The final TimeWarp: Using Form and Content to Support Player Experience and Presence when Designing Location-Aware Mobile Augmented Reality Games

Lisa Blum[1], Richard Wetzel[1], Rod McCall[2], Leif Oppermann[1], Wolfgang Broll[1]

[1]Fraunhofer FIT
Schloss Birlinghoven
53754 Sankt Augustin, Germany
{firstname.lastname}@fit.fraunhofer.de

[2]University of Luxembourg
Rue Richard Coudenhove-Kalergi
1359 Luxembourg, Luxembourg
Roderick.mccall@uni.lu

ABSTRACT

Designing Augmented Reality location aware games requires an understanding of how form and content issues impact on presence. A study of 60 players was conducted using questionnaires, video analysis and interviews. The results indicate that content including: moral dilemmas, strong narratives, using real locations effectively and applying simple physical behavior within virtual characters to improve embodiment have a positive impact on player experience. The results are presented in the form of guidelines.

Author Keywords

Mobile Augmented Reality (AR), Presence, Mixed Reality (MR), Multimodal Interfaces, Pervasive Gaming, Location-aware games, Game Design, Guidelines

ACM Classification Keywords

H.5.1 [Multimedia Information Systems]: Artificial, augmented, and virtual realities H.5.2 [User Interfaces]: Evaluation/methodology - Graphical user interfaces (GUI) - Input devices and strategies. I.3.1 [Hardware Architecture]: Input devices. I.3.6 [Computer Graphics]: Methodology and Techniques - Interaction Techniques. K.8.0 [Personal Computing]: General - Games.

INTRODUCTION

Mobile and in particular location-aware Augmented Reality (AR) gaming is an area which has seen significant developments in recent years with industry becoming increasingly interested in its potential. While most so called mobile "AR" applications are actually limited to rather simple 2D overlays superimposing a live video stream (as e.g. in Layar or Wikitude), location-aware AR gaming as applied in our approach refers to a fully registered set of virtual 3D objects. This allows for rich content, almost seamlessly integrated into the real environment of the user providing the correct perspective from the user's current viewpoint and viewing direction.

The increasing potential of mobile AR gaming makes it all the more important to understand how certain seemingly contradictory game elements can influence player experience, in particular how different form and content issues will impact on the users' perceived sense of presence within an AR experience. Our user study reveals that while elements from virtual environment research are relevant within this context, this will not cover all aspects. In particular, striving for elements such as realism may be the wrong approach whereas using simple techniques for encouraging embodied interaction or the engagement within a strong narrative seem to be more appropriate.

The paper starts with a background on location-aware games and an overview of previous presence research. It then provides an overview of the final iteration of a game known as TimeWarp as well as results from an extensive conducted study. It concludes with the provision of a set of guidelines based around Lombard and Ditton's form and content presence determinants [14].

BACKGROUND

The availability of usable GPS data for ordinary consumers since 2000 has resulted in the development of pioneering works in the field of location aware computing. GeoCaching [7] [16] and ARQuake [21] represent opposing ends with regards to technical requirements and the way in which they allow users to fill in gaps in the overall perceptual experience. GeoCaching is based around the concept of a simple treasure hunt game, where players use GPS devices to locate hidden treasures. The game uses comparatively basic technologies and rules. In contrast, the ARQuake prototype used a highly sophisticated technical setup to run a modified version of Quake in which players hunt virtual monsters in an Augmented Reality environment. While ARQuake players reported some level of enjoyment, they commented misalignment of the real and the virtual aspects caused irritation [22]. Nevertheless, ARQuake pioneered the use of animated avatars in location aware gaming. Other work has also highlighted the relevance of the embodied element of interaction. For example Heartlands [12] brought elements such as player

DIS 2012, June 11-15, 2012, Newcastle, UK.

position and their physical status (e.g. heart rate) into the game rules, thus making the physical act of walking or running important within game design.

In the current iteration of TimeWarp and its previous versions it was decided to anchor the game within the context of the city of Cologne, e.g. by drawing on famous local characters or historical elements. Therefore, in many respects the game moves beyond previous work such as AR PacMan [9] where the content of the game has little relation to the surrounding space and more in the direction a game like REXplorer [2] where it is the interplay both on a physical and content level between the real and virtual elements which is key. In location-based gaming, such a connection is often inherent in the game design and thus there already exists work on how to best create such an experience [19]. Examples include the evaluation of The Westwood Experience [26] or Viking Ghost Hunt [8]. Also, playing a game in the real world can have unexpected but beneficial effects on the player's experience that can and should be exploited [18].

TimeWarp shares many aspects of ARQuake in that it presents a sophisticated augmented world. It also draws on using the act of walking or running to enhance player experience. Furthermore, we explore the use of roles for players and blurring the boundaries between game and physical space. Finally, the study presented here builds on earlier work [13] [25] both from game design and methodological perspectives.

Presence: Definitions and Determinants

There are three broad categories of presence, two of which are explored to varying degrees within TimeWarp, these are: physical, social and co-presence. Physical presence is feeling of being in another place, social presence being together with another real or virtual person, while co-presence refers to the feeling of being together with someone at a remote location and is not explored here. In addition Lombard and Ditton [14] defined three areas that give rise to a sense of presence: form, content and user characteristics. Form variables cover aspect such as: number/consistency of sensory inputs, visual display characteristics, audio qualities, obtrusiveness of medium interactivity and stimuli for other senses (e.g. smell). Slater [20] also argues that "presence is a human reaction to immersion" and therefore is a determinant in the process and not the same factor. Content elements relate to aspects such as: social realism and task or activity. Finally the model or user elements cover aspects such as willingness to suspend disbelief, knowledge or prior experience.

While the Lombard and Ditton model is relevant there are some problems when applying it to Augmented Reality. Firstly, in contrast to Virtual Reality the aim is not to replace all sensorial cues with virtual equivalents. Furthermore, aspects such as realism are also problematic as heightened awareness of faults especially when comparing virtual and real objects only serves to undermine the sense of presence. Also, as the real city remains part of the game, passersby, buildings and non-planned events may all in theory become content elements, where as in virtual environments the objective would be for content to be purely virtual.

The form and content elements of the Lombard and Ditton approach provide another area to explore. For example in TimeWarp a strong narrative (content) is used to explain why aspects do not look or behave as if they were real (see game design section). Added to this is the use of real world locations and scenarios which build on normal events; this allows the user to draw on existing knowledge and model the augmented experience within a familiar context, thus allowing them to create a "mental imagery space" [5] – an aspect within the MEC (Measurement, Effects, Conditions) questionnaire [23] which is used in this study. As Biocca argues it is the mental imagery which fills the immersion gap and thus gives rise to a sense of presence. However, although our approach asks them to "suspend disbelief" [10] much like people do when they watch a film, we are not asking them to suppress awareness of reality.

GAME DESIGN

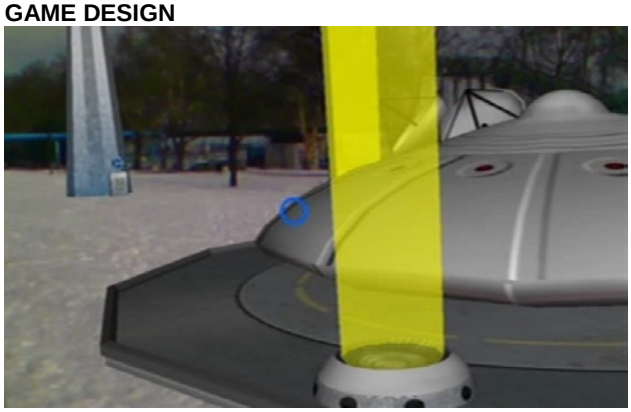

Figure 1. Screenshot from AR player's UMPC.

Overview

The final version of TimeWarp [24] is played cooperatively by two players who have different user interfaces on their Sony Vaio UX280P Ultra-Mobile PCs (UMPCs) and perform slightly different roles in the game. The device of player 1 (AR player) provides an Augmented Reality view of the environment. This is created by using data gathered from a xSens MTi-G sensor (which is a combined inertial and GPS sensor with an integrated Kalman filter) to create the so-called "magic lense" effect [4]: Virtual objects and characters are overlaid on the live camera image of the UMPC as illustrated in Figure 1. The AR player can furthermore interact with the augmented content. A crosshair changes its color when pointing at an object or character ready for interaction which can then be performed by pressing a button. The actual interaction can take various forms such as starting to talk to a character, picking up an object, or repairing an apparatus.

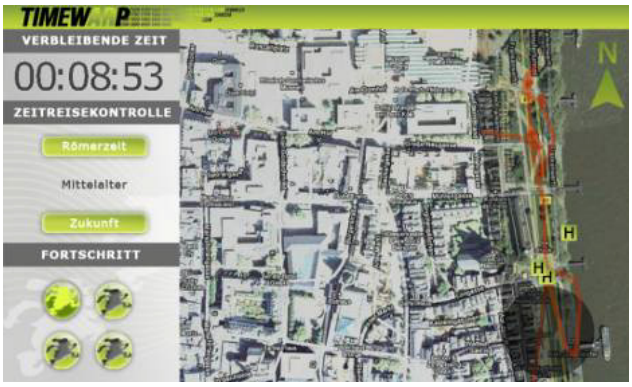

Figure 2. Screenshot from Navigator's UMPC.

Player 2 (Navigator player) is in control of a map overview of the game area. The players can see their current position as well as interesting places that are marked on the map as soon as the players get within range. This player is also able to control dialogues with virtual characters by selecting one of typically three pre-defined statements. Furthermore, the screen of the device shows the remaining time and the state of progress that the players have made so far (Figure 2).

The devices of both players are connected via an adhoc wireless network and constantly exchange data to keep the game state synchronized.

The game is running in Marvin, a player for VR and AR content based on the Morgan AR/VR framework [17]. The AR game content is using the X3D format and the game logic is implemented in a descriptive language called Behaviors [6]. The frame rate of the devices would usually be between 15 and 30 frames depending on the amount and complexity of the visible 3D objects.

The game itself is played on the banks of the river Rhine close to the old town of Cologne. It has a strong narrative element influenced by typical science fiction stories. Both players are hired by the ChronoGuard, an agency dealing with anomalies in the space time continuum. Their supervisor is Agent Morgan who appears throughout the game in short video clips that are seemingly live broadcast from the 32nd century. According to him, a group of newly manufactured household robots has developed conscience and escaped from the factory by time travelling. It is now the task of the players to follow them into (three) different time periods, locate them and send them back to their original time as otherwise they would create anomalies in the space time continuum endangering the universe itself.

All virtual robots are animated in synchronization with what they are saying (e.g. arms, head) and voiced by actors in order to give them an individual and recognizable character (see Figure 3). The overall design of the robots is based on the legend about the "Heinzelmännchen of Cologne", little gnomes that used to help people during the night in their households until the nosy wife of a tailor scared them away.

Figure 3. Cast of characters, HM-RO1 (roman time), HM-3M4, HM-3ML (both medieval time) and HM-F4L6 (future) (from left to right).

Each time the players encounter such a robot they have to solve a challenge (two of which are described further below). After solving it, they have to make the choice to either sending them back to Agent Morgan or setting them free in a time zone of their choice (and then accordingly opening a blue or a red time portal). Before the players start with the actual game, the basic game play and the background story is first introduced by a short tutorial. Afterwards the players do their first journey through time. The Navigator player therefore has to create a time portal by selecting a certain time period as target period and then place the time portal on the map. It then appears as a large wobbly sphere in the augmented view of the other player (see Figure 4), and both players have to physically walk through the time portal before it collapses (after 30 seconds). The players have to perform the same actions again each time they want to switch time periods. They can do so at any time during the game but would typically do it after solving a challenge as there is only one robot per time period. The typical game flow is visualized in Figure 5.

Figure 4. Screen from AR player showing a time portal.

The available time periods are the roman time, medieval time and the future set in the year 2678. Each time period holds a challenge for the users and consists of a variety of typical buildings and objects that appear in the environment like an archway, tents, fountains or radar. When placing the virtual content into the real world, we considered the underlying structure of the real world, so that both would complement each other nicely whenever possible (e.g. staging a virtual wedding at a real church or placing the Roman content in an area where there are still remains of the real Roman period of Cologne).

For this paper we put the emphasis of our analysis on two contrasting challenges that the players face in the medieval and in the future time period, labeled "UFO" and "Wedding" respectively.

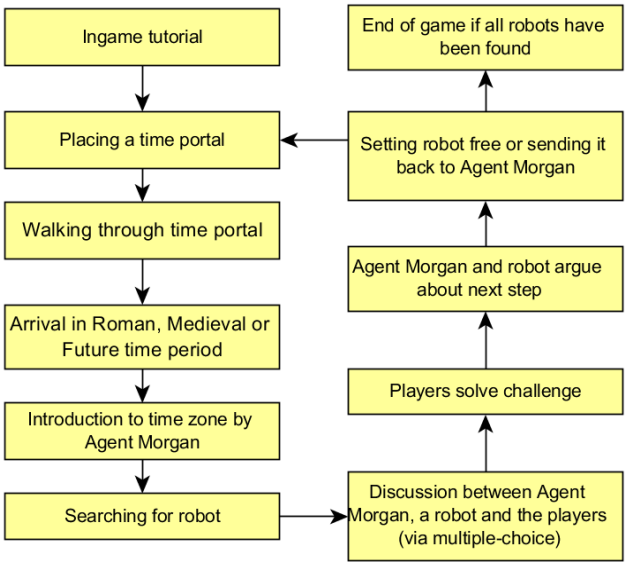

Figure 5. Typical game flow.

UFO

The Heinzelmännchen-robot the players meet in the future urges them to quickly help it. The players have to check out three landing light relays and repair them in order to manage a safe landing of a spaceship that has run out of fuel. Although there is no explicit time limit to the task, the UFO that is flying over the heads of the players conveys a strong sense of urgency (see Figure 6) which is supported by the behavior of the robot. The players can repair the relays by employing the simple point and click mechanism: Walking close to the relay, aiming at it with the AR device and then pressing a button. The challenge takes place on an open meadow to ensure maneuverability of the players and to have a believable spot for a landing platform.

Wedding

In the medieval time period the players have to reunite a Heinzelmännchen-robot wedding couple by finding the groom that has lost his way. The players first meet the bride who emotionally describes the situation and asks them to find her fiancé and bring him back. In order to do this the players have to find the groom robot and convince him to come with them. He then indeed follows the path of the players and this can be seen by the players as they return to the bride. The wedding then takes place including traditional church music and a kiss between the two robots. Afterwards, the players again have to decide whether they want to set both of them free or to send them back to Agent Morgan.

The bride is found by the players next to a real world church which gives the challenge a strong anchor in reality. The groom on the other hand meets the players very close to the riverside as his GPS broke down while he went swimming.

Figure 6. Players (left) exploring the UFO while being observed by the evaluation team (right).

STUDY

The studies were conducted in January and early February 2010 in the city of Cologne, Germany. They were performed during the morning and afternoon of each day and only during daylight hours. During the studies Germany (and much of Europe) experienced extreme weather conditions consisting of sub-zero temperatures, snow and ice.

Participants

In total 66 players took part in 33 groups, and participants were only removed from the trial if there were technical problems or if they failed to complete the game. As a result, data from 60 players was used (42 male/18 female), including people from various vocational background. All participants indicated that they used computers everyday with 8% indicating they played computer games on a daily basis. However, the vast majority indicated they played computer games once a week or less.

Data Capture Methods

One key aspect of the study was to relate in-situ data with post-experience analysis in order to allow for the exploration of higher level themes such as presence from the perspective of what was actually observed during the trials. In order to achieve this, a range of data collection approaches were used including questionnaires, interviews, direct observations and video analysis with audio recordings. As the first language of all participants was German, the study has been conducted completely in German as well. In this paper, all quotes by players and snippets from the questionnaire have been translated into English.

Questionnaire

We used a modified version of the MEC Spatial Presence Questionnaire [23]. MEC covers a range of areas including

process factors (e.g. attention allocation and spatial presence etc), states and actions (e.g. higher cognitive involvement or suspension of disbelief), and personality traits (e.g. domain specific interest). However, as this questionnaire is drawn from virtual environments research, we had to adapt it to focus on the AR aspects of the experience. In particular on how virtual and real objects were related to each other and how they impacted on the sense of presence. For example, asking if people felt present in the real or virtual gaming elements for the duration of the experience. Another area of change was how people felt towards the collaborative elements such as the other player, non-playing characters and even passers-by. In order to support the latter, social elements we added in questions from the Bailenson et al. [1] social presence questionnaire. Drawing on the work of Benyon et al. [3], questions were added exploring the users' sense of place. In one final change the questionnaire rating scale was changed from a 5 point Likert-style response to a 7 point scale. A 7-point Likert scale was used allowing for more discrimination between responses in the middle of the scale.

Video Observation

A camera attached to a steadycam was used to capture the players during the game, this allowed for the video to be smooth and easier to interpret than with a hand-held camera. In addition, microphones were attached to the players and the audio from the UMPC was captured and synchronized at the same time with the video data.

The data from the videos was analyzed from two perspectives. Firstly, a quantitative analysis of certain interactions was recorded in the form of codes covering elements such as: portal decisions, following virtual characters and running. These codes were drawn initially from the work within the IPCity project and themes which were identified during the early viewing of the videos. Secondly, a record of quotations of interest was kept. In the following paper the quotations take the following form for both video and interview data:

[Questionnaire, p10]: This quote is taken from the Questionnaire of the player with the ID number 10.

[Interview, p11]: This statement was said by the player with ID 11 in the post-game interview.

[Video, p11]: This statement was said by the player with ID 11 during the test run.

Interviews

After the experience the players took part in an open-ended interview. The interview questions were intended to uncover information about their general feelings towards the game, any interesting behavior that were observed during it and to explore certain answers in their questionnaires. Each interview lasted approximately 15-20 minutes.

Procedure

Each trial lasted 60-90 minutes and each player was given a brief introduction to the game. The rest of the introduction and how to use the devices was done in-game by Agent Morgan and his assistant in form of a tutorial mission.During the game they were video recorded and following on from the game they were asked to complete a questionnaire and take part in an interview.

RESULTS

As explained in the game design section, TimeWarp utilizes a number of concepts to keep the player engaged with the game. For example while the UFO challenge or the time-travelling elements are more action based the medieval challenge contains a more emotional story. In the following section we focus upon different aspects which played a key part in the gaming experience. Six game elements were identified that were crucial for the success of the TimeWarp game. They can be grouped by their main characteristics, i.e. if they are physical qualities of the game or whether they approach the player in a mental/social/emotional way (see Table 1).

Table 1. Overview of game elements in TimeWarp

Category	Physical Quality	Mental Quality
Environment	World Exploration	Emotional Storyline
Interactions	Action Scenes	Moral Decisions
Characters	Humanlike Behavior	Believable Characters

Action scenes

When were you most involved in the game and why?

"In the future our time was running out […]. That helped me getting immersed" [Interview, p11, male]

"When I had to search for the portal – due to the time pressure." [Questionnaire, p37, female]

In a mobile Augmented Reality game physical involvement is a key aspect influencing the game play. In this iteration of TimeWarp the players had to walk to the different virtual historical places spread across an area which was about 175m wide and 375m long. While the general game playing speed could be considered as moderate, several parts of the game forced the player to speed up, move faster and solve tasks in a limited time. The most time-critical activity of the game was traveling between time zones. The vast majority of players successfully managed to travel in time and experienced this activity as an action-packed task that amused them. Often the players had to walk faster or run to reach the time portal which caused higher levels of physical engagement.

"When creating and searching for time portals I was most involved in the game. It seemed to be a time-critical task" [Questionnaire, p22, male]

"The most diverting part was to search for the portals and approach them because you had the time pressure of 30 seconds and really had to walk over rough and smooth." [Interview, p38, male]

The previous quotes indicate that the time pressure and physical effort had a positive impact on many players and helped them to fully focus on the game, getting engrossed in the story. The video analysis provided further evidence of this. Additionally, displaying the remaining game time in the user interface reminded the player about the possibility of failure. Thus, they often strived to solve the tasks. However, elements such as snowy weather conditions or "barricades" such as the river Rhine or large buildings often reduced the ability of players to solve the tasks. Players also stated that they became frustrated after they had failed on several consecutive occasions to jump through time portals. They also said they stopped concentrating when they had to pay too much attention to their own safety (which is not surprising) and therefore points to the need to thoroughly examine all aspects from street furniture to traffic before selecting game locations. Ideally locations should offer enough empty space to allow for running and should be free of potential dangers such as traffic, stairs, or crowds of people. Also weather conditions such as snow and ice should be considered as they may lead to dangerous situations or result in the game being aborted. In some cases this had the effect that the players' teamwork increased through warning each other.

World Exploration

Physical engagement was also necessary to explore the big Roman arches or buildings from close by. Due to the comparatively small field of view of the UMPC the players had to "scan" the scenery and in case of very high virtual objects had to hold the UMPC up to explore the objects in their entire size (see Figure 6). In many cases this resulted in amazement and the players were impressed and spent several minutes walking around and watching the objects from different angles. Holding the UMPC seemed to help the players to understand the scale of the virtual objects relative to themselves e.g. directly comparing the size and height of the virtual objects with their own body size.

Emotional storyline

In contrast to the action-loaded parts of the game the wedding story of the medieval time was intended to approach the players in a more emotional and human way.

When were you most involved in the game and why?

"I liked the Middle Ages most as the love story between the two Heinzelmännchen felt more „real" to me than the 3D objects." [Questionnaire, p34, male]

"The Middle Ages because I liked the lovers story most." [Questionnaire, p24, female]

"When I saw the second robot that had to be collected for the wedding. The reason might be that you were integrated into social behavior." [Questionnaire: p9, male]

The virtual marriage touched most of the players as the statements above illustrate. The behavior observed from videos also pointed to people sympathizing with the Heinzelmännchen couple. Often they would smile and express their empathy by commenting on what they saw.

The challenge shows that social behavior, even if it is the social behavior of virtual creatures, can touch people and encourage player participation. Love and marriage are strong emotional topics that are attractive to many – though not all - players. Applying this human touch to the virtual characters made it easier for players to compare the Heinzelmännchen behavior with human-like behavior.

Moral decisions

The social and emotional state of the players was also addressed by another game design aspect as a narrative framework consisting of a significant element of decision making was utilized to underpin the interactions available within the game, for example deciding whether to follow Agent Morgan or the Heinzelmännchen. Depending on the decision the robots were either set free or returned to slavery or death.

"The moral decision of where to send the Heinzelmännchen preoccupied me a lot" [Questionnaire, p34, male]

"When we led Emil back and they got married, my game partner got emotional and wanted to rescue them both." [Questionnaire, p49, male]

"The Heinzelmännchen did argue convincingly and I felt with them." [Interview, p21, male]

"The other one is also in the blue one. In a threesome they can party!" [Video, p55, female]

"These marrying ones were indeed cute. You actually had to bring them together for moral reasons." [Interview, p8, male]

As noted in the quotations above, the players felt a strong empathy for the Heinzelmännchen, which in turn altered the importance they attached to the decision making process. This resulted in the decision often being taken as a result of negotiations between the players. The decision was further influenced by personal desires such as to fulfill a duty or to act against Agent Morgan or the particular scenario within the game. This became most obvious during the wedding challenge where a large majority of players decided to help the Heinzelmännchen instead of agreeing with Agent Morgan.

Table 2 provides an overview of all portal decisions made by our test players. In the table, "blue" means that the

players liberated the Heinzelmännchen, and "red" means that the players followed their instructions and sent the Heinzelmännchen back to Agent Morgan. The analysis (ANOVA) of social presence questions show that there is a significant (p=.022, F=5,595 n=58) difference between the groups that chose a red or a blue portal in the item: 'The person appears to be sentient (conscious and alive) to me'. Participants that chose the blue portal (n=47, M=5,27, SD=1,516), which means to set the Heinzelmännchen free, agree averagely 16,86% stronger to the item than those who chose the red portal (n=11, M=5,27, SD=1,421). Furthermore the social presence item: 'I felt I could interact with the virtual characters' (p=.104, F=2,737) shows a tendency that participant who chose the blue (M=2,26, SD=1,295) portal have higher ratings than those who chose the red (M=3,36 SD=1,567) portal. These results show that people who choose the blue portal and set the Heinzelmännchen free tend to perceive the virtual characters as more real. The reason for this behavior could lie in the feeling of sympathy or even empathy towards the virtual characters.

Table 2. Portal decisions by players in the different time zones.

	Total occurences	Blue portal (set free)	Red portal (sent back)
Roman time	30	43.33%	56.67%
Medieval time	30	76.67%	23.33%
Future time	30	54.33%	46.67%
Total	90	57.78%	42.22%

Conflict is an intrinsic element of all games [11] and here the players encounter a rather easy to solve conflict (from a game mechanics point of view). However, as it is an emotional topic, making decision was hard for some players. While the Roman and future times are more or less balanced, there is a strong deviation in the medieval time. Here it becomes clear that the players made the decision mostly based on their perception towards the couple. The players gave the following reasons for setting the robots free: Empathy (18 teams), Equality (2), Habit (2), Rebellion (1). Teams that send the robots to Agent Morgan gave Order (7 teams) as the main reason. These positive feelings seem to be stronger with the couple than with the other two Heinzelmännchen robots. Further evidence can be found within some of the player quotes in relation to this challenge illustrating that although both characters are virtual, the concept of getting married still creates a strong feeling of empathy. As noted earlier, players who indicated a higher social presence with the characters also showed greater tendency to rescue them.

Humanlike behavior

Being followed by a virtual character was another game design element that fascinated the majority of players. In the medieval challenge the players had to find the groom HM-3ML (or Emil as he likes to call himself) and bring him back to his fiancé HM-3MA (or rather Emma) in order to marry her. When walking back to Emma, Emil is following the players. The AR player can see this when turning round and facing backwards towards Emil.

When were you most involved in the game?

"When Emil followed as and we guided him to the marriage. That was real behavior and could be checked by watching behind yourself with the UMPC" [Ques, p42, male]

"He is following us. That is really a bit eerie." [Video, p2, male]

"I found it funny, that when we met the one in the Middle Ages, he really followed us when I turned around." [Interview, p37, female]

Figure 7. Players watching how Emil is following them.

Most players intuitively looked behind them to verify if the Heinzelmännchen was really following and were fascinated. Figure 7 illustrates players when discovering that the virtual creature was indeed following them. Often the players turned around several times to check if Emil was still there or were even walking backwards. Some players even attracted the virtual character by sounds as if they would try to attract a little child or an animal. Others could not stop looking at the creature that was following them and walked backwards for large parts of the way back to Emma.

It seems that a virtual character accompanying players in the real world is a unique AR-game specific feature, making him a companion of the players. This draws the line between stationary video games which are often used as a comparison to the TimeWarp experience and a location based AR game. If a player realizes they are being followed it draws their attention to the virtual character due to the fact that this phenomenon is new to the participant. This unexpected but natural behavior creates an element of surprise and realism and adds to the richness of the user experience.

Believable Characters

Responses to the cartoon-like visual nature of the Heinzelmännchen were as expected with people perceiving them as not being real (see Table 3). This approach was used so that people would not seek to compare a computer generated character with a real person and thus automatically concentrate on the short-comings (which due to limited computing power of the UMPCs and modeling budget would have been obvious and possibly distracting). To compensate for the lack of visual realism, animations of the virtual characters as well as engaging voice acting were utilized as well as trying to engage the players in the narrative of the game.

Table 3. Question: "I perceive the person as being only a computerized image, not as a real person." 1=Strongly agree, 4=No opinion, 7=Strongly disagree (n=60, M=2.75, SD=1.85)

Answer	1	2	3	4	5	6	7
# players	23	10	7	8	6	3	3

Table 4. Question: "I perceived that I was in the presence of another person." 1=Strongly agree, 4=No opinion, 7=Strongly disagree (n=60, M=3.4, SD=1.72)

Answer	1	2	3	4	5	6	7
# players	8	14	13	8	8	6	3

This approach appears to have been successful in that the players indicated they perceived that they were in the presence of another person when they were interacting with the Heinzelmännchen (see Table 4). Furthermore, the quotes in the previous sections illustrate that many players developed positive feelings towards the Heinzelmännchen and set them free instead of fulfilling their order.

DISCUSSION

From the six core game elements presented in the results chapter we derived a set of game design guidelines and put them in context of Lombard and Ditton's presence determinants. Naturally, not all of them are applicable for all mobile AR games.

Encourage players to explore virtual elements.

When players are walking around the environment and inspecting virtual objects with the help of their AR devices, the physical element of changing position and posture is a beneficial factor for player engagement. Including objects of a size that forces players to walk around them to fully take them in is one possible option. Tall objects force the players to lean back and hold up their device before they can see the whole of it. And if players are walking towards such a large building for example, a sort-of virtual skyline is created. Furthermore an AR view increases the understanding of size and location of a specific object. In a game without AR content, an image of a tower might have the information that it is 100m tall. But when the players actually see it in the real environment and need to perform physical actions like described above, they are much impressed by the sheer size of the tower. Such an experience can additionally be fostered by spreading out virtual elements and requiring players to walk between them which creates a better understanding of the spatial attributes of the augmented world. Objects flying high up in the sky (and not just floating above ground) are another good example of being excellently suited for AR.

Presence determinants: Content

Include short but intensive physical tasks.

An even stronger physical engagement can be reached in mobile AR games through time critical tasks that have a strong physical focus (e.g. running to travel through the time portals, quickly moving from one broken terminal to the next). While one should not force players to run the whole time during the game, such tasks can be very effective when used sporadically. This creates a physical peak for the players which is accompanied by an emotional one when the task is successfully completed. The task should be set-up in such a way that the players can use the AR view the whole time so that there is no context switching necessary (e.g. looking up from the device to orient oneself like in map-based location-based games). When players are moving fast through the environment, the game designers need to take the safety into account as players easily become so immersed into the task at hand that they may trip on uneven ground or cross streets without paying attention to traffic. Having a collaborative set-up might help in such a case – as well as the obvious choice of not playing the game directly on city streets.

Presence determinant: Form

Allow virtual characters and objects to become meaningful in the real world.

As the main game content in a mobile AR game is typically virtual, it should have repercussions in the real world as well in order to truly engage the players. In TimeWarp one prime example for this guideline is the virtual character that becomes a companion to the players during the wedding challenge. As he is seemingly walking next to them and can only be seen when the players move their device accordingly (similar to when a real person is walking behind you and you have to turn around in order to see her), he acquires a physical representation in the real world. Equally, the time portals gain physical qualities as they behave like a real time portal might (vanishing together with a typical sound when entered). Sound can play a crucial part for the creation of this effect. In technically more advanced AR systems, the virtual objects should behave physically correct in relation to real world obstacles (bouncing off real walls, being occluded by buildings).

Presence determinant: Form

Tap into existing emotions of players.
When a mobile AR game challenges the players also on an emotional level, players are drawn stronger into it as it makes it easier for them to suspend disbelief. Choosing topics for the narrative that are familiar to the players (e.g. a wedding) helps players to identify with the story and characters. In addition it also acts as a countermeasure to the often times overwhelming and new experience and visual sensation of a mobile AR game. Like in location-based games, the selection of locations for the game becomes very important as they can enhance or hinder the atmosphere of a game (e.g. playing the wedding challenge at a real church). The same is true for dynamic properties of the environment (e.g. weather) that can work for or against a desired effect.

Presence determinant: Content

Confront players with meaningful decisions.
One can increase the emotional investment of the players into a mobile AR game, if they are confronted with social or moral dilemmas that have no clear correct solution. This is especially beneficial in collaborative AR games as such decisions spark discussions between the players and require further reflection with the game content. While this seems like an obvious characteristic, previous mobile AR games are more often than not neglecting the opportunities that such a narrative driven approach can provide in favour of a more gamistic approach (e.g. basing the game on logic puzzles dexterity challenges).

Presence determinant: Content

Do not focus on visual realism.
In order for the players to feel emotionally attached to the characters, one should not focus on the visual representation alone. Realistic rendering is not necessary and can even be harmful. Instead, virtual content should have more than just a visual representation (e.g. audio and sound effects) and behave naturally (e.g. animations, following the players around). This way characters and objects become more convincing which is the necessary base for creating engaging interactions with these (see previous guidelines). Creating truly visually believable virtual characters on today's devices is still a very hard task due to limitations in rendering power and tracking precision while in a mobile environment. Moreover, visual realism does not seem to be the most plausible approach anyway. Comic theorist Scott McCloud based his notion of *amplification through simplification* on the analysis of different drawing styles in comics like Japanese Manga, where backgrounds are often depicted in a naturalistic style, whereas the protagonists are drawn in stylistic abstraction [15]. He concludes that such visual abstractions better support the recipient in identifying with the content and being emotionally engaged by letting him appropriate the representation and fill in the gaps for himself. With the backgrounds in AR being not only naturalistic, but real, it seems conclusive that virtual protagonists in AR should thus be depicted in a stylistic abstraction to amplify their effect. The character design should thus focus on the most critical formal elements in order to support the overall user experience and help induce emotions and a feeling of presence through immersion with the content.

Presence determinant: Form and Content

CONCLUSIONS
The study conducted here was carried out with the intention of exploring the relationship between presence and game design factors, e.g. realism (or lack of), city context, narrative (including emotional aspects and dilemmas), embodiment and interaction within the context of augmented realty location aware games; in particular, using content to bridge the immersion gap rather than complex technical solutions. We found that anchoring scenarios within the context of the urban environment from either a narrative or location perspective is vital to the success of the game and more important than visual quality of the AR content. Instead it is important that there is a reciprocal physical relationship between the player and virtual character. In our example this is the following behavior of the Emil character. In conclusion the results build on prior work within the context of virtual realities and gaming but provide designers with an approach which can be used to overcome technical limitations through an improved understanding of how to utilize various content elements.

FUTURE WORK
Future work includes improving the data capture methodologies and improving the guidelines. While analyzing the data we also identified possible links between social presence and emotional aspects like sympathy and empathy toward virtual characters. As meaningful decisions can lead to a moral dilemma these aspects should be considered in the evaluation of further work. With the advance of smart phones both concerning technical capabilities and availability in the general public we foresee that engaging mobile AR experiences and games will have the chance to evolve from a niche to wider adoption – if their quality is of a high enough standard. Here, further research on how to design such applications will be of great benefit for upcoming developments.

ACKNOWLEDGMENTS
The authors thank their colleagues at the Mixed and Augmented Reality Solutions Department at Fraunhofer FIT for their comments and contributions. They further wish to thank their project partners of the IPCity project for their ideas, cooperation, and their support. IPCity (FP6-2004-IST-4-27571) was partially funded by the European Commission as part of the 6th Framework.

REFERENCES

1. Bailenson, J.N., Blascovich, J., Beall, A.C., Loomis J. Equilibrium Theory Revisited: Mutual Gaze and Personal Space in Virtual Environments. 2001. p. 583-598.
2. Ballagas, R., Kuntze, A., Walz, S.P. Gaming Tourism: Lessons from Evaluating REXplorer, a Pervasive Game for Tourists in Pervasive Computing. 2008. Sydney, Australia.
3. Benyon, D., Smyth, M, O'Neill, S., McCall, R., Carroll, F. The place probe: exploring a sense of place in real and virtual environments. 2006, MIT Press. p. 668-687.
4. Bier, E., A., Stone, M., Pier, K., Buxton, W., DeRose, T. Toolglass and magic lenses: the see-through interface, in Proceedings of the 20th annual conference on Computer graphics and interactive techniques. 1993, ACM: Anaheim, CA.
5. Biocca, F. Can we resolve the book, the physical reality, and the dream state problems? From the two-pole to a three-pole model of shifts in presence. in EU Future and Emerging Technologies Presence Technolgies Meeting. 2003. Venice.
6. Broll, W., Herling, J. and Blum, L. Interactive Bits: Prototyping of Mixed Reality Applications and Interaction Techniques through Visual Programming. 3DUI '08 Proceedings of the 2008 IEEE Symposium on 3D User Interfaces. IEEE Computer Society Washington, DC, USA. 2008
7. Cameron, L. & Ulmer, D., The Geocaching Handbook, Globe Pequot Press, 2004
8. Carrigy, T., Naliuka, K., Paterson,N. and Haahr, M. Design and evaluation of player experience of a location-based mobile game. NordiCHI '10 Proceedings of the 6th Nordic Conference on Human-Computer Interaction: Extending Boundaries. ACM New York, NY, USA. 2010
9. Cheok, A.D., Goh, K.H., Liu, W., Farbiz, F., Fong, S.W., Teo, S.L., Li, Y., Yang, X., Human Pacman: A mobile, wide-area entertainment system based on physical, social, and ubiquitous computing. Personal and Ubiquitous Computing, 2004. 8(2): p. 71-81.
10. Coleridge, S.T., ed. Biographia Literaria. ed. J. Shawcross. Vol. 2. 1907, Oxford: Clarendon Press.
11. Crawford, C., The Art of Computer Game Design. 1982.
12. Davis, S.B., Moar, M., Jacobs, R., Watkins, M., Shackford, R., Capra, M., Oppermann, L. Mapping Inside Out, in Pervasive Gaming Applications - A Reader for Pervasive Gaming Research, C. Magerkurth and C. Röcker, Editors. 2007, Shaker.
13. Herbst, I., Braun, A.K., McCall, R., Broll, W. TimeWarp: interactive time travel with a mobile Mixed Reality game. In Proceedings of the 10th international conference on Human computer interaction with mobile devices and services. 2008.
14. Lombard, M., Ditton, T., At the Heart of It All: The Concept of Presence. Journal of Computer-Mediated Communication, 1997. 3(2).
15. McCloud, S., Understanding Comics: The Invisible Art. Tundra Publishing. 1993. p. 50-67
16. O'Hara, K., Understanding Geocaching Practices and Motivations, CHI, Florence, Italy 2008
17. Ohlenburg, J., Herbst, I., Lindt, I., Fröhlich, T. and Broll, W.The MORGAN framework: enabling dynamic multi-user AR and VR projects. VRST '04 Proceedings of the ACM symposium on Virtual reality software and technology. ACM New York, NY, USA. 2004
18. Reid, J. Design for coincidence: incorporating real world artifacts in location based games. In Proceedings of the 3rd international conference on Digital Interactive Media in Entertainment and Arts (DIMEA '08). ACM, New York, NY, USA, 18-25. 2008.
19. Reid, J., , Cater, K., Fleuriot, C., and Hull, R., Experience Design Guidelines for Creating Situated Mediascapes, 20-Jan-2012. [Online] [verified 11.04.2012] http://goo.gl/Leb6z.
20. Slater, M., A note on presence terminology. Presence Connect 3:3. 2003.
21. Thomas, B., Close, B., Donoghue, J., Squires, J., Bondi, P.D., Morris, M., Piekarski, W. ARQuake: An Outdoor/Indoor Augmented Reality First Person Application. in IEEE International Symposium on Wearable Computers. 2000. Atlanta, GA.
22. Thomas, B., Krul, N., Close, B., Piekarski, W. Usability and Playability Issues for ARQuake. in International Workshop on Entertainment Computing. 2002. Tokyo, Japan.
23. Vorderer, P., Wirth, W., Gouveia, F.R., Biocca, F., Saari, T., Jäncke, F.. MEC spatial presence questionnaire (MEC-SPQ): Short documentation and instructions for application. 2004.
24. Wetzel, R., Blum, L., McCall, R., Oppermann, L., Broeke, S., Szalavari, Z. IPCity Deliverable D8.4: Final Prototype of TimeWarp application. 2010. [Online] [verified 11.04.2012]. http://goo.gl/oYVWw
25. Wetzel, R., McCall, R., Braun, A., Broll, W. Guidelines for Designing Augmented Reality Games in Proceedings of the 2008 Conference on Future Play, Toronto, Canada: ACM, New York, NY, 2008.
26. Wither, J., Allen, R., Samanta, V., Hemanus, J., Yun-Ta Tsai, Azuma, R., Carter, W., Hinman, R. and Korah, T. The Westwood Experience: Connecting story to locations via Mixed Reality. IEEE International Symposium On Mixed and Augmented Reality - Arts, Media, and Humanities (ISMAR-AMH), 2010