3PI Experiment: Immersion in Third-Person View

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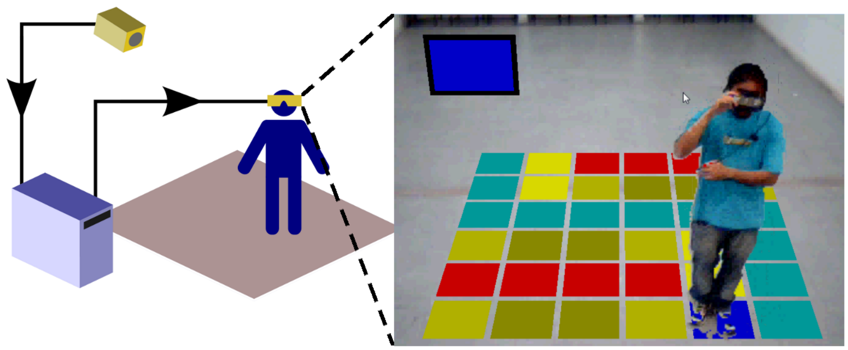

Figure 1: *The third-person immersive interface. Left: system diagram; Right: view experienced by the user*

Abstract

In this paper, we present the results of the "3PI Experiment" project. The objective of this project is to propose and evaluate an immersive interface based on a third-person view from a video camera, that can be used in augmented reality games. Since this type of interface has not been explored in games, a prototype involving interaction through navigation was developed and employed to assess the impact of the proposed interface on gameplay experience. Different user interface evaluation methods such as cognitive walkthroughs, automatic data collection and questionnaires were combined. It was possible to determine that the proposed interface caused no significant discomfort and had a short learning time, making it suitable for use in games.

CR Categories: H.5.2 [Information Interfaces and Presentation]: User Interfaces—Evaluation/methodology, Interaction styles; K.8.0 [Personal Computing]: General—Games

Keywords: game user experience, user interface evaluation, augmented reality

1 Introduction

Providing new user experiences and increasing user immersion have been goals of the electronic game industry for many years. The current generation of game consoles have been accompanied by several different input devices, from motion-sensing controllers to digital cameras, aiming to create new ways for players to interact with games. The use of Augmented Reality in games is another alternative for the creation of new forms of user experience and interaction. A game using augmented reality displays a composition of real and virtual elements in the same medium; according to Azuma [1997], an augmented reality system must also allow real-time interaction and perform 3D registration between the virtual and real elements.

The use of a third-person point of view is common in electronic games, especially those where awareness of the surroundings of the entity controlled by the user is important, such as team sports games and action-adventure games. On the other hand, immersive environments – using head-mounted displays (HMDs) – have been used for many years for training, simulation and other applications, but the prevalent display perspective is that of a first-person view. It can be argued that such point of view is more intuitive to users who are deprived from the view of their surroundings by wearing a HMD. However, that does not imply that other alternatives are not viable nor have their own advantages.

This paper presents the "3PI Experiment" project, which was motivated by the above observations. The main objective of this project is to develop and evaluate a novel augmented reality interface for

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games. Players wearing a HMD can observe themselves from an external point of view captured from a digital video camera – hence the name "third-person immersion" or 3PI. A prototype version of a game using the proposed interface has been implemented and used to perform evaluation tests, described in this text. Figure 1 presents a simplified diagram of the system implementation and the third-person view experienced by a user of the game.

2 Immersion and Presence

In this work, we use the term "immersive interface" to refer to human-computer interfaces that aim to increase the sensation of presence on the user, including 3D interfaces [Bowman et al. 2005], tangible interfaces [Ishii and Ullmer 1997] and augmented reality interfaces. By increasing the player's sense of presence we facilitate his engagement into the activity in course. As a consequence one should expect the player to have fewer impediments to entering a flow state, which was described by Csikszentmihalyi [1991] as "being completely involved in an activity for its own sake. [...]Your whole being is involved, and you're using your skills to the utmost."

Back in the 1960's decade Sutherland [1968] had developed the first HMD and had already proved the concept of the sense of presence in virtual environments, by making a person wear a HMD connected, by a video camera, to an external view from the top of a building. When the camera looked down the street from the rooftop, the viewer panicked [Carlson 2003].

For the International Society for Presence Research (ISPR) "Telepresence, often shortened to presence, is [...] a sense of 'being there' in a virtual environment and [...] an illusion of nonmediation in which users of any technology overlook or misconstrue the technology's role in their experience."[ISPR – International Society for Presence Research 2009]. Biocca [1997] identifies three types of presence: Physical, the sensation of 'being there'; Social, the feeling to be with someone else; and Self presence, a mental model, created by the user, for his own body inside the virtual environment.

We believe that by putting the vision of the player's body inside the arena where the play is taking place, and giving him a third person visualization of himself, the player will, at the same time, ignore the technology's role in the process, thus increasing his sense of presence, and construct a more realistic model of self presence, imagining that he really is walking over the game arena.

3 Evaluation of immersive human-computer interfaces

Although there is a large body of knowledge regarding the evaluation of human-computer interfaces, there are comparatively fewer studies related to augmented reality interfaces [Dünser et al. 2008]. Bowman et al. [2005] discuss the specific features of 3D interfaces that interfere on their evaluation, such as the influence of the physical environment, the possible need of multiple evaluators, the difficulty of defining the relevant characteristics of the target user population, and the lack of standards in this type of user interface. Because of these difficulties, those authors recommend the use of multiple evaluation techniques and metrics when assessing the characteristics of 3D user interfaces.

The formal evaluation of game interfaces is also a relatively recent topic. The works collected by Isbister and Schaffer [2008] present different views on the subject; the discussion about Player Experience by Lazarro [2008] is particularly interesting in the context of our work. Although that author concluded that traditional usability analysis techniques may not be well-suited for games, the authors believed that a formal evaluation of a new game interface, such as the one proposed in this paper, is invaluable to determine its characteristics and consequently, its applicability.

4 Related works

Augmented reality games have been explored in the last few years. A commercial example is the Eye of Judgement[1] game for the Playstation 3 game console, and different games for smartphones and other handheld devices have been announced. In the academia, there are various projects involving different technologies, such as table-based augmented reality games [Magerkurth et al. 2005], immersive displays and tangible interfaces [Ohshima et al. 1998] and handheld devices [Wagner et al. 2005]. A comprehensive survey of augmented reality games can be found in [Bernardes Jr et al. 2008].

Of particular interest are projects that present an external view of the user. One such project is the martial arts game developed by Hämäläinen et al. [2005] where users can see themselves inserted in a virtual scenario, and use that view as a reference to perform their actions. However, given the nature of that application, the user maintains the view of his surroundings, which is different from our proposal. A relatively common interface metaphor in augmented reality systems is that of a mirror that presents the reflection of the user merged with virtual elements. Examples of this technique include the "magic mirror" described by Fiala [2005] and the training system proposed by Kuramoto et al. [2009]. As in the case of Hämäläinen et al. [2005], mirror interfaces are not meant to occupy the user's whole field of view. We did not find in our research, projects that proposed a third-person view interface presented through a head-mounted device or similar immersive display.

5 Description of the third-person immersive interface

Our proposed interface consists of presenting users with a third-person view of themselves, obtained from a fixed video camera and processed to perform the registration and interaction with virtual elements. In the current proposal, a HMD is worn by the user, so that only this image is visible to him.

To evaluate the interface in third person, a puzzle game with rules similar to "Mined Out" or "Minesweeper" was developed. The choice was made because this kind of game requires a context view of the field and it has a adjustable mental workload depending on the number of mines and the size of the field [Grabisch et al. 2006].

Two versions of the puzzle game were developed. The first one shows a purely synthetic image on a conventional display and is played through a standard computer keyboard. As will be explained on the next section, this version was used to get the test subjects acquainted with the rules of the game. Figure 2 shows a screen capture of this version.

The second version of the puzzle is intended for use with a digital video camera – even a simple "webcam" – and a HMD. Interaction in the immersive version is driven by navigation of real space by the users. As they move around, their position is matched against the virtual minefield. A virtual information panel displays how many mines exist in neighboring cells, both as a series of small marks and through color-coded information – warmer colors indicate more mines. If the user steps on a cell containing a mine, the current game session ends.

A block diagram representing the system architecture is presented

[1] http://www.us.playstation.com/EyeofJudgment/

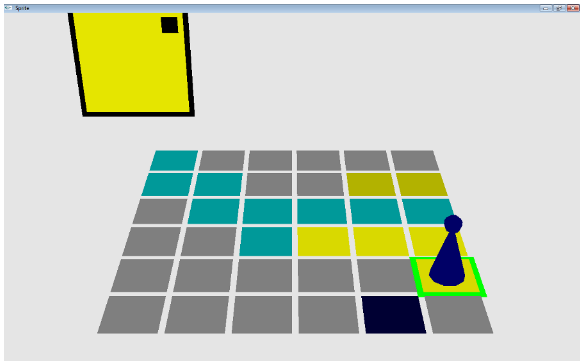

Figure 2: *Keyboard-driven version of the puzzle game*

in Figure 3. Initial calibration of the camera position relative to the ground plane is performed by detecting a fiducial marker, using the ARToolkit library [Kato and Billinghurst 1999]. The user's silhouette is segmented from the video frame by means of a background subtraction technique [Piccardi 2004]. The registration of the user's position on the virtual game board is performed as follows: first, an axis-aligned bounding rectangle of the user's silhouette is calculated. The coordinates of the midpoint of the bottom edge of the rectangle are then used in a picking operation against the 3D primitives of the virtual board. The picking operation can be implemented through OpenGL selection mode.

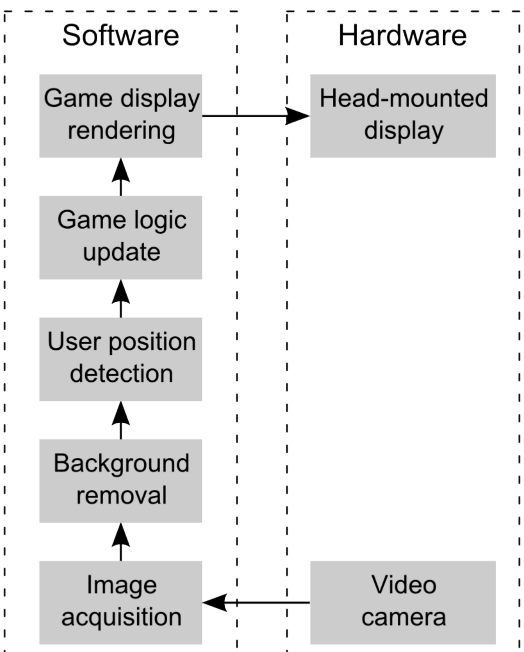

Figure 3: *Block diagram representing the main subsystems and information flow of the immersive mine puzzle*

6 Methodology

Three different evaluation methods were adopted: cognitive walkthroughs [Polson et al. 1992], indirect observation through automated data recording and formal evaluation through questionnaires. The cognitive walkthrough was performed by four students involved in the development of the interface. To realize the evaluation of the interface (for both indirect observation and questionnaires) 47 subjects volunteered. During these tests, an i-Glasses PC3D Pro head-mounted display was used, along with a Microsoft LifeCam VX-6000 for video input.

6.1 Test Procedures

The procedures for the cognitive walkthrough were simple. Each participant had to do certain predetermined tasks inside the immersive environment and from those tasks he would evaluate the environment in three aspects: illumination, coherence of visual elements and visibility.

For the other evaluation methods, the procedures followed a strict set of steps:

1. Read and sign the research consent term;
2. Play the keyboard-controlled version of the game for clarification on the rules of the game:
    - Two game sessions in a field without mines, to get familiarized with motion control;
    - Three games with mines, to understand the rules of the mine dodging puzzle;
3. Play the third-person immersive game version:
    - Two games in a field without mines, to get used to walking inside the environment;
    - Three games with mines to avoid;
4. Answer the evaluation questionnaire.

While the subjects were playing the game on the keyboard-controlled and on the immersive game, the software recorded the delay between the steps taken by the user inside the game. This system is similar to the tools for Tracking Real-time User Experience (TRUE) [Kim et al. 2008] to get quantitative information from user experience. The analysis of these session logs consisted in the third evaluation method.

6.2 Data analysis methodology

To evaluate the feasibility of the interface for use in augmented reality games, we proposed a set of hypotheses that should be tested:

1. While there may be difficulties in the use of this innovative interface (such as adaptation to the HMD, handling the data cables, orienting oneself in third-person view), their perception by the user does not depend on his or her degree of experience with the use of computers or 3D interaction;
2. The decision time between actions in the application does not depend on the user's previous experience;
3. The interface aids in the resolution of problems that require an analysis based on context and, in general, users do not suffer significant physical or mental discomfort while using the interface.

From the questionnaires and from the tool for tracking the time users took to make decisions inside the game, we analyzed several variables: knowledge of computers, familiarity with immersive interfaces, familiarity with third-person view 3D games, time between decisions (steps) in the game, and the qualitative answers of the questionnaire.

7 Results

7.1 Cognitive walkthrough

Most problems detected while performing the cognitive walkthrough of the prototype were related to the size of the cells of the minefield, sensitivity of the video camera to changes in room lighting and limitations in the resolution and field of view of the HMD. The first category of problems was solved by modifying the size of the board cells, and the second category was avoided during the formal tests by using a room with controlled lighting. While it was not possible to obtain other models of HMD for this experiment, that may be a possibility in the future.

7.2 User evaluation

The first step in the analysis of the tests was to classify the 47 subjects in user groups based on their profile. At first, we intended to separate the users in four groups:

1. Users with little to none computer experience;
2. Users experienced in the use of computers, but with little or no experience with 3D Interaction and games;
3. Users experienced with 3D Interaction and games, but not with a third person view;
4. Users experienced with third person 3D computer games.

After analyzing the questionnaires, however, we realized that only two users fit in the first group, and only three in the third. From them on, we treated groups one and two as a single group of users without 3D experience, with a total of 22 users, and groups three and four as the group of users familiar with 3D interaction, with 25 users.

After these classifications, the questionnaires also provided clear evidence in favor of a couple of hypotheses. Regarding the difficulties perceived by the users, there is no statistical difference between what is reported by users of both groups. Both groups of users also found the third-person immersive experience pleasant, causing no significant physical or mental discomfort.

Most users of both groups reported that their adaptation to viewing themselves in third person was fast or very fast. No user answered that this adaptation was very slow and only two out of forty seven found it slow, and both belong to the group that had no experience with either 3D interaction or third person view. Not only was the adaptation to the third person view considered fast, users reported that it caused little or no problem. In a scale where 1 means it causes little or no problem and 5 that it caused severe problems, the average answer for both groups of users was below 2 and the answer mode was 1. The same happened to problems caused by the lower resolution lower resolution of the images displayed by the HMD, despite the fact that we were initianlly concerned about whether it would hinder the interaction.

The game's playability using the third-person immersive interface was considered good by most users, on average. With 1 meaning very good and 5 very bad, the average answers for both user groups was very close to 1. Most users of both groups answered they were very convinced or convinced that this form of interaction should be used in other games and applications.

The two problems users found most severe where the time it took to adapt to the use of the HMD and the cables attached to the HMD hindering movement. In a scale where 1 meant fast adaptation and 5 meant very slow, the average value assigned by both groups of users, with and without 3D experience, was slightly above 3. Experienced users, on average, complained more about this, and their mode for this answer was 5. The mode for users without 3D experience was 4.

Another problem also graded as severe by many users was a difficulty to walk on the game board. This is correlated to a difficulty in orientation. The test boards were set up so the user would be facing towards the camera if walking forward from the initial point to the target. Users had no problems when walking with one side of their body or with their back turned to the camera, or when moving back and forward, but when facing the camera and stepping sideways, the movement they saw was mirrored in relation to the direction perceived by proprioception. Simply mirroring the HMD images caused problems when the users had their back or a side turned to the camera, so we opted for not mirroring the images and seeing how users adapted to it. In general this caused relatively few mistakes during the tests (as in a user stepping right when he or she meant to go left) but was reported as one of the cognitive difficulties when using the interface.

The times between each step, both in the PC and the immersive version of the game, were collected for only eight of the forty seven users, three of whom had experience with 3D and five who did not. These results, therefore, have less statistic precision than those obtained in the questionnaires. Some tendencies can be observed, however. The first step in each board was discarded from this analysis, because it includes a large setup time for the system and eventual explanations or conversations with the user.

When there are no mines on the board (and thus the problem becomes one of simple navigation instead of puzzle solving), users with 3D experience performed consistently and significantly faster than those without. Both groups of users showed improvement from their first contact with both the PC and the immersive interfaces to the second time they used it, to thread a path twice as long, but still without mines on the board. Experienced users, however, showed only a small improvement in the time between steps when using the PC interface, with which they were already familiar, but great improvement when using the immersive interface (in the second time, each step took, on average, only 42% of the time spent in the first time). Users without 3D experience showed similar improvement the second time they used both the PC and immersive interfaces, larger than the improvement experienced users had with the PC but smaller than their improvement in the immersive environment. When no mines were present, using conventional interaction was much faster than walking using augmented reality (aproximatelly eight times faster or more).

When mines are present, however, this ratio between the times spent in the Immersive and PC interfaces falls dramatically. First, the difference that existed between experienced and inexperienced users looses any statistical significance in this case. In the first board with mines (but only a few and not placed close to the target), using the immersive interface takes only twice as long as using the keyboard and monitor. For a second, similar board, however, still with only a few mines but which are now closer to the target (making the problem slightly more complex), the use of the conventional interface takes longer than before, but using the immersive interface actually takes less time despite the more complex problem (a strong indication that users were still learning how to interact in that way, but learning fast). In this case, the immersive interface consumes less than 20% more time than the conventional one. And while our tests do not separate the time taken to make the decision from the time taken to actually move on the board, walking remains considerably slower than tapping the keyboard just as when there were no mines, so we believe most of the gain in relative speed from the immersive interface comes from reduced decision times.

The test data, including all questionnaire aswers and the raw time data recorded for the eight users, is available by contacting the authors and will be posted on a webpage for the project.

8 Conclusion

The objectives, metholodogy and results of the 3PI Experiment have been presented on this paper. It was possible to determine, from our evaluation tests, that a third-person immersive interface is a viable alternative to be explored in electronic games, with most problems being related to HMD limitations. The same evaluation methodology could be applied to other novel game interfaces, in order to determine their feasibility, not in technical terms but in the way that they affect the game experience.

The authors intend to continue the research on this interface. Future works include the development of new game prototypes with other interaction styles with game entities, including collision detection – as well as studying the effects of visual occlusion by virtual entities in the game experience. Since this interface inherently motivates players to physically move around, analyzing it under the framework proposed by Mueller et al. [2009] may also lead to useful results.

While the comparison between the conventional and immersive interfaces showed some interesting results, we believe it would be more interesting to compare an immersive first-person interface with immersive third-person, comparing both the sense of immersion and the problem-solving capabilities (especially when contextual data is necessary) and that is one future development planned for this work.

Another interesting future work, more related to implementation than to testing, is to determine when the user is facing the camera or not (for instance using face detection algorithms) to decide when to mirror the user's image in the HMD, to minimize the orientation and walking problems related by the users.

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