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Experiences of Evaluating Presence in Augmented Realities

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ABSTRACT

This paper presents an overview of a study of 24 people who used an augmented reality game called TimeWarp. The paper initially discusses the game and evaluation methods chosen, it then explores emerging issues from the evaluation which are applicable to other augmented reality games and how existing user testing methods require further improvements in order to capture data relevant to the issues.

Keywords: *Augmented Reality (AR), Multimodal Interfaces, Mobile Gaming, Pervasive Gaming, Mixed Reality (MR).*

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1. Introduction

Location aware technologies such as widespread mobile computers and varying location sensors provides a vast array of possibilities for extending game playing into streets, buildings and even the rural landscape. New and extended forms of location-aware games including mobile or pervasive phone games, smart toys, role-playing games as well as Augmented Reality (AR) games all demonstrate promising new forms of game play. Substantial work has also gone into new game concepts, sophisticated technology and viable business models. However, research on the methodological issues of studying mobile player experiences in augmented reality games. This paper explores our experiences of using standard methods which were modified to specifically explore place, presence and usability in augmented reality games.

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The paper initially explores the underlying theories which the methodologies intend to address, followed by descriptions of an existing system and evaluation approaches. While it presents some findings relevant to the design of mixed reality systems the objective is to explore the underlying methods. A further description of the results can be found in Herbst, Braun, Broll, & McCall (2008). It concludes by indicating that there is a need to further develop the approaches so that they are more able to explore changes in sense of presence within augmented realities.

2. Related Work

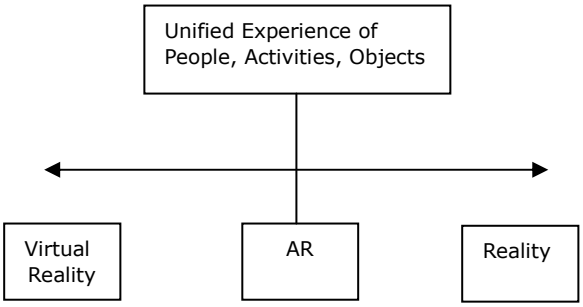

Figure 1. The overall Augmented Reality (AR) experience.

One of the main challenges within augmented reality environments such as the one discussed later is how to create a unified sense of place and presence. By this we mean that the user feels as if the virtual elements are as real and natural as those from the real environment and that they are constantly within the *overall* AR experience (see Figure 1). This diagram to some extent is based upon the work of Milgram (Milgram, Takemura, Utsumi, & Kishino, 1994) who developed the idea of the virtual to reality continuum. The idea of a unified sense of presence also has many commonalities with Gibson's concept of affordances (Gibson, 1979), where he sees no difference between real or virtual. Instead affordances arise due to the user's perception of the features in the environment. It has been argued by some that through these affordances the user interacts in the environment and thus feels present.

At the outset one key area of exploration is the user's sense of presence within such environments. Research from virtual reality points to presence being a combination of physical and social attributes, for example, feeling present in the environment and with other people. Both of these are highly relevant within AR contexts however for slightly different reasons. For example if the desire is to make people feel simultaneously

present with real people and places, as well as virtual people and places. This also requires an examination of some of the elements contained within standard presence questionnaires such as attention, awareness, interest, engagement and involvement. For a unified experience to be created it would therefore be necessary to maintain the user's interest and attention in the experience even when there are little or no virtual aspects. Furthermore, as the experiences take place in reality they should also posses some awareness of real people, places and objects. Therefore the sense of presence is co-constructed through the experience of real and virtual elements and as such understanding this relationship becomes critical.

All AR experiences by default occur in a real space, which is augmented with virtual elements, which through the user's personal interpretation will contain meanings and significances. This gives rise to the idea of place, and as noted by Relph (1976), a place is a combination of physical properties, activities and meanings. Tuan's (1977) conceptualization of place encompasses these aspects in a four layer model consisting of cultural significance as well as social, personal and physical aspects. There are other models, for example Gustafson (2001) emphasizes the importance of self in relation to the environment and other people. Regardless of which model of place a developer or evaluator adopts, it should serve as a starting point when considering where to locate AR experiences, as well as which virtual and real elements to include as part of the experience. Otherwise there is the potential to create virtual elements which ill fit the environment in which they are located. Thus possibly making the user largely ignore the rich experiences provided by reality and focus their attention on the purely virtual elements. This may in turn give rise to them feeling that they are more present in the virtual world and not in the overall AR experience.

3. The TimeWarp Approach

3.1 Design Objectives

TimeWarp was designed to provide a rich gaming experience which explores the full potential of 3D animation and spatial AR sound. The game takes place within a real city and allows the user to experience the city in several different time periods. A combination of virtual objects, augmented sounds and music which represent appropriate aspects of the various time periods are used to alter the player's sense of temporal, physical and social presence. It also support non-linear gameplay.

3.2 Story and Structure of the Game

The TimeWarp game is staged in the old part of the city center of Cologne and is based on the famous tale of the so called “Heinzelmännchen” (Figure 2). These small elves worked clandestinely for the citizens during the night carrying out their household tasks. However one morning they disappeared thus then forcing the citizens to carry out their own tasks. The story has been modified for use in the game so that now the Heinzelmännchen are still in the city but are trapped in different time periods (epochs) and it is the players task to bring them back to the present day. It is for this reason, that the player is equipped with an Augmented Reality system. Using the AR system the player is able to see all artifacts from the particular time period in which they are situated. To travel in time, the player has to reach one of the time portals, which are distributed in the city. In each time period, several tasks have to be solved to free an elf. These tasks are related to the history of Cologne and to the current epoch. Once all the Heinzelmännchen have been freed the game is over.

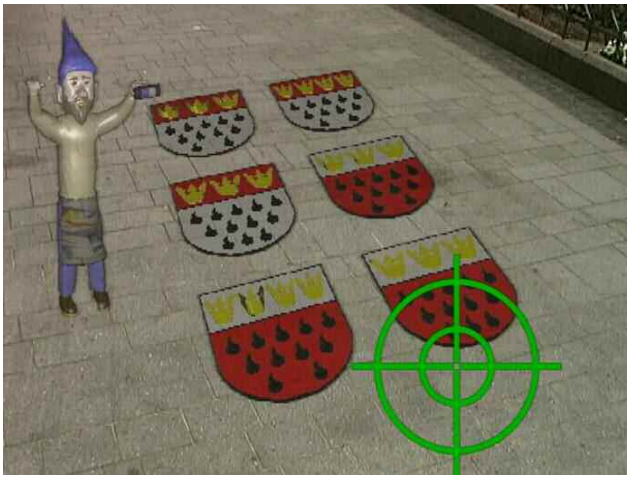

Figure 2. TimeWarp Challenge

3.3 System Concept and User Controls

The AR system used in this game consists of a head-mounted display (HMD) with an orientation sensor attached (Figure 3). The player’s position is tracked via GPS and as they walk around the virtual content (which they see through the visor) is placed at the relevant locations. The system runs on a laptop which is inside a backpack and which is worn on a so-called AR vest. The vest contains the connections between the various devices. In addition to the mobile AR system, a handheld-based device supports the player during the game. On an interactive map the current position is shown either in map or in satellite mode. Besides the guidance of the player, the map tool provides

several features such as zoom-in and zoom-out and the display of important game related locations. Furthermore, the actual game state, information about the game play and system help is provided by the handheld device.

Figure 3. AR system (left) and handheld device (right).

In the first prototype of TimeWarp, three different types of interaction techniques were developed. The first technique uses the physical proximity of the player to a real object and when the user approaches an object from a preset distance an event or action will occur. The second approach allows the user to focus on an object by using a gaze based pointer and by pressing the mouse button, a special action for the selected object will be activated. The third technique uses a gyroscopic mouse, this approach lets the user interact with and place objects in mid-air.

4. User Tests

A large-scale test was conducted during summer 2007, the study took place on location in the City of Cologne and the objective was to test many aspects of the system from user experience (usability, sense of place and presence) through to

technical issues. The study utilised a number of accepted methods which are outlined in more detail below these included a questionnaire, observation method, video observation and a semi-structured interview. Broadly speaking all users experienced the system for around 1 hour, although a few participants took part for up to three hours. A total of 24 people took part in the study these ranged from IT students through to city tour guides, however not everyone completed the questionnaire this was due to a number of issues including technical problems causing the studies to last too long or problems understanding the questionnaire. Our objectives in using a variety of data sources was to look for corroborating evidence but also to identify where existing methods did not accurately capture interesting phenomenon.

4.1 Questionnaire

A review of existing presence methodologies was conducted in order to ascertain which if any would be applicable for the study. One of the main problems with most methods was that they were derived from presence research conducted within virtual environments and often under strict laboratory conditions. These approaches while relevant in many respects ignored several aspects of urban-based AR experiences namely that they are not laboratory based and sense of social and spatial presence is the direct result of the blending of real and virtual elements. In particular users have the ability to compare the feeling of reality between real and virtual elements instantaneously. The MEC questionnaire (Vorderer et al, 2004) was chosen as a starting point as it provided many of the aspects which were relevant to our study, in particular social and physical presence, moreover, it has been extensively validated. The additions were also made so as to reflect the idea of where people feel present. In addition the Bailenson, Blascovich, Beall, & Loomis (2001) social presence questionnaire was added as this addressed many of the elements of interacting with real people (including game and non-game players) as well as virtual characters which we wished to explore.

Switches between the real and virtual elements of the game were a common occurrence and the questionnaire was modified to reflect this Also the attention section of MEC was widened to include more elements relating to mixed reality. Firstly the rating scale was modified to include seven points with 1 representing the real environment, 4 the overall (or blended environment) and 7 virtual environment. A seven point scale was used to allow for a finer grained analysis of the results. This was different from the standard MEC questionnaire in that it only asked people to rate on a

scale of 1 to 5 whether they agreed with a certain proposition such as “my attention was focussed more on the medium”. An additional five questions were added which were intended to explore where people felt the game actions took place and whether they were focussing more on the real or virtual objects for navigation tasks.

In order to remain consistent with respect to scoring, the rating scale for all remaining sections ranged from 1 to 7, with a 1 reflecting a strong agreement with a proposition and 7 a strong disagreement. Unlike virtual reality we are not as concerned with issues related to the creation of mental maps. Consequently fewer questions were asked from MEC and three new questions relating to the perceived reality of the virtual elements were added This resulted in this component of MEC reflecting slightly different themes than before.

MEC also places significant emphasis upon the sense of spatial location which participants have. For this section we retained the general feel of the initial MEC questionnaire instead fitting our wording to suit the experience, in this case a game. However as noted earlier one of the main interests was any switches which occurred while taking part in the experience, in particular when putting on or taking off the visor, as this in theory should change the sense of place and hopefully presence which the users experience. For this we added questions specifically related to changing sense of presence when entering or leaving the experience.

MEC does not deal with temporal presence and so a number of questions were added which specifically covered this area. These included specifically asking people if they had felt like they had visited different time periods. In order to ensure further certainty additional questions were added to explore if people felt any change while moving between time periods and whether they felt different towards the environment or it altered their behaviour.

Social presence forms a key part of TimeWarp either from the perspective of player/player interaction (although the game is designed only for single players), player/character or player/non-player interaction. We modified the Bailenson social presence questionnaire to reflect these aspects by specifically addressing the array of relationships which can ensue within location-aware augmented reality games. The objective of measuring the various forms of social presence which may exist within such an experience was to allow for comparisons between different forms of social presence. Furthermore we were interested in exploring the awareness others, in particular with respect to whether people felt that non-players felt they were acting strangely.

We were particularly interested in how people felt their sense of place would change when in different time periods, and indeed whether they felt the building, characters and other aspects had any impact. For this we added in a number of additional qualitative questions drawn from The Place Probe (Benyon, Smith, O'Neill, McCall, & Carrol 2006), in particular those which would help us identify differences between different time periods and general information regarding the overall experience.

4.2 Observation/iPerG Method

During their experiences the participants were recorded and/or observed, this approach allowed us to capture the social elements of their experience in particular responses from non-game participants. Furthermore it allowed the observation of how the users responded to real and virtual elements, navigated and interacted with the technology. Where possible an additional observer also followed the users, this observer took notes covering aspects such as player-player interaction, player-non player interaction, player-game element interaction and interaction with the technology – this approach was predominantly devised from work carried out within the EU funded Integrated Project on Pervasive Games (IPerG).

4.3 Interviews

After each trial (and if they subjects agreed) they took part in a short-semi structured interview. The objective of the interviews was to probe users further on their experience, in particular to explore any interesting observations which were made during the trial or issues which arose within the questionnaire answers. Such areas would include where people appeared heavily involved in the experience, or when they experienced problems. The questionnaire data was also used to form particular lines of questioning, for example when participants gave conflicting responses about the experience or indicated strongly they felt that time the periods had changed they would be asked to explain their position.

5. Results

5.1 Summary of Implications for Re-design

The study resulted in a number of core issues being identified, these included: *understanding attention allocation, simplifying the interaction scheme, user safety,*

design appropriate paths through the environment, understanding the locale, interaction with others, seamful design, using a combination of real and virtual objects and finally providing a continuous experience (see Table 1). The issue of user safety will not be fully addressed within this paper however, it should be noted that game elements which draw the user's attention away from real elements, in particular cars and other people should be taken into consideration from the outset. This paper will focus on the results from the study and how these core elements should form the basis of new evaluation approaches for mixed or augmented reality games. A more thorough review of the results can be found in (Herbst et. al, 2008).

Understanding attention allocation
Simplifying the interaction scheme
User safety
Design appropriate paths through the environment
Understanding the locale
Interaction with others
Seamful design using a combination of real and virtual objects
Providing a continuous experience

Table 1. Design guidelines.

As noted in the results, users appeared to alter their focus of attention between the real and virtual elements, typically seeking out virtual elements then returning to reality when there were no virtual elements. Such switches in attention play a crucial role in shaping the experience, for example when attention is more focussed on virtual elements users may feel more part of the virtual experience; and possibly even ignore aspects of reality. Therefore making blends of experience somewhat difficult, conversely when focus of attention is on real aspects of the experience (for example when chatting with the evaluator) the user will be missing out on elements of the virtual experience. In addition to the spacing between elements (which is discussed later) another driving factor was the design and placing of elements. For example, use of virtual objects which appear radically different from the surrounding environment will also draw the user's attention.

Interaction within mixed or augmented realities is a new experience for most users. In the case of TimeWarp this involved a range of devices including a mouse and PDA, as well as a visor and a range of mixed reality interface techniques. These interaction

techniques not only alter experience from the perspective of usability but also can distract the user from the surrounding environment and overall game experience. For example if the user constantly has to look at the PDA in order to navigate then they are arguably ignoring elements of the mixed reality game content. Alternative approaches include using auditory cues to direct people towards specific locations or objects – in later versions of the system the latter approach was adopted. Furthermore interface widgets and interaction styles within AR games are often quite complex. As a result there is a need to consider carefully the nature and type of devices used as well as how to make interacting with widgets as natural as possible. Methods could include making interacting with the virtual elements similar to interacting with comparable real elements. Moreover, where possible users should be familiarised with the interaction scheme through the use of a training scenario, however this should form an integral part of the game.

AR games are by default situated within a real space and they rely on the relationship between the real and virtual elements to create the overall experience. Within TimeWarp it was clear that although the game was situated within the urban environment it did not make use of the underlying structure of the location (beyond using specific locations or allowing people to walk between them). This is potentially quite a substantial loss as paths between locations form the basis of cognitive models of spaces, thus aiding in navigation and also in the construction of a sense of place (Appleyard, 1970; Devlin, 1976; Lynch, 1960: Norberg-Schultz, 1971). Therefore when designing experiences the MR environment should take into account the nature and layout of paths, which can encourage participation within objects or locations (e.g. paths which intersect through content) or allow a more passive observation approach (e.g. paths which pass-by locations). Furthermore path structures can be used to heighten experiences, for example the use of clear, starting, middle and end points can be used to provide a spatial narrative as well as to improve navigation. From the perspective of AR this approach should involve creating paths which bring together real and virtual elements.

Following on from the idea of path structures is that of using and understanding the locale in which the game is situated. In TimeWarp many locations exist within the area in which the game takes place, including shopping streets, cafes, open spaces (such as the grassy area near the Rhine Promenade) and a Cathedral. Each of these provides a rich tapestry of physical properties, people, meanings and experiences. Thus when situating such games these aspects should be taken into account such that

for example drinking a coffee and socialising with people at a Café or simply using at as a location to stop observe people. There has already been substantial work on layouts within towns and cities, for example Ching (1996) provides information on more generic layouts while Alexander (1977) provides a list of common patterns which can be found in cities. Therefore understanding the people, activities and potential meanings of any location could prove invaluable in designing mixed reality systems.

Social presence is a key aspect of such systems, ranging from interacting with other players and virtual characters through to causal encounters with non-game participants. The lack of believable interaction with virtual characters, and other players was a major problem within the game. Furthermore non-game participants only became part of the experience when they interrupted the gaming experience. These interruptions had the effect of distracting the player from the gaming experience, rather than being useful. Given the vast array of possibilities to include real people in such experiences e.g. to answer questions about the location etc, it would appear logical to include them within the game.

Related to the topics discussed above is the ability of mixed reality to create a continuous experience, by this we mean that as users walk around they feel as if they are in the given time period or place for the duration that they are intended to be in such an experience. In order to support this concept we propose two further criteria the idea of seamful design which was initially developed by Chalmers (2003). We also propose a further concept of integrating real elements into the gaming experience. The idea of seamless design approaches technical problems from an alternative angle. For example where wifi signals are weak then these black out areas should form an integral part of the experience for example providing locations where people can hide from other players without detection. The use of real and virtual objects should also be considered with care. For example real objects should be integrated into the experience where it is possible to do so and where any virtual equivalent would result in more usability problems. Also real elements should be integrated into the experience where they form a key part of the game play, for example collecting objects to complete a task. However it should be noted that integrating real objects within such experiences can be problematic without accurate computer vision or marker based techniques.

5.2 Evaluation Methods

The interviews, video analysis and data observation proved the most successful in obtaining data which formed the basis of the results above. Due to the completion and

return rate of questionnaires they were broadly speaking only useful for identifying possible interview strategies. Furthermore this was the first iteration of questionnaires and there is room for improvement, in particular reducing the number of questions.

Video and direct observation proved very useful in looking at aspects such as shifting focus of attention at different points in the game. While it is impossible to say that a specific observation is a direct result of any internal cognitive state it does alert us to the changing behaviours of players throughout the experience. Examples include observing people wearing or removing their headsets, interacting with the evaluator or running towards or interacting with virtual objects. This would imply that direct observation approaches which use semi-structured forms to capture data should explore where and when people appear to switch between experiences. While this was partially addressed within the IPerG approach, i.e. it asked for a log of communications between player/player and non-player/player, it does not specifically deal with these issues.

Although many of the methods pointed to interesting themes, in themselves they did not permit an adequate exploration of the issues surrounding them. Such issues included using the underlying locale or using paths from within the environment. This is despite the fact that they could play a part in shaping the game experience. There are of course other methods which explore navigational perspective such as ENiSpace (McCall & Benyon, 2003), however ENiSpace focuses on designing and evaluating purely electronic environments and as a result it is not entirely applicable within the domain of mixed or augmented realities. Moreover approaches such as the Place Probe upon which parts of the questionnaire only captured basic overall experiences and not information regarding experiences which altered during the game e.g. the changing sense of place and presence.

The evaluation techniques chosen also focused heavily on presence related issues, although they were capable of detecting some usability problems when they arose - in particular people having problems with the training scenario. However the methods chosen and alternatives from the VR community many do not fully explore how to integrate real elements into the game space, hybrid objects which use a blend of augmentations and real elements or purely real or virtual aspects.

Social presence was a critical element of the gaming experience and this was reflected within the questionnaire as well as observations and video analysis, for example it was often noted how the users felt out of place, in particular with respect to non-players – some of whom made comments in the street. The approach was broadly

speaking successful however there is still room for improvement, in particular allowing for more details to emerge with respect to the various forms of social presence within the experience.

6. Discussion

The start of this paper focussed on how mixed or augmented realities require an understanding of where an experience is meant to occur, for example more within the real or virtual space or a balance of the two. Furthermore whether during the game experience the user should be aware of changes in where they are meant to feel present e.g. when then move between different time periods.

During the study we uncovered that failing to make use of the real environment effectively within the game space often led to people appearing to enter or leave the experience. This was characterised by them removing the visor, chatting with the evaluator or appearing not to take much interest in the content. Conversely they would appear to return to the game experience when near or interacting with virtual content. As a result there were often large gaps between locations when there was little for players to do, and therefore they did not appear to be part of TimeWarp game space. While this is not always a problem it can lead to users feeling bored, which is not desirable. Therefore there is a need to bring reality into the virtual game world, either through the use of path structures in real space which can excite the user, or by allowing real objects or people (non-players) to become part of the game experience. The range of themes uncovered during the study are heavily geared towards the idea of letting people interact within a new place which is a blend of real and virtual, rather than focussing purely on the virtual experience.

As noted later many of the evaluation methods used were heavily geared towards purely virtual experiences and thus ignore these blends. Furthermore they did not permit an adequate examination of such themes, in particular allowing the detection of where problems arose or how to rectify them. While certain themes such as seamfulness and attention have been explored by others a more detailed analysis is required, in particular how to support evaluators and designers of mixed reality experience on issues such as selecting appropriate paths, or making more effective use of the locale. Additionally there is also a need to explore methodologies which can support the detection of such issues. Approaches such as MEC and the Place Probe,

do not allow for an examination of when switches or breaks in presence occur. While observation does to a limited extent illustrate when people start interacting with virtual objects it only provides a very crude approximation of when people switch in and out of an experience. Further details can be drawn from interviews, but these are post experience and thus are again not ideal. Alternative methods such as measuring breaks in presence (Ijsselsteijn, De Ridder, Hamberg, Bouwhuis, & Freeman, 1998) allow people to self report during the experience but require the user to carry yet more equipment and may in themselves cause breaks in presence as people need to interact specifically with the measurement device.

7. Conclusion

The study presented in this paper uncovered a number of themes which are relevant to the design and evaluation of mixed reality games. However to date many of the themes are not adequately addressed by existing presence research and there is a need to focus on developing methodologies which explicitly deal with the complexities of mixed or augmented reality environments. In addition to the themes it is our belief that the complex cues which form part of mixed reality games require a variety of methods to be adopted from observation through to interviews, as it was through this approach that the current themes emerged. The work presented here is not complete but rather is intended to help people understand some of the issues related to developing such games and to inform the development of future design and evaluation methods. In our future work we intend to develop methods which will allow the evaluation of systems based around the themes highlighted earlier.

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