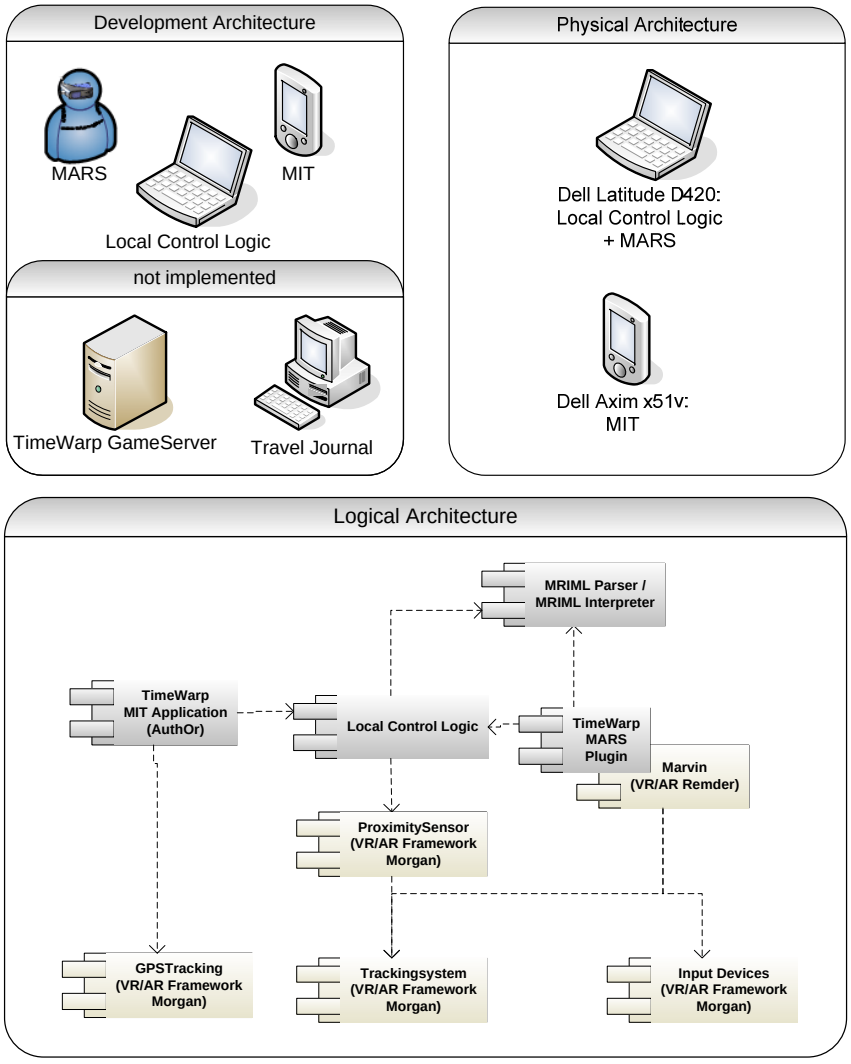


Figure 3 Architectural Views of TimeWarp: The development Architecture, the physical architecture and the logical architecture.

4.2 Local Game Control

4.2.1 Description

The Local Game Control component controls the game flow depending of the user input (user interaction is explained in detail in 4.3.1) providing an appropriate interface.

As *TimeWarp* is location based, the first core interaction control is realized through proximity in real world. The maps (see Figure 6 to Figure 11) show the game area (rose colored) and the spatial and temporal distribution of the *TimeWarp* game locations (colored spots) over city and time levels. In *TimeWarp* following location types are distinguished: Challenge locations, markets and time portals (see Table 1 for a detailed description). The player can travel to Roman, Medieval, Modern and Future time, the time level Training is introduced for the special purpose to make the player familiar with the system and the different interaction controls.

No	Name	Color Code	Description

0	Support Station		At the support station players are introduced into the game story and equipped with hardware.
1	Challenge Locations		Locations where players can rescue a Heinzelmännchen.
2	Markets		Locations where players can buy tools.
3	Time Portals		Locations where players can change time levels.

Table 1 Overview of game location types

The Local Game Control component is a `Proximity Sensor Subscriber` to subscribe to proximity events. In the Year 2 demonstrator, the authoring of the game flow is based on the Mixed Reality Interface Modelling Language (MRIML) [1]) It is possible to specify the position of a game location, type dependent variables (e.g. the price of a tool) and the reaction on user input (e.g. proximity or selection of a certain virtual item). Figure 5 shows an example. Each time level had two or three challenges (see Table 2), two markets (with two or three tools each (and a total of 8 different tools), see Table 3;), and four time portals (see Figure 4; each arrow denotes from where to where a player can travel).

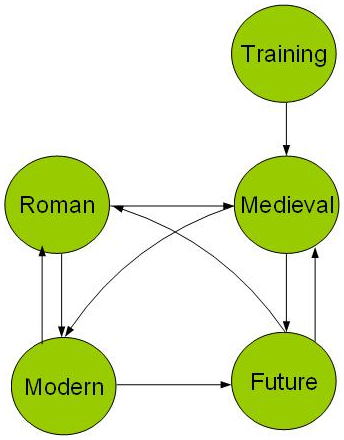


Figure 4 Overview of the Time Portals

```
<Frame id="marketplace1">
        <position>101 0.0 410</position>
        <orientation>0.0 0.0 1.0 0.0</orientation>
        <bindingType>worldRelated</bindingType>
        <Variable>
                <name>locationType<name>
                <value>MARKET<value>
        </Variable>
        <Frame id="marketplace1-medieval">
                <position>0 0 0</position>
                <orientation>0.0 0.0 1.0 0.0</orientation>
                <bindingType>elementRelated</bindingType>

                <Variable>
                        <name>timeLevel<name>
                        <value>MEDIEVAL<value>
                </Variable>
                <Frame id="Media3D">
                        <position>0 0 0</position>
                        <orientation>0.0 0.0 1.0 0.0</orientation>
                        <bindingType>elementRelated</bindingType>
                        <boundTo>marketplace1</boundTo>
                        <Media>
                                <description>"3D media"<description>
                                <source>"marketplace1.x3dv"</source>
                        </Media>
                </Frame>
                <Frame id="AudioMedia">
                        [...]
                        <Media>
                                <description>"audio media"<description>
                                <source>"marketplace.wav"</source>
                        </Media>
                </Frame>
                [...]
                <ProximityListener id="proximity15">
                        <Action>
                                <Call><method>viewpointerSelectEnable</method></Call>
                                <Call><method>mouseButtonEnable</method></Call>
                                <Call>
                                        <method>playSound</method>
                                        <param>interactionEnabled.wav</param>
                                        <param>2</param>
                                </Call>
                        </Action>
                </ProximityListener>
        </Frame>
</Frame>
```

Figure 5 MRIML example

Name	TimeLevel	Description
JewelBox	Training	Scenario to train selection interaction
Column	Training	Scenario to train selection interaction
Plane	Training	Scenario to train placing interaction
Shape Puzzle	Training	Scenario to train placing interaction
Roman Street	Roman	Scenario where the player has to use a tool
Roman Sports Arena	Roman	Scenario where the player has to answer a question
Roman Name of Collogne	Roman	Scenario where the player has to answer a question

“Stapelrecht”	Medieval	Scenario where the player has to answer a question
Coat of Arms	Medieval	Scenario where the player has to answer a question
Number of “Gaffel”	Medieval	Scenario where the player has to answer a question
Gardener at River Rhine	Modern	Scenario where the player has to use a tool
Number of Bridges	Modern	Scenario where the player has to answer a question
Space Station	Future	Scenario where the player has to place an object
Cathedral Workshop	Future	Scenario where the player has to answer a question

Table 2 Overview and description of the different challenges

TimeLevel	Available Tools
Roman	romanjewel crystal
Roman	cameo magicdust steak
Medieval	cameo magicdust crystal
Medieval	cameo magicdust crystal
Modern	romanjewel herbicide steak
Modern	beamer beamer crystal
Future	romanjewel herbicide beamer

Table 3 Overview of the existing arkets

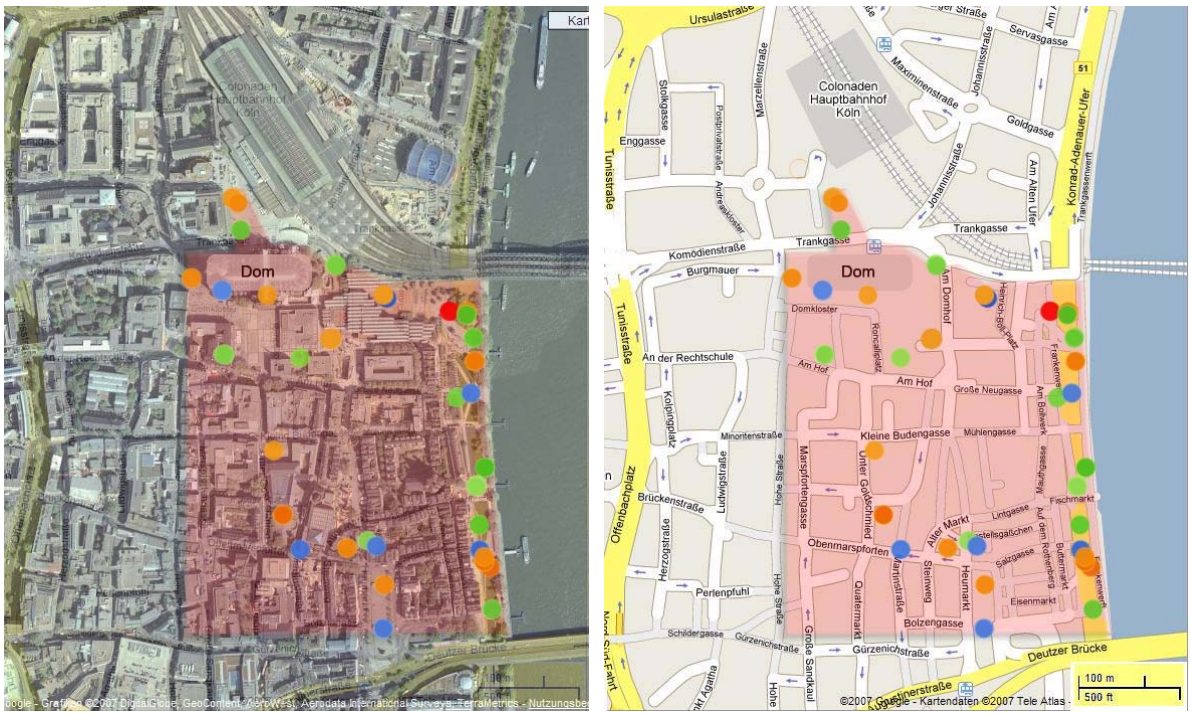


Figure 6 All relevant game locations in TimeWarp (left: satellite view , right: map view)

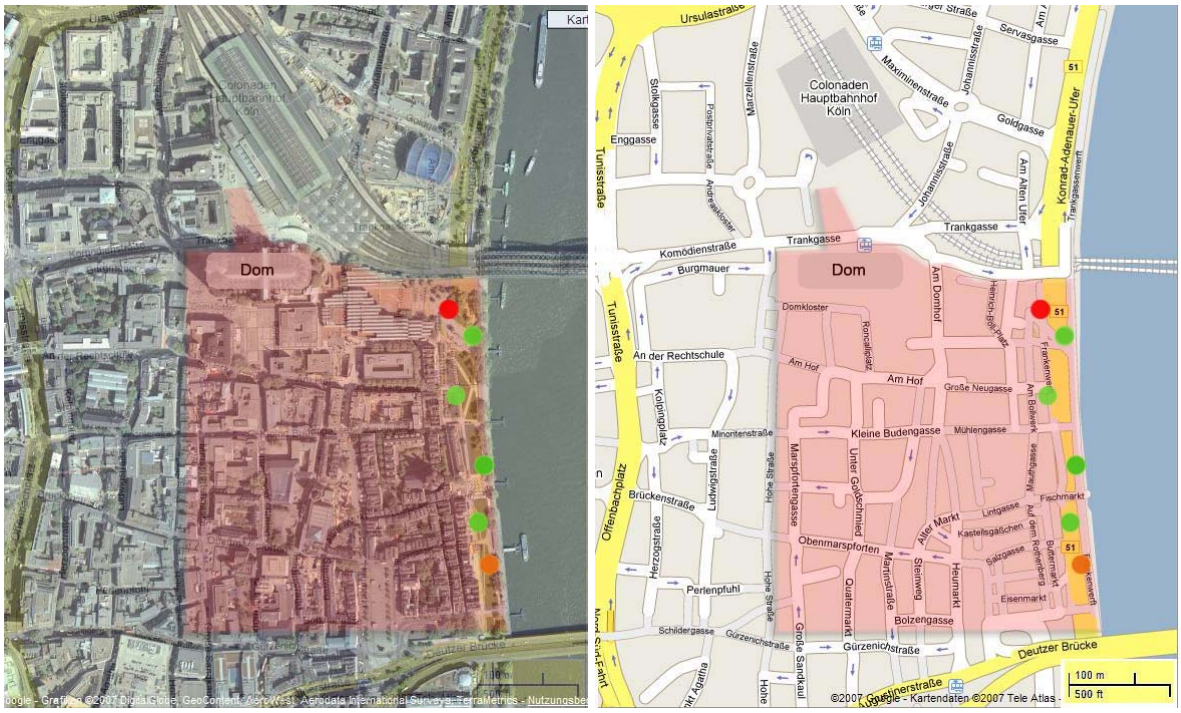


Figure 7 Game locations of the level “TrainingsCamp” (left: satellite view , right: map view)

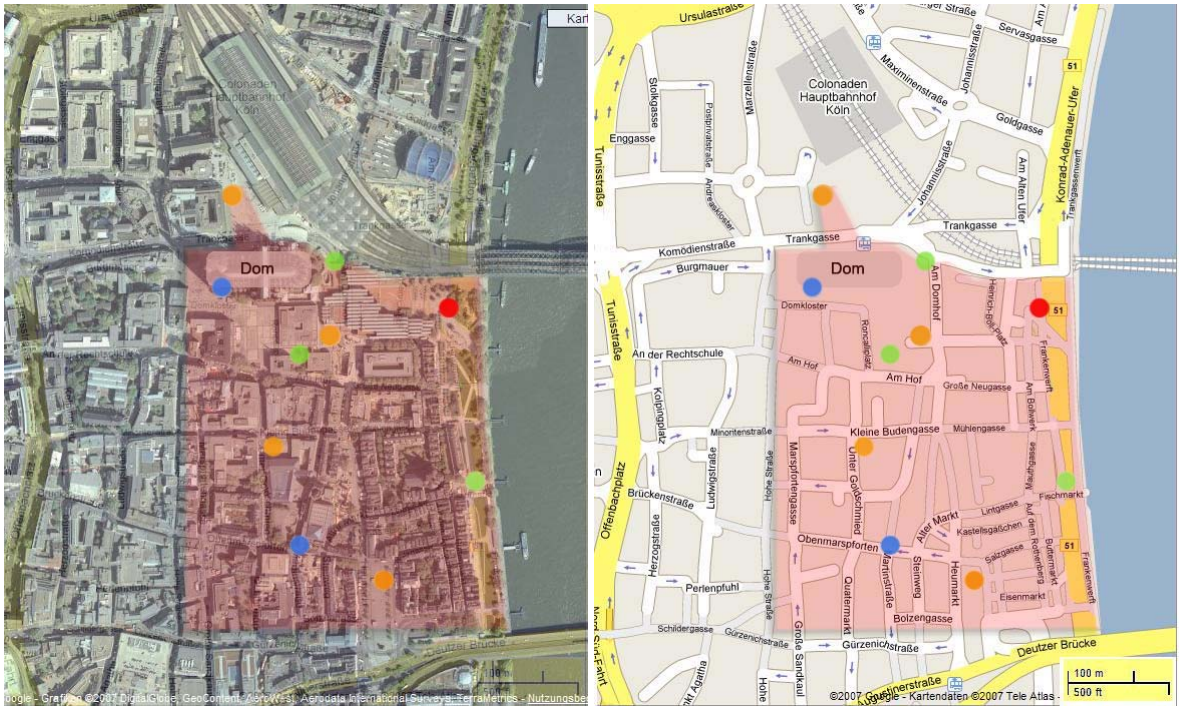


Figure 8 Game locations of the level “Roman” (left: satellite view , right: map view)

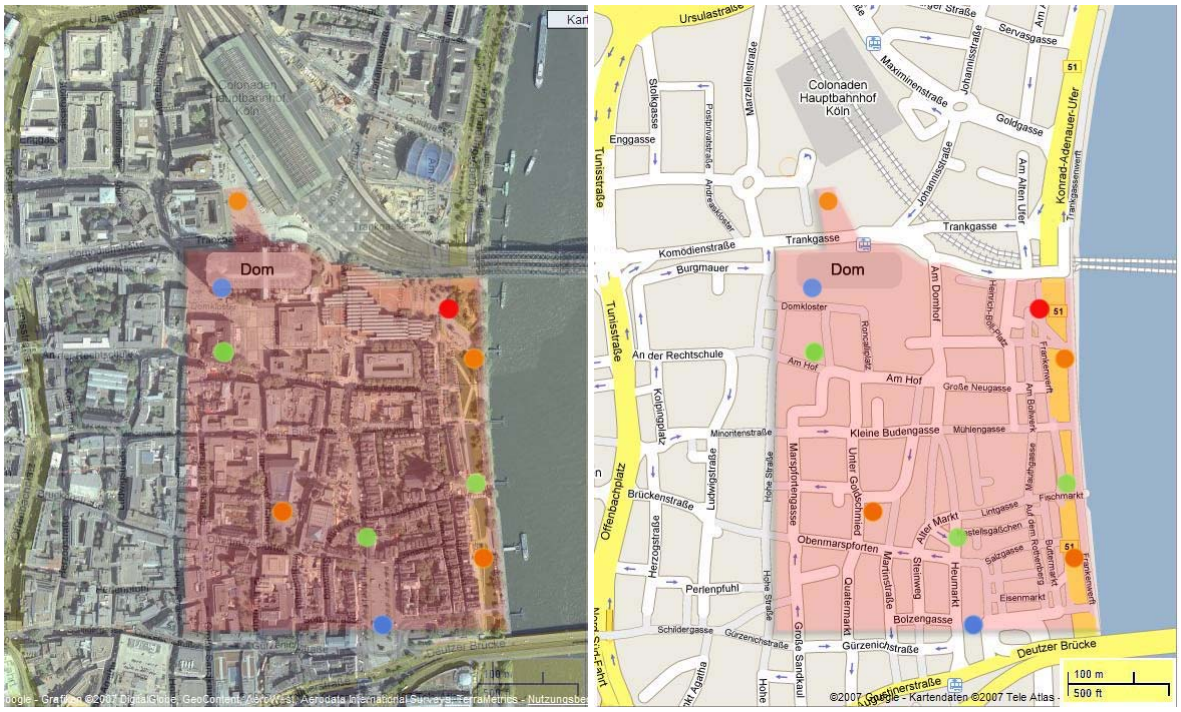


Figure 9 Game locations of the level “Medieval” (left: satellite view , right: map view)

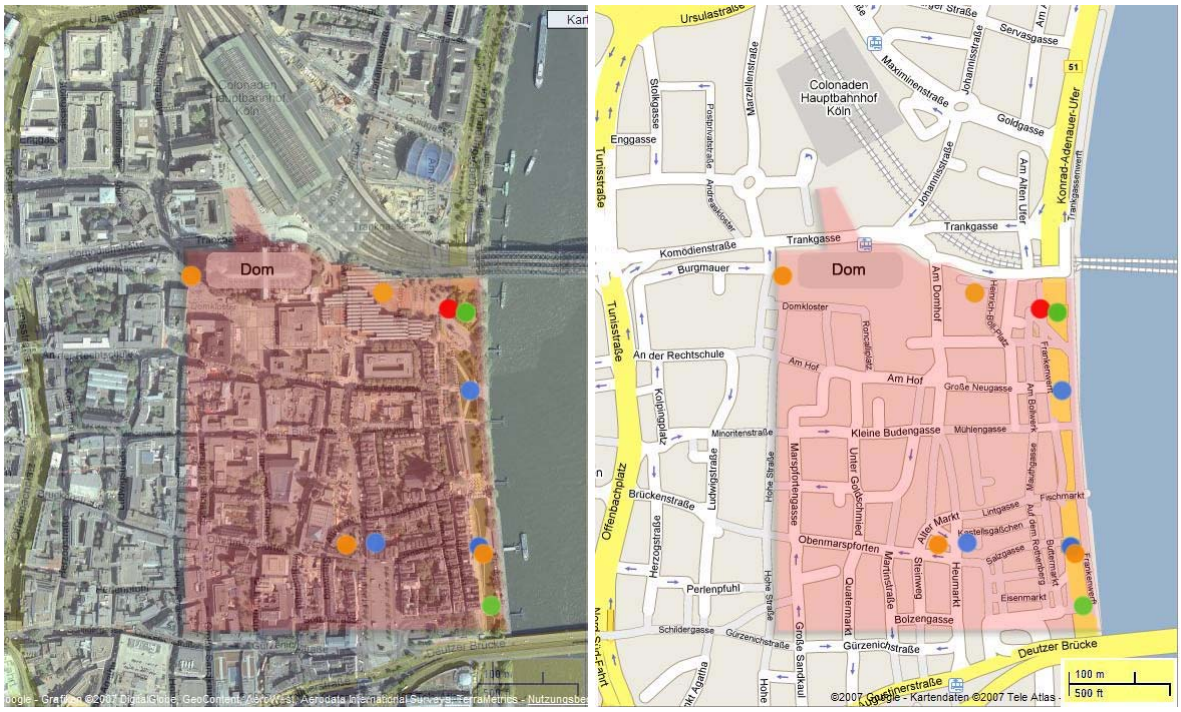


Figure 10 Game locations of the level “Modern” (left: satellite view , right: map view)

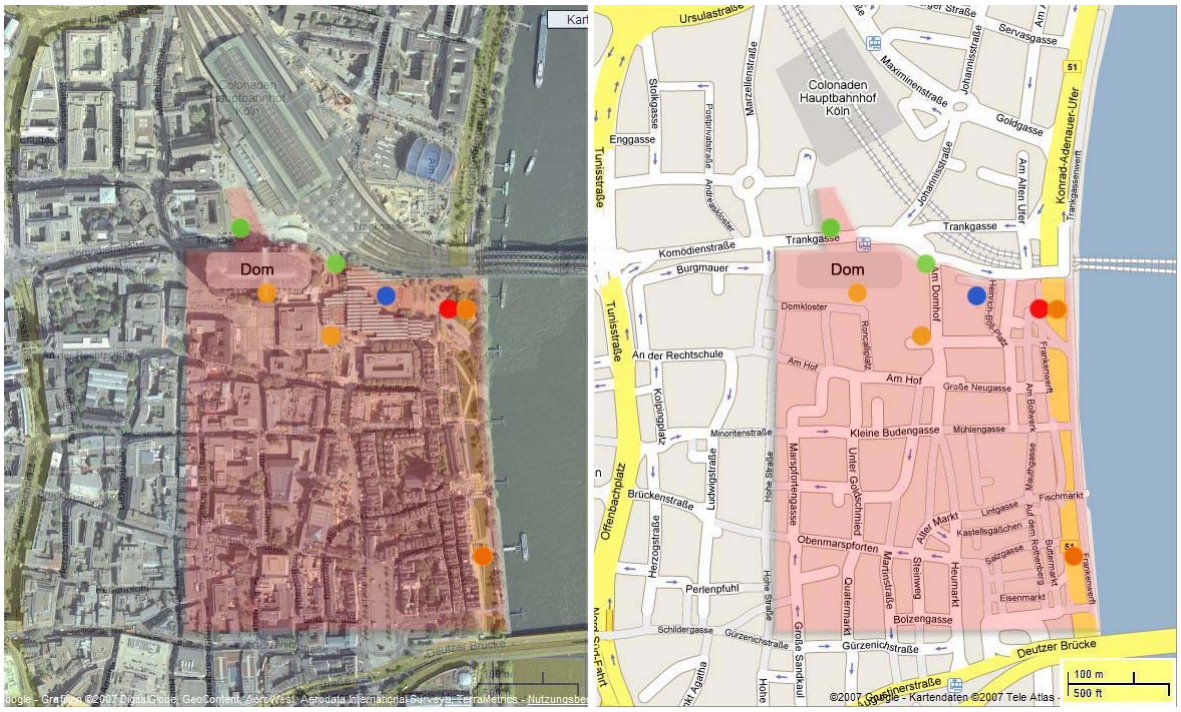


Figure 11 Game locations of the level "Future" (left: satellite view , right: map view)

4.2.2 Specification

Hardware and OS	• DELL Latitude D420 (shared use with MARS) • Trackingsystem, (any devices that realize a 6DOF tracker to control player's position and orientation, e.g. `SpaceMouseTracker6DOFAdapter` or `Tracker3DOFCombiner`) • Windows XP
Software	• VR/AR Framework Morgan • TimeWarp LocalGameControl Component • MRIML Interpreter
Core Features	• VR/AR Framework Morgan: starting and connecting devices for user tracking and proximity sensor • Single Player Game Logic • Text-based authoring of game flow
Status	beta prototype
Intended users	People who wants to author the game
Research Workpackages	WP4 & WP5: using provided infrastructures and tools
Relevance beyond project	

4.2.3 Testing / Evaluation

“Difficulty reading due to GPS jitter.. I know GPS has trouble with buildings so I tried to stay away from buildings.” (TT, Male)

“I think the problem was that the virtual objects did not fit into reality… it was flying about. “(JC, Female)

While GPS provides approximate information on user position, usually within a few metres, this is not suitable in situations where users must interact with objects or see things at a particular location. One main problem involved objects floating round spaces and users chasing them, then becoming frustrated. Tracking problems also resulted in people altering their game playing behaviour, either as interaction was difficult or they knew that they would experience problems at certain locations. The GPS tracking issues combined with the graphical realism of the objects also caused problems for the users, in particular they were very aware that such objects were not real.

Although the level of content and functionality varied across the various iterations of the system, many users reported paying more attention and focussing more on experiences in the virtual dimension – although on further examination their attention was often focussed on dealing with technological aspects rather than the game. However conversely they felt more present in the real environment than in the game, this may be reflective of the feeling that there was not much game content and hence they were going from point-to-point rather than constantly being within a mixed reality environment. The behaviour observed from videos also pointed to people feeling more engaged with the virtual than real elements, typically they would walk towards and object then if it moved chase it until either the position stablised and they were able to interact with it. Other behaviours included people walking towards then away from virtual objects, often repeating the motion several times. This behaviour may have been symptomatic of general problems with the system – an issue highlighted by some responses to how people felt towards errors. For example some noted they felt they concentrated on the errors and problems required further exploration.

“I did not notice any difference in time periods….. there are very few virtual objects.” (JH, Male)

Feeling towards temporal presence were mixed, although those taking part in the last version of the system used in the trials (and also the most developed) did not note any substantial differences in temporal presence. There appeared to be little in the way of feeling present with other users (social presence). This is in part due to the game not including support for between player communication. With respect to in-game characters the users felt they were not real and subsequently did not feel present with them. The lack of temporal and spatial presence experienced during the game was also noted to have been caused by the lack of content.

The future was noted as the users most favourite time period or indeed location. This may have been due to the slightly odd nature of the objects. With respect to places, both real and virtual there was little interaction with users in aspects of many of the real locations. For example they would not pick up real objects or interact with passers-by – this may explain the seeming lack of feeling towards and places. Both actions, and sense of others (and their behaviours, type etc) are strong factors in sense of place.

“I felt like an Alien… Sometimes you were involved in the game so much you did not notice them….” (LC, Female)

“A great help would be to have more audio guidance… a great help would be some audio feedback from the Heinzelmenchen.” (TT, Male)

“You feel kind of special” (CX, Male)

User also commented on the need to add sound queues to aid in navigation and interaction, and the strange behaviour from non-game participants e.g. staring or asking questions (Figure 12). There were also issues with becoming so focussed on game elements that they were unaware of safety issues, for example cars or trees (Figure 13).

(In connection to interacting with aspects of the real environment) “Well people talked to me, and if there was a tree” (JH, Male)

Figure 12 People pointing at player ()left, people looking at (turning around for) player (right)

Figure 13 The player has to pay attention because of the traffic.

4.3 Mobile AR system

4.3.1 Description

The Mobile AR System augments the real world with graphics and sounds incorporating a head-mounted display and open headphones. The user interface design takes the limitations of being in public, uncontrolled and unrestricted space into account. Furthermore user interface should contribute to the game experience and the player should explore the city in space and time.

As described above, the first core interaction control is physical proximity. *TimeWarp* has three proximity ranges: outside, near, and at a game location. For most of the game area there is no augmentation (neither visual nor spatial audio), and thus the GPS signal is sufficient to track the player’s path, display his current position on the PDA, and play ambient sound. Entering the range of a game location, precise tracking is required to register graphical and audio augmentation. As the field of view of the HMD is rather limited, a sound

icon informs the player that they are near a game location. To avoid unintentional use of the AR interaction device, input is only enabled while the player is at a game location. A specific sound icon informs the player about the activation and deactivation. Additionally, particular actions may be executed immediately.

The interaction with time portals is an example for this type of control: as the player approaches the game location of a time portal, he hears a mysterious sound of wind chimes. If he gets closer to the portal and finally enters it, traveling in time is carried out automatically and immediately. A roll of thunder accompanies this interaction and a view related label denotes the changed time period.

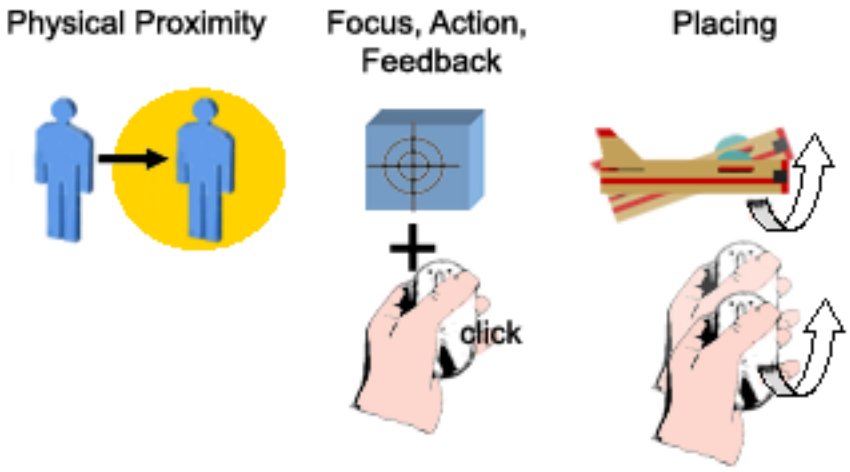


Figure 14 Illustration of the three realized interaction controls

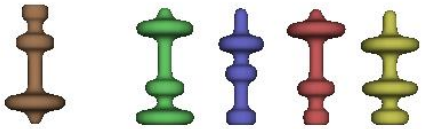
The second core interaction control is based on focus and click events. Focus either is controlled with a gaze-based view pointer, a view related crosshair, or by stepping through selectable items in predefined order using the mouse wheel. The view pointer is controlled by the viewing position and orientation, thus the view pointer makes advantage of the user tracking which is anyway required for registration. If a game item is in focus, in this first version of the game, its bounding box is drawn around it.

- Actions and feedback associated with a click can be manifold, for example:
- Items appear on the PDA interface (e.g. the player buys an item)
- Items disappear in the MR augmentation (e.g. he player buys an item)
- Sound icons may be associated with a click (e.g. dropping coins)
- Response from the virtual characters (e.g. speech and animation)
- View related labels

The third was inspired by the Wii remote controller to place an virtual item in 3D space to realize the interaction at the game locations. Movements with a gyroscopic mouse in mid air control the orientation of an item, whereas translation speed is controlled by the mouse wheel. The interface designer specifies a target sphere the item has to hit to finish the interaction task. Actions and feedback associated with a click can be manifold as well (see above), depending on the individual needs of the designed challenge.

Figure 14 illustrates these realized user controls.

The graphics (see Table 4) are especially modelled for the game, whereas the sounds are from free web database such as www.stonewashed.net or http://www.partnersinrhyme.com.

Name	TimeLevel	Graphics
JewelBox	Training	
Column	Training	
Plane	Training	 
Shape Puzzle	Training	 
Roman Street	Roman	
Roman Sports Arena	Roman	
Roman Name of Collogne	Roman	
“Stapelrecht”	Medieval	

Coat of Arms	Medieval	
Number of “Gaffel”	Medieval	
Gardener at River Rhine	Modern	
Number of Bridges	Modern	
Space Station	Future	
Cathedral Workshop	Future	

Table 4 Overview of the graphical representation of the challenges

Figure 15 TimeWarp Tools: Crystal, Herbicide, Magic Dust, Roman Cameo, Spade, Beamer, Rain pipe, Steak (from left to right)

The Mobile AR System is realized as a Marvin plug-in. The software component is a `Mouse-Subscriber` to be notified about mouse events and a `LocalControlLogicSubscriber` to be notified about game events. The plug-in implements a `Viewpointer` that realizes viewpointer selection, and incorporates a `Sound` component to control the playback of sounds.

An MRIML interpreter maps pre-defined user controls (e.g. viewpointerEnable / viewpointer-Disable, playSound / stopSound) to method provided by the plug-in.

4.3.2 Specification

Hardware and OS	• DELL Latitude D420 (shared use with Local Control Logic) • Shimadzu DataGlass2 • MR vest • Bluetooth mouse • Windows XP
Software	• VR/AR Framework Morgan • VR/AR Renderer Marvin • MRIML Interpreter • TimeWarp Marvin Plugin
Core Features	• VR/AR Framework Morgan: starting and connecting interaction devices • VR/AR renderer Marvin: Rendering of graphic and sound • Realizing user control • Text-based description of user interface
Status	beta prototype
Intended users	People who wants to play the game using the AR interface
Research Workpackages	WP4 & WP5: using provided infrastructures and tools
Relevance beyond project	

Regarding the concept we came up during Phase I, we realized all of it and even implemented new features

- Processing units
  - ✓ Laptop (Dell Latitude D420, 1.2 GHz, ~1,3kg)
  - ✓ UMPC (Sony Vaio VGN-UX180P, 1.2GHz, 4.5 ’’, ~0,5kg)
- HMDs (Resolution 800x600. monocular)
  - ✓ Liteye LE-750
  - ✓ Shimadzu DataGlass2
  - ✓ NEW: with sun-visor
- Attached with several sensors and trackers
  - ✓ Intersens InertiaCube3
  - ✓ Holux GPS Tracker
- TimeWarp runs under WindowsXP
  - ✓ Morgan Framework
  - ✓ DEVAL
  - ✓ Marvin
  - ✓ Cald3D XSG
  - ✓ NEW: MRIML
  - ✓ NEW: Spatial Sound
- NEW: Vest

4.3.3 Testing / Evaluation

One of the main problems with the system related to the weather conditions, in particular high levels of sunshine. On very bright days during the trail the mixed reality elements were often invisible of difficult for users to see without the aid a sun block. A number of different sun block techniques were tried, however the final one was quite bulky (Figure 16) and resulted in strange responses from members of the public. Where people did not use a sun block they often reverted to using their hands to block out the sun (Figure 17). The problems caused by the sun and the need to frequently adjust the position of the visor appeared to distract the users on a number of occasions and had a negative impact on the experience. Despite its appearance there were no noted problems with the MR vest (Figure 168).

Figure 16 Final sun-block visor

Figure 17 Covering display with hands

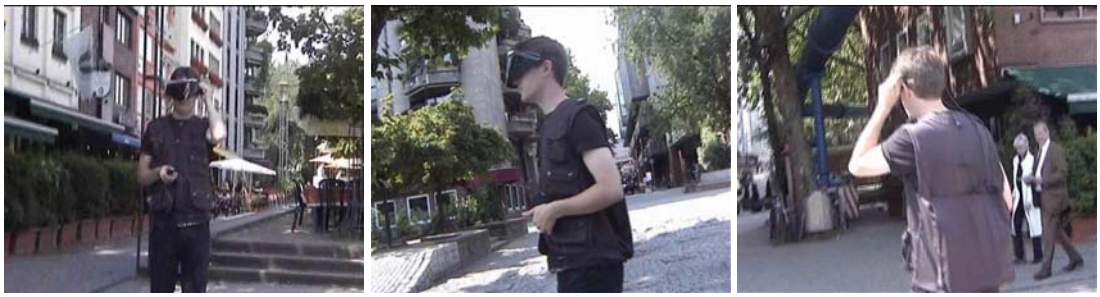


Figure 18 MR Vest

“It was not clear what to do when I arrived at these places, I don’t know do I click the mouse or interact with the PDA?” (TT)

Another challenged faced within the game was the number of devices which participants must use. In addition to the visor users also carry a PDA and mouse (to allow interaction with 3D elements) (Figure 19). This resulted in users often switching between devices, or carrying and potentially dropping all the devices.

Figure 19 Holding PDA and mouse

Interaction with virtual game elements was problematic, especially during earlier versions of the system. This was in part due to the confusing interaction techniques used and the lack of any former of user familiarisation with the technologies. In later versions users were given a brief training scenario and the interaction techniques were simplified. This resulted in a more positive experience for most users, however some problems remain.

4.4 Mobile Information Terminal

4.4.1 Description

The Mobile Information Terminal (Figure 20) is a PDA-based system for additional information and orientation. It supports the player during the game providing helpful hints.

The system is running on a Dell Axim x51v with Windows Mobile 2005. The device is connected via bluetooth to the mobile AR system.

The application consists of four page tabs. The first tab is an overall information page. It contains the game state: the currently owned tools, the amount of the current budget and the time left for the game. On the second page, the position of the player is displayed on an interactive map. The map is either in satellite or in map mode (similar to services such as Google maps) and supports zoom in and zoom out. Besides the player's position important game related locations like markets and timeportals are shown on the map. On the third tab, specific game related information such as historical knowledge of the city is provided. On HTML-based pages, important hints help the player to solve the challenges. According to each timeperiod, the historical background information for each challenge is explained with text and pictures of persons and places. Thus the player gets an idea, where to search for the Heinzelmännchen and how to solve the challenge. Furthermore an overview of all challenges is given, so the player knows how many challenges exist and how he is able to solve them – answering a question, applying a tool and which tools are helpful. On the fourth tab technical help is provided. The player gets an instruction of the several interaction techniques (viewpoint mechanism, steering and movement control). Furthermore markets and timeportals are explained. The player learns the different icons and gets an overview of the available tools. Finally, the different sound and their meanings are shown in a table

Figure 20 The Mobile Information Terminal. The overall information page (left) and the map in satellite mode (right).

Regarding the concept we came up during Phase I, we realized most of it and implemented additional features

	Name	Description
√	Game Status	Tools: current owned tools Money: current amount of money
(√)	Orientation Map (AuthOR)	Zoom function: in and out of a map. Information filters : Player's path, Nearby time portals, Nearby players Navigation function: navigate back to the base station
NEW: √		Help pages on challenges and system use
–	Browser	Access to the Travel Journal web page.

4.4.2 Description of interaction Specification

Hardware and OS	• Dell Axim x51v • Windows Mobile 2005
Software	• AuthOr
Core Features	• Overall information page (game state, owned tools, budget, time) • Interactive map with current position of the player • Historical background information to the city • Technical help page
Status	throw-away prototype
Intended users	The intended users are the players. Currently eight PDAs are available, so theoretically eight players could use the system.
Research Workpackages	WP4 & WP5: using provided infrastructures and tools
Relevance beyond project	

4.4.3 Testing / Evaluation

The PDA was used to present navigation information as well as information about various game locations etc. However users found the navigation system difficult to use, and would use the photographs of the locations to orientate themselves. In earlier versions their position was not presented on the map, in later versions this problem was resolved however many indicated they would prefer the PDA display to more accurate reflect issues such as the current time period etc. The PDA often presented too much information early on, in particular stories of the various locations. As a result users were unsure what was relevant to what they were doing. They were also unsure as to where they could obtain content to let them complete the game challenges.

“I tried to find the places that were shown in the pictures, just the same point of view. Like the take of the photographs. “ (TT, Male)

5 Evaluation Summary

Based on the study it was clear that certain elements of the Time Warp game required improvement or redesign. From a usability standpoint it is clear that a simpler more intuitive interaction scheme is required, for example using only one device, a training scenario and an easier method of interaction may help reduce problems. From a technical viewpoint the single largest problem (and also negative effect on game play) remains the issues with computer vision based tracking.

From a scientific perspective the Time Warp study proved invaluable in identifying areas of mixed reality experiences which are essential to altering the users' sense of place and presence. By this we mean the desire to ascertain exactly where users feel they are present, e.g. in a different place or time period and how game play elements (given it is not possible to augment an entire city) can play a part in this. Key aspects include placing greater emphasis on where the action takes place and understanding and therefore using the real locale more effective and using aspects such as paths through the environment and real people and objects more effectively. Additionally understanding how real and virtual objects impact on the experience, in particular the almost implicit problem of people focussing more on the virtual than real elements, thus to some extent negating the purpose of mixed reality.

As this was the first in depth study of Time Warp it provided an ideal opportunity to develop, adapt and test the evaluation techniques. Based on the experience we now have a better idea of what aspects to improve in future versions. Moreover, the evaluation provided us with a method of identifying common themes and patterns which the users were engaging in and thus question strategies during interviews.

Finally, we came up with some guidelines which to consider the design of MR experiences. They are intended to highlight the importance of considering reality when building MR experiences, in particular how to make use of real spaces, people and objects in order to create a unified game experience. Finally, although they share a number of aspects with the mobile game design patterns by Davidsson et al [6], their approach and focus are different.

(1) Understand Attention Allocation

People are easily drawn to objects which engage them in some way, for example animations or those which appear out of place. Consider the impact on the users attention when introducing objects, in particular when you want attention focused more on virtual elements than real elements, also when to balance the two.

(2) Simplify the Interaction Scheme

Avoid using too many types of interaction devices or behaviours. In common with standard usability practice the interactions should be intuitive, for example, where appropriate be comparable to real world behaviours and should not be overly complex. Some of these issues can be overcome by providing training scenarios, however such scenarios should be an integral part of the game play and not separate.

(3) User Safety

Users often become so involved in the game experience that they fail to take into account roads and traffic. Avoid placing key or primarily virtual experiences near roads or other places likely to result in an accident.

(4) Design appropriate paths through the environment

Paths play a crucial role in shaping our perception of space, they can be used to pass-by and pass through spaces. Select routes through the environment which are interesting and terminate game aspects at interesting locations.

(5) Understand the Locale

Alexander [14] provides a summary of common layouts used within environments e.g. Cafes and their uses. Locations can also play a part in creating game ambience.

(6) Interaction with Others

Where appropriate integrate non-game participants into the game. For example the player could ask a passerby for advice.

(7) Seamful Design

Make use of environmental features within the game to overcome technical problems. As noted by Chalmers [4], certain technologies for example GPS may not work at all given locations, hence when this is not the case use the problems to enhance the game experience.

(8) Use a combination of real and virtual objects

Use real objects within the game experience where they (1) provide a more intuitive form of interaction (2) can play a key part in the game play.

(9) Provide a continuous experience

It is important that game play is constant, for example people should not suddenly have to interact with virtual elements in one space then face a long walk to the next experience. Therefore the game should make regular use of real and virtual objects so as to maintain the user's interest.

6 Dissemination

The main dissemination plans of phase 2 of TimeWarp were focus on scientific publications and a one day presentation for journalists.

6.1 Accepted Publications

- Workshop Paper: The “Where” of Mixed Reality: Some Guidelines for Design. McCall, R., Herbst, I., Braun, A., and Wetzel R. CHI 2008: Urban Mixed Realities- Technologies, Theories and Fonteers
- Poster: Iris Herbst, Sabiha Ghellah, Anne-Kathrin Braun: TimeWarp: An Explorative Outdoor Mixed Reality Game, SIGGRAPH 2007
- Poster: Iris Herbst, Anne-Kathrin Braun, Rod McCall, Wolfgang Broll: Interactive City Exploration through MR, IEEE VR 2008
- Poster: McCall, R. Using evolving histories to enhance place and presence, Pergames 2007
- Journal Paper: Wolfgang Broll, Irma Lindt, Iris Herbst, Jan Ohlenburg, Anne-Kathrin Braun, Richard Wetzel: Towards Next-Gen Mobile AR Games. IEEE Computer Graphics & Applications

6.2 Appearances in public press / television

- http://www.wdr.de/themen/computer/2/virtuelle_realitaet/070928.jhtml (28.09.2007, wdr online)
- http://www.neuepresse.de/newsroom/medien/art663,111314 (Neue Presse online)
- http://www.media.nrw.de/media2/site/index.php?id=73&tx_ttnews%5Btt_news%5D=53719&cHash=7da261f6c4 (21. September 2007, NRW media)
- http://www.wdr5.de/sendungen/leonardo/1008008.phtml (06.11.2007, WDR5)

7 References

[1] Bailenson, J.N., Blascovich, J., Beall, A.C., & Loomis, J.M. Equilibrium revisited: Mutual gaze and personal space in virtual environments. Presence: Teleoperators and Virtual Environments, 10, 583-598, 2001.

[2] Björk, S., Falk, J., et al. Pirates! – Using the Physical World as a Game Board. In Proceedings of Interact 2001, Tokyo, Japan, 2001, 9-13

[3] Broll, W., Lindt, I., Ohlenburg, J., Herbst, I., Wittkämper, M., and Novotny, T.: An Infrastructure for Realizing Custom-Tailored Augmented Reality User Interfaces, IEEE Transactions on Visualization and Computer Graphics, 11 (6), Nov. 2005, 722-733.

[4] Chalmers, M.**:** Seamful Design and Ubicomp Infrastructure. Proceedings of Ubicomp 2003 Workshop at the Crossroads: The Interaction of HCI and Systems Issues in Ubicomp, 2003.

[5] Cheok, A.D., et al., Game-City: a ubiquitous large area multi-interface mixed reality game space for wearable computers, Sixth International Symposium on Wearable Computers.

[6] Davidsson, O., Peitz, J., Björk, S., Game Design Patterns for Mobile Games. Project report to Nokia Research Center, Finland, 2004.

[7] Ermi L., Mäyrä F.: Fundamental Components of the Gameplay Experience:1 Analysing Immersion, DiGRA 2005 Conference: Changing Views – Worlds in Play, 2005

[8] Güven, S., Feiner, S., Interactive Techniques for Exploring Historic Sites through Situated Media. Symposium on 3D User Interfaces 2006, Alexandria, Virginia, USA

[9] Mountain, D., et al., Mixed reality (MR) interfaces for mobile information systems, Aslib Proceedings.

[10] Piekarski, W. and Thomas, B. 2002. ARQuake: the outdoor augmented reality gaming system. Commun. ACM 45, 1 , 36-38, 2002.

[11] Reid, J., Geelhoed, E., Cater, K., Clayton, B., Parallel Worlds: Immersion in location-based experiences. CHI 2005, Portland, Oregon, USA

[12] Vogiazou, Y., et al., Design for emergence: experiments with a mixed reality urban playground game, Personal and Ubiquitous Computing.

[13] Walz, S., Ballagas, R., Borchers, J., Mendoza, J., Kratz, S., Wartmann, C., Fuhr, C., Tann, M., Shin, D., Hameed, B., Bardos, L., Hovestadt, L.,. Cell Spell-Casting: Designing a Locative and Gesture Recognition Multiplayer Smartphone Game for Tourists. PERGAMES, Third International Workshop on Pervasive Gaming Applications at PERVASIVE 2006, Dublin, Ireland, May 2006.

Acknowledgements and Further Information

IPCity is partially funded by the European Commission as part of the sixth framework (FP6-2004-IST-4-27571

For further information regarding the IPCity project please visit the project web site at:

ipcity.eu