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Interactive augmented experiences for cultural historical events

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Abstract

This paper presents a project called Bidaiatzera based on Augmented Reality technologies for leisure and educational applications with tourist, cultural or socio-economic contents. Augmented Reality technologies provide a seamless interaction with both real and virtual worlds, so that the player can see the real world with superimposed 3D graphical objects providing additional information. Sua is the first prototype based on the board game metaphor with a board, a die and tokens, enhanced by some augmented cards. The player can revive the historical events that took place in Donostia-San Sebastian city in 1813 using Mixed Reality technologies while interacting with other players. This first prototype has been assessed in a real scenario with different target users.

Categories and Subject Descriptors (according to ACM CCS): I.3.4 [Computer Graphics]: Graphics Utilities

1. Introduction

Playing games has always been an important part of human life. Board games have been played for literally thousands of years contributing to fun, relaxation and education. Although nowadays computing technology has brought forth a multitude of gaming alternatives to those traditional board games, the former are still going strong even over modern computer games in many countries around the world.

The unbroken success of old-fashioned board games clearly relates to the social situation associated with them. Almost all of these games have been designed for multiplayer use and game sessions are often organized as social events, where friends spend time together in a cohesive manner. The social situation is very rich, because players sit together around the same table, they look at each other to interpret mimics and gestures, which may help them understand the others' actions, they may laugh together or even shout at each other.

Additionally, many board games include beautiful and sometimes custom-painted playing pieces that feel good to touch, collect and place on the game board. Even though these tangible components and game boards contribute to the enjoyable user experience, their purely physical nature also narrows down the range of realizable games and sometimes leads to awkward interaction patterns. Whenever dynamically changing game worlds, complex game rules, or multimodal stimulation are desired, the static nature of traditional board games does not allow the implementation of believable and immersive game concepts.

On the other hand, playing computer games introduces many highly interesting possibilities that enhance game play. Game presentation is augmented with audio and visual support and game content is limited only by the imagination of the developers. Players can get immediate feedback on their actions in the game world which fosters emotional involvement and the feeling of immersion into the game.

This paper presents an ongoing project called Bidaiatzera based on Augmented Reality technologies for leisure and educational applications with tourist, cultural or socio-economic contents. Such technologies provide seamless interaction with both real and virtual worlds, so that players can see the real world with superimposed 3D graphical objects providing additional information. Within the Bidaiatzera framework, Sua is the first prototype based on the

board game metaphor with a board, dice and tokens, enhanced by some augmented cards.

The paper is organised as follows. Section 2 briefly summarizes some of the existing projects related to Augmented Reality technologies applied to Cultural Heritage and entertainment. The objectives of the project are described in Section 3. Section 4 deals with the methodology for content selection, the virtual reconstructions and the storytelling. In Section 5, the technical components of the system are presented, including hardware and software, the tracking of the markers and the implementation of the game. Section 6 describes briefly the main conclusions from the evaluation of the prototype in a real museum. Finally, Section 7 includes the conclusions and further improvements for the prototype.

2. Related work

Traditional board games such as Chess or Go have been popular for thousands of years; they are still strong today despite the arrival of attractive computer entertainment technology. Their success can clearly be attributed to the direct interaction and communication between the players, who sit together around the same table, facing each other at a short distance.

The lack of computing technology necessary for multimodal stimulation with audio and visuals, or smart and proactive behaviours hinders the implementation of many believable and immersive game concepts. Psychologists claim that one of the drawbacks of computer games is the lack of social interaction in a face-to-face setting, which board games provide. At the same time, computer games offer the attractions of computer technology, which board games lack. Therefore, it is only a natural evolution to combine the benefits of computer and board games into a novel type of augmented board game to provide new and engaging gaming experiences.

Although there has been considerable research in how Augmented Reality (AR) technologies can be used in industrial, medical and scientific applications, there has been less work on their application in an entertainment setting. Milgram's vision of a continuum between reality and virtuality can be applied to such settings as a way of enhancing user experience [MK94].

There are several characteristics that differentiate AR games from other types of games. AR systems track a full range of motions of the user so that a wide range of physical interactions, including location, gestures or posture, can be used. Physical objects may also be tracked, allowing the use of props, sport equipment and more. In AR settings, players are not immersed in virtual environments, rather, virtual elements are added to the real world, which provide playing areas and can also affect players in ways impossible for computer games.

Moreover, the ideal entertainment experience comes from the combination of physical experience, virtual content, storytelling and the imagination of the user. AR offers both physical and virtual aspects, leaving creative designers to stimulate the imagination.

One of the key characteristics of AR interfaces is their ability to overlay virtual information on an outdoor environment. As a clear example of this outdoor entertainment experiences, the German Geist project [Bra03] focuses on the benefits of AR games in outdoor environments. Storytelling and an immersive atmosphere in a historical adventure game set in the 17th century in Germany are crucial, using the Heidelberg castle as the real scenario. Players explore the castle and interact with virtual characters to solve various adventure puzzles associated with them.

As significant computing and graphical power has become available on the handheld platform during the last years, researchers have begun to explore the use of Personal Digital Assistants (PDA) for AR applications. The potential of these applications is shown by ARQuake [TCD*02], where players can navigate a Quake level by walking around in the real environment and shoot their enemies using a handheld plastic gun. This particular project uses GPS, compass and vision tracking in order to place the position of the player. Although the game requires the use of a bulky wearable computer, it demonstrates the ability of AR to merge normal outdoor games with computer games.

Moreover, several cases that deal with cards and patterns based on AR technologies based on ARToolKit have been analysed. Many of them use an individual device such a Head Mounted Display for visualizing the rendered 3D content. One example can be the Battleboard 3D project [AKNG04], which was an interesting integration of real Lego pieces with an AR game. The experience focuses on games between children and found that while children were pleased with the personal viewpoint afforded by Head Mounted Displays, they had some trouble communicating among them.

The BlackMagic Kiosk [WBL*03] uses AR presented as a MagicBook to tell the history of the America's Cup. When people look through a handheld visor at the pages of a normal book, animated virtual models leap out of the pages. While 3D images appear attached to each right-hand page, normal text provides background information on each left-hand page. As the computer knows which page is being viewed, it can also trigger other events relevant to the current page such as narration and sound effects. As an extension of this concept, the AR Volcano Kiosk is an exhibit that teaches people about volcanoes, including details on subduction, rifts, the Ring of Fire, volcano formation, eruptions and tectonic plates. It is a six page AR book, attached to a turntable and viewed through a handheld visor.

Furthermore, the S.O.L.A.R. System is an educational exhibit that teaches people aboout the position of each planet in the Solar System [WBL*03]. Using a set of nine AR planet

cards, participants place each planet orbit around the Sun. When all of the planets are in their correct locations, they begin to orbit the Sun at accurate relative size and speed. The surface of each planet is highly detailed and based on accurate satellite imagery.

Finally, several approaches have combined AR technologies with board game concepts. For example, in the Invisible Train game [WPLS05], two players control their virtual trains on a real wooden miniature railroad track. The virtual trains are only visible to the players through the PDA's video see-through display.

One of the more elaborated platforms in the field of Augmented board games is called STARS [MMES04], which consists of a dedicated hardware setup of devices such as public vertical displays and Personal Digital Assistants (PDAs) centred on a smart interactive table. The central component of each STARS game is an interactive game board on which the respective game boards are displayed. Physical playing pieces provide a tangible interface that feels similar to the interface of traditional board games. The playing pieces are detected by an overhead camera that also determines the positions of the players by tracking their hands as they reach over the surface of the table.

Another interesting research prototype is Smart Jigsaw Puzzle [Boh04], a hybrid board game that augments the physical pieces of a jigsaw puzzle with RFID tags. The underlying RFID reader technology is linked to a PC application that displays a virtual representation of the jigsaw puzzle's physical state. The game supports a one-player solitary game mode and a competitive game mode for two players.

Finally, Hybrid AR Worms has been an attempt to port the popular PC game Worms to a board setting using AR [NLL04]. The game area is a large table set up between the players. Each player wears a Head Mounted Display with an attached web camera. The game area is augmented with a deformable 3D terrain, with worms laid out randomly across it. During the validation sessions, there were some limitations due to the AR hardware in use.

3. Objectives of the project

The aim of the Bidaiatzera (Let's travel in Basque) project is the development of leisure and educational applications based on Augmented Reality technologies including tourism, cultural or socio-economic contents. These technologies provide seamless interaction with both real and virtual worlds, so that players can see the real world with superimposed 3D graphical objects providing additional information.

The main objective of the first prototype of Bidaiatzera, the Sua (fire in Basque) game, is the recreation of a historical event using new technologies in order to disseminate it to the general public. Therefore, the application should be based on a well-known game dynamics, with a set of rules widely known among different target groups of players. Thus, the application has been developed following the Goose game approach as the game is mostly played in Europe and seen as family entertainment. Moreover, the design of the game should force players to take an active role, which is achieved by their physical interaction (players are their own token).

Sua recreates the siege of the Donostia-San Sebastian city by the Anglo-Portuguese troops to free the city from Napoleon's French army in 1813. The prototype includes virtual storytellers who narrate the historical events from several points of view. Augmented cards are provided for each of the 19 squares of the game, so that players can interact with 3D virtual reconstructions of soldiers, walls and other key elements of the story. Moreover, each square has an associated 30-second 3D multimedia video, which further explains the historical events in a chronological order.

One should note that Bidaiatzera can be considered an application of informal educational games to Cultural Heritage, as historical events are narrated in an attractive and interactive way. Educational games represent a new type of product where the pedagogical approach is integrated with the gaming aspects that are so motivating and engaging.

Current museum visitors want to know, experience, see and touch even in a virtual way. They look for enjoying experiences from which they could learn something. Therefore, it is crucial to achieve an effective communication and make them be part of what is going on. AR technologies implemented in the Sua prototype and in the whole Bidaiatzera project should allow more collaborative and interactive approaches to innovative exhibitions, with a bigger implication of the public.

4. Historical content design and generation

4.1. Selection of the historical event

As it has been mentioned before, the Sua prototype is a story narrated by some of the characters that had a starring role in the events that took place in the city of Donostia-San Sebastian from the 28th of June to the 8th of September 1813. In 1808, Napoleon Bonaparte leading the French army, conquered Spain with the objective of invading Portugal. Britain could not permit the invasion of Portugal due to the strategic location of the country. Therefore, they formed an alliance with the Portuguese and Spanish troops to expel the French army from Spain.

Little by little, the British army led by the Duke of Wellington forced the French army to retreat to the city of Donostia-San Sebastian. After suffering a siege from the Anglo-Portuguese troops who came to free it, the city was burnt by the liberation army on August 31st before the French army surrendered.

Although several themes related to the history of the city

have been assessed for the validation scenario, there have been several reasons for choosing the siege and the fire-raising of Donostia-San Sebastian city in 1813 for the real implementation of the Sua prototype. On the one hand, a participant of the consortium has already organised several workshops related to this historical episode, so a significant amount of information was already available.

On the other hand, the Town Hall of the city has promoted a City Museum related to the collective memory of Donostia-San Sebastian. Although each year the city celebrates the day of the fire-raising, many citizens know nearly nothing about the real historic events that motivated the fire-raising. Moreover, war and battle issues provide a very attractive environment for the application of 3D modelization techniques to recreate non-existing historical elements of the city (castle and walls of the city for example).

Regarding the historical documentation methodology, it must be mentioned that the fire-raising burned almost all the city archives, both public and religious. Therefore, in order to document the project, several maps, books and documents published out of the city have been used, mainly coming from British archives.

4.2. 3D virtual reconstruction of the city

The reconstruction of the walled city has been based on collected graphical documentation, enhanced with graphical and written descriptions from other historic documentation and some scale models (Figure 1). For instance, the Town Hall which was completely burnt during the fire has been reconstructed on the basis of a black and white reproduction of the facade of the Town Hall of the city of Oñate, from the same region and similar historic period.

Figure 1:

Virtual reconstruction of Donostia-San Sebastian city.

The reconstruction has been historically validated by historians and curators, as one of the main objectives of the project is informal learning to enhance collective memory. Therefore, all the details of the reconstruction of the city have been carefully analysed and cross-checked with several recognised authorities.

4.3. Virtual storytellers

Four main participants narrate the story they are living in Donostia-San Sebastian in 1813 (Figure 2). These characters represent both sides of the battle: two French soldiers, Louis Doupont and Pierre Blanchet, who lived in the castle, and two soldiers from the Anglo-Portuguese side, John Griffith and Manoel Pereira, who came to free the citizens. The selection of the characters has been a key aspect in the storytelling. Therefore, they have been dressed and physically characterized as close to the historical age as possible in order to enhance the realism of the experience.

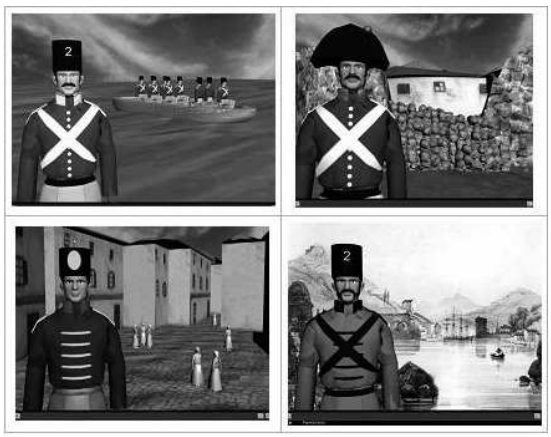

Figure 2:

Charaterization of the avatars.

Due to the different personalities of the avatars, their voices have been recorded by different actors so that players can identify themselves with the corresponding avatar. The audio of the experience has been complemented with sound effects such as cannon shots, sea sound, shouts and so on. Moreover, the story is narrated in first person, so that a dialogue is established between the avatars and the players in order to provide an interactive and collaborative experience.

4.4. Storytelling techniques for script writing

The script has been written by a professional scriptwriter, who has worked with the historians in the definition of the required contents to fulfil the informal learning objectives of the experience. The script summarizes the events from the 28th of June to the 8th of September of 1813, divided in 18 episodes (one for each square of the game board). Two additional squares (number 1 and 20) have been added as an introduction and conclusion in order to place the events in the historical context.

The first audio-visual content presents the way each avatar is dressed, so that players can identify themselves with their own virtual guide. There are many episodes which recreate the life inside the walled city, including both the life of the citizens during the siege, and the life of the Anglo-Portuguese army in the ships outside the walls (Figure 3).

Figure 3:

Anglo-Portuguese troops on the Survillante.

The final episodes are related to the final battle and the fire-raising by the Anglo-Portuguese troops. The way the fire spread out through the city has been recreated in some of the episodes (Figure 4). Other episodes render the surrender of the French army and the abandoning of the city from a well-known tourist Point of Interest in the city called La Brecha (The gap). Although most of the citizens do not know, the origin of the name of the place refers to the weakest point of the walls of the city in 1813.

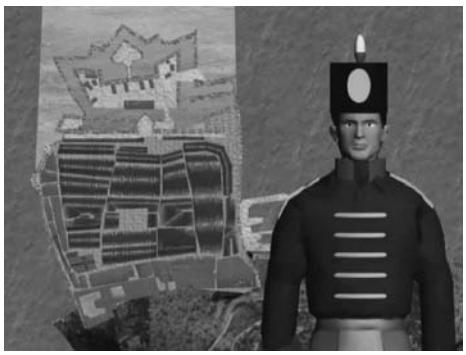

Figure 4:

Fire-raising by the French army.

One of the main challenges that the scriptwriter has faced is to avoid redundancy among contents. In order to make the game dynamic, the story told by each of the four avatars is complementary. Imagine that four players are playing, two from the French side and the other two from the Anglo-Portuguese side. If two players from the French side drop on the same square during the same game, the information provided to each player is different and complementary. This enhances multiple combinations for the same player: the more the player plays, the more complete will the information about the historical event be.

5. Description of the Augmented game

The board game has been implemented as a two, three or four player game. The prototype is composed of a 3.8 x 3.5 m board, with a track with 19 squares; a projection screen and a six-sided piped dice in the range from one to three as shown in Figure 5. The board is a copy of a 2D map of Donostia-San Sebastian in 1813 (walls, trenches, houses). Each square has an additional card with the approximate size of a DIN-A4 sheet. One of the sides of the card has a pattern in order to be recognised by the tracking system.

Figure 5:

Physical set-up of the Sua prototype in the real validation scenario.

Each participant has an associated avatar, who will be his/her virtual storyteller. In order to enhance the immersion of the participants, they are encouraged to get dressed as the virtual avatar.

The information is displayed in two phases. The player throws the dice, counts and picks up the card on the square, showing it to the camera of the tracking system. The computer recognises the pattern and displays the corresponding 3D model on the screen (boats, city map, Town Hall, citizens). The player can rotate the pattern so that the point of view of the 3D object is adjusted in real time to the point of view of the player.

After a predetermined time, the screen displays an episode of the battle which is narrated by the corresponding avatar. Each avatar is standing in front of some scenarios in the virtual reconstruction of the city, which has been populated with different avatars representing the citizens.

6. Technical implementation of the prototype

6.1. Hardware and software components

The prototype includes two main hardware components: a camera and a PC. The selected camera is responsible for the acquisition of the images for pattern recognition. The main requirements for the camera are:

- The camera should be oriented to capture the whole board. Players staying on the board will show the cards to the camera depending on the square they are standing on. The camera should capture the whole pattern in order to identify the corresponding 3D object using image recognition techniques.
- The captured image should be as vertical as possible, so that, when the patterns are displayed, the image should be completely plain.
- The recorded image should have a good resolution.

Taking all these requirements into account, we have selected a CV-M50-IR JAI camera on a 2.5 meter high tripod. It is a high-resolution camera (756 x 582 pixels) with an analogue output. The PC includes an image recorder to digitize the camera signal and process it for pattern recognition. A Nvidia Gforde graphic card for rendering 3D objects and multimedia contents and a minimum of 1GB of RAM are additional requirements.

The Sua prototype has been developed in C++, which is specially designed for the development of Microsoft Windows DirectX APIs. Two additional libraries (ARToolKit and Quick Time SDK) have also been used to fulfil the required functionalities. While the former is used to track the patterns of the card on each square, the latter activates the multimedia contents which narrate the historical episodes.

6.2. Tracking system based on ARToolKit

We have used ARToolKit for the optical tracking of the cards. It is a cheap marker-based optical tracking system that can be easily integrated into an AR system. Only a camera is needed for the tracking of the markers. A marker or a pattern is a square piece of paper which can be produced using a normal printer. It has to contain a black frame, a white frame inside and a unique symbol in it.

Eighteen patterns had to be created for the dynamics of the Sua prototype (as many as squares). These patterns must be completely different from each other, without any type of symmetry. Since existing standard database only includes ten patterns, the markers have been generated using several spectra from the cosine function.

Once the markers have been generated, the following process has been completed. First, a basic pattern is opened, which includes a black frame with a white square inside where the pattern or marker is drawn using a graphical editor. The result is printed on a 120 x 120 mm sheet. Then, the system should recognise and store the generated patterns. The pattern is shown to the camera in similar environmental conditions (light, background, distance) as the ones in the real validation scenario. When the pattern is recognised, the black frame is highlighted with a red and green line. This pattern is saved with a name in order to be univocally retrieved afterwards. The process is repeated for each of the patterns.

6.3. Generation of the 3D objects and the multimedia content

Once one of the players throws the dice and moves into the corresponding square, the pattern of the card is shown to the camera. The system identifies the 3D object depending on the player and the square and the multimedia content is displayed on the screen.

Therefore, virtual models have been designed for the generation of both 3D objects and multimedia videos using the Studio Max software. The implemented 3D models have been exported to VRML format so that the 3D objects could be rendered taking into account the point of view of the player and the camera. 72 models or 3D objects have been created, four for each of the 18 squares. The game application keeps track of the game and displays the proper content to each player although there is only one card per square (Figure 6). Some of the 3D objects for the AR application have been used in more than one squares.

Figure 6:

Graphical objects rendered on the cards using ARToolKit.

Once modelled with the 3D Studio Max tool, the multimedia audio-visual content has been created. The modelling tool can also animate the models, building different short

movies about an episode. Finally, audio narrating the corresponding scene for each square has been added. We have used Quick Time SDK for the generation of the final videos (Figure 7).

Figure 7:

Multimedia content related to one of the squares.

The final step in the process is the definition of the correspondence among the patterns, 3D objects and audio-visual content. This means that we have to specify the 3D objects that should be rendered on each of the patterns and the associated audio-visual content.

6.4. Generation of the Sua application

The game dynamics has been designed and programmed. The developed application is based on Visual Studio, using the additional ARToolKit and QuickTime SDK libraries.

Before starting the game, several parameters must be defined, such as the number of players that will take part (two, three and four), the language of the audio-visual content (Basque or Spanish) and the player (French or Anglo-Portuguese) who starts the game. A user-friendly interface has been implemented so that the conductor of the game can easily update the game parameters.

Once the number of players and the language for the audio-visual content have been defined by the conductor of the game, the first player throws the dice. Depending on the result, the player moves to the corresponding square, showing the card to the camera. The tracking system identifies the card, rendering the corresponding 3D object on the pattern depending on the player and the number of the square. Moreover, the player can rotate the card so that the image is rotated as well in real time. After some predefined time, the audio-visual content will be rendered on the screen.

Therefore, the game management has three main interruptions: searching for the patterns and the corresponding actions, displaying the model on the pattern of the card and rendering the final audio-visual content.

7. Evaluation in real scenario

The validation of the prototype by the general public took place in the San Telmo museum in Donostia-San Sebastian in October 2006 during two weeks (Figure 8). Regarding the socio-demographic data of the players, two thirds of them were women with an average age between 16 and 30 years. Most of the players were graduate students. Also, most of the participants in the evaluation live in the region. The evaluation methodology has been based both in quantitative and qualitative analysis.

Figure 8:

Group evaluating the prototype.

Players of Sua declared that the instructions prior to the game and their previous knowledge were sufficient to understand the dynamics of the game. Although many of the participants were familiar with the use of new technologies and to the rules of the Game of the Goose, they have appreciated them very much as the interviews proved.

When players held the card and the 3D object was rendered on it, players were generally surprised (Figure 9). This feeling is enhanced with the appearance of the avatar after the predefined time-gap. However, the dynamic and innovative aspects of the patterns and the 3D objects that are rendered in the screen in real time are not in consonance with the static perception of the audio-visual contents.

As for the contents in general, the questionnaires have shown that players had a positive impression. The most attractive ones were the 3D objects for the AR application and the multimedia reconstructions. Moreover, nearly half of the players had also enjoyed the virtual avatars as a personal guide in the game. However, the avatars look too rigid and simple for many of the players.

Finally, when being asked about the applicability of Augmented board games in cultural institutions, players agreed on the positive contribution of such experiences for the image of the institutions. Nearly two thirds of the players would

Figure 9:

Player from the French army during the validation.

recommend the experience to other people. Finally, players would, in general, not pay for the experience. The results of this evaluation will be published in future papers.

8. Conclusions

In this paper, we have presented the Sua prototype, a tangible AR system designed on the basis of a board game metaphor. The aim of the prototype is to evoke the impression of playing with a real-world board game while enjoying the possibilities of a computer game. Thus, it unifies the advantages of computer games and board games.

The prototype combines the best features from board games and computer games, and extends the aesthetic game experience. The physical cards in each square are associated with 3D objects which show a virtual representation of historical events. This kind of augmentation allows new ways to interact with computers and enables players to interact physically as in board games. Since it is our objective to augment board games, the key features of such games have been identified: the placement of the players, the physical settings of the game play and the social interaction between the players. Such features have been included in the Sua prototype.

ARToolKit was selected as the technical platform, allowing the use of a camera to detect a pattern associated with 3D graphics placed on top of the marker when detected. The markers were attached to the bottom of the cards and tracked by the tracking camera installed near the screen. Thus, we avoid the occlusion problem in board AR environments.

To conclude, the evaluation in a real scenario has shown that games have a unique potential to engage people in collaborative activities. On the other hand, collaborative games are rare and extraordinarily difficult to design. We believe that Augmented computer games not only have the potential for addressing many of the issues discussed but also many approaches to solve them.

9. Acknowledgement

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