Multimodal augmented reality tangible gaming

Liarokapis, F. , Macan , L. , Malone , G. , Rebolledo-Mendez, G. and de Freitas, S.

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Fotis Liarokapis, Louis Macan, Gary Malone

Interactive Worlds Applied Research Group Coventry University, Coventry, UK

{F.Liarokapis, macanl, maloneg}@coventry.ac.uk

Genaro Rebolledo-Mendez, Sara de Freitas

Serious Games Institute, Coventry University, Coventry, UK

{GRebolledo-Mendez, s.defreitas}@coventry.ac.uk

Abstract This paper presents tangible augmented reality gaming environment that can be used to enhance entertainment using a multimodal tracking interface. Players can interact using different combinations between a pinch glove, a Wiimote, a six degrees-of-freedom tracker, through tangible ways as well as through I/O controls. Two tabletop augmented reality games have been designed and implemented including a racing game and a pile game. The goal of the augmented reality racing game is to start the car and move around the track without colliding with either the wall or the objects that exist in the gaming arena. Initial evaluation results showed that multimodal-based interaction games can be beneficial in gaming. Based on these results, an augmented reality pile game was implemented with goal of completing a circuit of pipes (from a starting point to an end point on a grid). Initial evaluation showed that tangible interaction is preferred to keyboard interaction and that tangible games are much more enjoyable.

Keywords *Serious Games; pervasive computing; augmented reality; multi-modal interfaces.*

Introduction

Computerised games which have learning or training purposes demonstrate a popular trend in training due to the wide availability and ease of use of virtual worlds. The use of serious games in virtual worlds not only opens up the possibility of defining learning game-based scenarios but also of enabling collaborative or mediated learning activities that could lead to better learning [1]. An added benefit of using serious games in combination with virtual worlds is that learners engage with these in a multimodal fashion (i.e. using different senses) helping learners to fully immerse in a learning situation [2] which might lead to learning gains [3]. The multimodal nature of virtual worlds [4] and the facilities they offer to share resources, spaces and ideas greatly support the development and employment of serious games and virtual worlds for learning and training. The use of games as learning devices is not new. The popularity of video games among younger people, led to the idea of using them with educational purposes [5]. As a result there has been a tendency to develop more complex serious games which are informed by both pedagogical and game-like, fun elements. One common example of these combinations is the use of agents [6]: The idea behind agents is to provide pedagogical support [7] while providing motivating environments in the form of agents [8]. However, the use of agents is not the only motivating element in serious games as the use metaphors [9] and narratives [10] have been used to support learning and training in game-like scenarios.

Tangible games can sometimes have an educational aspect. The whole idea of playability in tangible games is the player's interaction with the physical reality. In addition, the accessibility space that is the key to the oscillation between embedded and tangible information [11]. On the contrary, augmented reality (AR) has existed for quite a few years and numerous prototypes have been proposed mainly from Universities and research institutes. AR refers to the seamless integration of virtual information with the real environment in real-time performance. AR interfaces have the potential of enhancing ubiquitous environments by allowing necessary information to be visualized in a number of different ways depending on the user needs. However, only a few gaming applications combined them together to offer a very enjoyable and easy to use interface.

This paper presents tangible augmented reality gaming environment that can be used to enhance entertainment using a multimodal tracking interface. The main objective of the research is to design and implement generic tangible augmented reality interfaces that are user-friendly in terms of interaction and can be used by a wide range of players including the elderly or people with disabilities. Players can interact using different combinations between a pinch glove, a Wiimote, a six degrees-of-freedom tracker, through tangible ways as well as through I/O controls. Two tabletop augmented reality games have been designed and implemented including a racing game and a pile game. The goal of the augmented reality racing game is to start the car and move around the track without colliding with either the wall or the objects that exist in the gaming arena. Initial evaluation results showed that multimodal-based interaction games can be beneficial in gaming. Based on these results, an augmented reality pile game was implemented with goal of completing a circuit of pipes (from a starting point to an end point on a grid). Initial evaluation showed that tangible interaction is preferred to keyboard interaction and that tangible games are much more enjoyable.

Background

In the past, a number of AR games have been designed in different areas including education, learning, enhanced entertainment and training [12]. A good survey of tracking sensors used in ubiquitous AR environments [13] as well a taxonomy of mobile and ubiquitous applications was previously documented [14]. This section presents an overview of the most characteristic applications and prototypes that integrate tracking sensors into AR tabletop and gaming environments. One of the earliest examples of educational AR was the MagicBook [15]. This is a real book which shows how AR can be used in schools for educational purposes is an interesting method of teaching. MagicBook was also used as a template for a number of serious applications in numerous AR games.

One of the earliest pervasive AR prototypes is NaviCam [16], which has the ability to recognize the user's situation by detecting color-code IDs in real world environments by displaying situation sensitive information by superimposing messages on its video see-through screen. Another early important work refers to the Remembrance Agent [17], a text-based AR wearable system which allows users to explore over a long period of time augmented representations and provide better ways of managing such information. EMMIE [18] is a hybrid user interface to a collaborative augmented environment which combines a variety of different technologies and techniques, including virtual elements such as 3D widgets, and physical objects such as tracked displays and input devices. Users share a 3D virtual space and manipulate virtual objects that can be moved among displays (including across dimensionalities) through drag and drop. A more recent prototype is DWARF [19] which includes user interface concepts, such as multimedia, multimodal, wearable, ubiquitous, tangible, or augmented reality-based interfaces. DWARF covers different approaches that are all needed to support complex human-computer interactions. Higher level functionality can be achieved allowing users to manage any complex, inter-related processes, using a number of physical objects in their surroundings. The framework can be used for single-user as well as multi-user applications. In another prototype, the combination of AR and ubiquitous computing can lead to more complex requirements for geometric models are appearing [20]. For such models a number of new requirements appear concerning cost, ease of reuse, inter-operability between providers of data, and finally use in the individual application.

In terms enhanced entertainment outdoor AR gaming plays a significant role. A characteristic example is the Human Pacman project [21] that is built upon position and perspective sensing via GPS, inertia sensors and tangible human-computer interfacing with the use of Bluetooth and capacitive sensors. The game brings the computer gaming experience to a new level of emotional and sensory gratification by embedding the natural physical world ubiquitously and seamlessly with a fantasy virtual playground. AR Tennis [22] is the first example of a face to face collaborative AR application developed for mobile phones. Two players sit across a table from each other, while computer vision techniques are used to track the phone position relative to the tracking markers. When the player points the phone camera at the markers they see a virtual tennis court overlaid on live video of the real world.

Another interesting project is STARS [23] which focused on the nature of state representation in augmented game designs and developed several games based on these principles. Moreover, Mixed Fantasy [24] presents a MR experience that applies basic research to the media industries of entertainment, training and informal education. As far as training is concerned, the US Army paid more than $5 million to design an educational game based on the Xbox platform to train troops in urban combat [25]. Another example is the MR OUT project [26] which uses extreme and complex layered representation of combat reality, using all the simulation domains such as live, virtual, and constructive by applying advanced video see-through mixed reality (MR) technologies. MR OUT is installed at the US Army's Research Development and Engineering Command and focuses on a layered representation of combat reality.

Architecture

The architecture of our system has been based on an earlier prototype [29] but it provides similarities with AR interfaces such as [18], [19], [27], [28]. In the current system, interaction is performed using a pinch glove, a six DOF tracker and Wiimote (2 DOF). The processing unit can be wearable (or mobile) and thus the Sony VAIO UMPC was selected to (1.3 GHz, two 1.3 mega-pixel cameras, VGA port, Wi-Fi, USB ports, Bluetooth and keyboard/mouse). The rest of the hardware devices used and integrated to the UMPC included a pinch glove (5DT Data glove), a Wii Remote, a 6 DOF tracker (Polhemus Patriot) and an HMD (eMagin Z800). An overview of the system is shown in Figure 1.

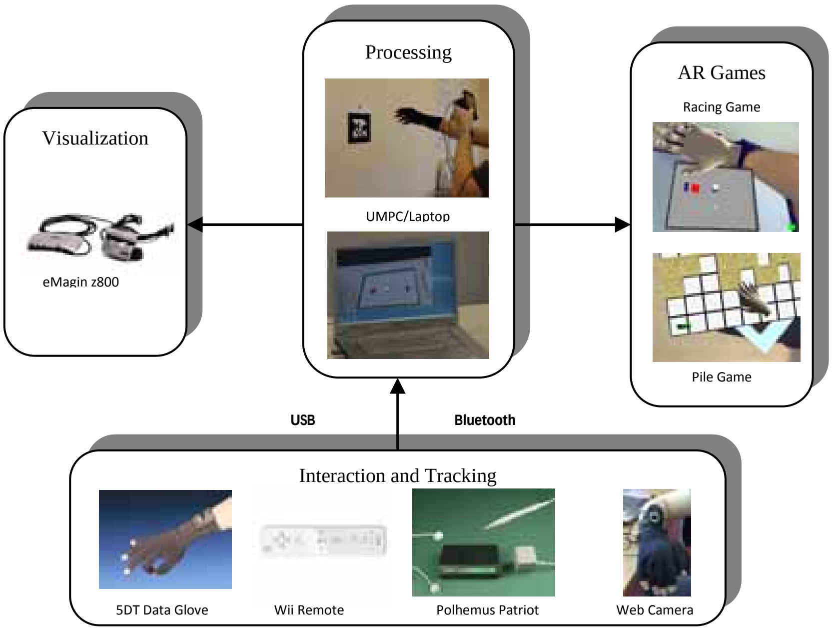

Figure 1 Multimodal Architecture for Tangible Gaming

Visualization is enhanced through the use of a head-mounted display (HMD) which includes a three DOF orientation tracker. Visual tracking is based on multiple markers which provide better robustness and range of operation, based on ARToolKit [30] and ARTag [31] libraries. To retrieve multimodal tracking data in real-time, a socket was created which was constantly waiting for input. The input comes in a structured form so data structures were set up in order to grab and store this information for the visualisation. This socket server function was placed inside a thread of its own to stop it affecting the whole process while it waits for data to be retrieved. Once the data are received, attributes are assigned to a particular marker or to multiple markers. When that marker comes into sight of the camera and the rendering part recognizes that the current marker has further data attached to it.

Tracking

An issue that arose early on with using the player's hand to interact with virtual objects in an AR environment were occlusions. Once the hand moves to interact with the AR scene, it obscures a real-world visual marker. As a result, the on-screen objects disappeared; the AR system relies on the markers to accurately register the virtual information on screen. This being the case, one of the objectives early on was to create a system that would use multiple markers to represent a single object or set of objects. This would mean that even if one or several markers were blocked by a user’s hand, for example, the objects would still be displayed based on where the visible markers were placed. The game uses a method of detecting which marker of the available markers on a sheet of paper is currently the most visible, based on a confidence rating assigned to it by a class in ARToolKit. This marker becomes the origin from which all other objects are drawn on the game board. If this marker becomes obscured, the program automatically switches to the next highest confidence rated marker. The confidence is based on a comparison between the marker pattern stored in memory and what is detected by the camera in the current frame.

The first problem encountered with a tangible interface incorporated into an augmented reality application was that of marker occlusion. In order for an object to be drawn on screen, the camera must have direct line of sight of a recognised marker. If that marker is even partially obscured, the program cannot recognise it as a square nor read the information on it, so the object will not be shown. This presented an important challenge for the project; if the game is to be controlled via a tangible interface, and then a user must be able to physically interact with the graphics which will mean frequently putting their hand between the camera and the marker. Thus, a method of preventing marker occlusion that would be simple for a user to set up and would still allow 3D movement was developed. Moreover, inspired by the currently unavailable ARTag [31] a multiple marker system was implemented. Using several markers to represent the game playing area; one marker at any given time is selected as the basis to draw many objects. This marker is selected through the use of a confidence value as explained in [29].

Multimodal Interaction

The main objective of this work was to allow for seamlessly interaction between the users and the superimposed environmental information. To achieve this, a number of custom interaction devices have been researched such as the PS3 controller, 3D mousse, etc. However, since usability and mobility were crucial, only a few interaction devices were finally integrated to the final architecture. In particular, six different types of interaction were implemented including: hand position and orientation, pinch glove interaction, head orientation, Wii interaction and UMPC I/O manipulation. A brief overview of these techniques is presented below.

Polhemus

Once integrated into the architecture, there were several issues that prevented this from being as effective as previously hoped. The sensors often suffer from inversion problems, meaning the user's hand is displayed in the wrong position and disrupting the interface for the game. A fix employed was to place the base sensor above and to the left of the game board, a position where the hand would always be expected to appear on the positive side of each axis. By taking the absolute value of each of the position vector's values, the inversion problem was resolved, though this does reduce the area in which movement is tracked. Moreover, Polhemus Patriot offers two ways in which the data can be captured: single mode and continuous mode. In the Pile game, the single mode of capture was used, as the program is not multi-threaded and would stop functioning when the Polhemus's continuous method of data capture was selected. In testing however, the single mode method was very slow in reporting the data, causing massively detrimental effects to the frame rate of the game.

Hand Tracking

Detecting the orientation of the user’s hand plays a large part in this project. The intention is to move around environments with ease. A separate measurement is needed from the player’s body position due to the hand being free to move in a different orientation to the player’s body. The tracking data were obtained by attaching a small USB web camera into the pinch glove. Based on ARTag tracking libraries hand’s pose was combined with the data of the player’s position and orientation in the environment and then used to compute where the hand is located in the real environment. Based on those readings, it is easy to define different functionalities that may be used for different configurations. As an exemplar, a 'firing' function was implemented based on localization of the hand (see next section). Another function that was experimentally implemented is multiple camera viewports (one originating from the UMPC camera and a second from the mounted web camera) to provide a more immersive view to the user.

Head Orientation

Head orientation was achieved through the capabilities of the HMD since it included a three DOF orientation tracker. The advantage of using head orientation is that it can illuminate the use of computer vision methods for head tracking. However, when used with monitor-based AR it can provide a distracting effect. Another problem that occurred after experimentation is that if it is used with conjunction with the rest of the sensors (Wiimote and pinch glove) it can confuse the user. For this reason the tracking capabilities of the HMD were not used in the application scenarios.

Wiimote Interaction

It was decided to implement the Wii remote as a device to obtain positional data of the user's hand for an alternative to mouse controls. Implementation was based on an extensive library written to manage the actual communication with the Wiimote, called Wiiuse. This takes care of all of the Bluetooth communication between the Wiimote and the computer. It also recognizes events and data received from the Wiimote accelerometers giving orientation information. When the Wiimote was implemented into the system, another thread was added to continuously retrieve data without affecting the rest of the application. When directional or action buttons are activated different operations may be performed (i.e. start the game, help screen, etc). The Wiimote was also found to be very useful, since it is a very 'mobile' piece of equipment. It is battery powered and can work for roughly 35 hours without needing a replacement and it emits data via Bluetooth. The only disadvantage of the Wiimote is that it provides 2 DOF tracking so it is not a complete orientation device. However, for a number of table-top games (i.e. puzzles, racing, etc) it is a very useful device since only the yaw rotation is useful.

Pinch Glove

The pinch glove has internal sensors that give the system data on each fingers position. If a user was placed their index finger into a curled up position, any event could be triggered. In some circumstances this is an ideal choice for user input, however if the user has to hold any other piece of hardware then it would become hard to make use of the glove’s data because their hand position would be set by whatever is in their hand. The pitch glove allows up to 15 different combinations. However, only 5 flexures have been implemented at this stage corresponding to a finger (translate X-axis, translate Y-axis, translate Z-axis, rotate clockwise and scale). In terms of operation, the glove is initialized and then a thread is created for the constant monitoring of the glove, this thread is responsible for grabbing the data for each finger and assigning it to a variable which can be used throughout the application.

I/O Interaction

The I/O interaction (mouse/keyboard) is adequate only when the HMD was not used. However, it allows users to perform more accurate manipulations of the superimposed information and thus it was explored only as backup option. On the other hand, the camera mounted on the rear could be used for marker detection and as the hand is holding the camera, the value returned from the ARToolKit would be a position and orientation of the hand.

Gaming Techniques

In the next sub-sections an overview of the main functionality of the generic AR multimodal system is presented.

Picking and Firing

Once it has been established that a user is interacting with a particular object, the program checks the state of the sensors on the glove. If it is detected that the user is bending all five sensors over a certain threshold, then the object adopts the same position and orientation as the user's hand. This gives the impression that the object has been picked up and is now held by the user. If the sensors running along the glove's fingers are detected to straighten, then the item is dropped and falls to the plane representing the virtual ground. One method of interaction that was not fully integrated into the game, but the framework was created, is a way of firing from the virtual hand. Figure 2 provides an overview of how firing is performed.

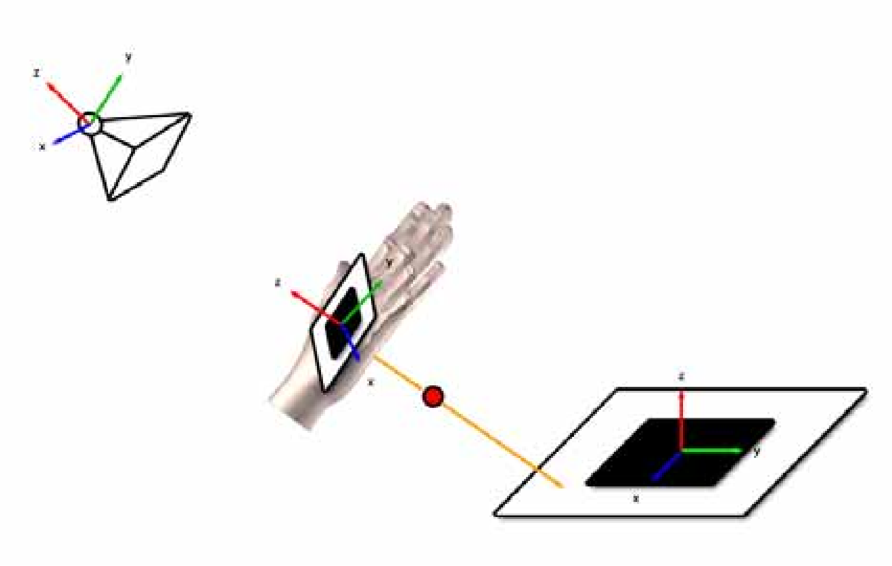

Figure 2 Augmented reality firing technique

By making a predetermined gesture, detected by the glove, a user is able to fire a virtual projectile into the scene. From the marker on the user's hand, we can apply a transformation from its orientation to that of the virtual world and thereby determine the direction a projectile would travel from the hand and whether it would intersect with other objects in the scene. Once integrated into the game, this would allow a user to destroy obstacles or non-player characters (NPCs).

Collision Detection and Spatial Sound

Using bounding boxes around each of the items in the scene and one to encompass the user's hand, intersection testing was used as a simple method of collision detection. Much as in any game, collision detection plays a vital role in gameplay; in the AR Racing game for example, the car is not able to cross the boundaries of the game board and its progress is impeded by the other obstacles. Importantly for this particular application, the collision detection also enables the program to determine when the user's hand in the real world is intersecting with an object in the virtual scene.

To enhance the level of immersion of the application, features from the OpenAL and AL Utility Toolkit (ALUT) APIs were added. In our system, the camera is always defined as the listener, making the levels of all sounds in the augmented part of the environment relative to the camera's position and orientation. For the AR Racing game, examples of sound sources defined by the game include ‘engine’ and ‘collision’ sounds. The ‘engine’ sound is assigned in the virtual car whereas the ‘collision’ sound represents the noise created when the car collides with other virtual objects in the scene, such as the moveable cubes. As the car is directed away from the centre of the camera's view, the sound of its engine gradually reduces in volume and, depending on the direction of movement taken; the balance of stereo sound is altered accordingly.

Collisions between the car and virtual objects on-screen will trigger the playback of a .wav file. The volume of this file in each audio channel will again be relative to the positions of both the camera and the collision. This functionality creates a base upon which a more complex system of sound could be developed. For example, the speed of the car affects the sound of the engine, by using different samples depending on the current velocity. Also, given the vehicle's velocity and the perceived material of another object in the scene, different sound files were tested representing varying levels of collision. A fast impact into a hard surface could sound completely different than a slight glance against a soft, malleable object.

Gestures

The main idea using gestures in AR gaming was to perform appropriate transformations (i.e. translations, rotations or scaling). Several possible solutions were considered. Firstly, using threshold values for rotation, wrist movements could be interpreted into larger rotations. By monitoring if rotations occur in a particular axis within a certain number of frames, it is inferred that the user wished to perform an operation (i.e. rotate a piece in that direction, Figure 3). Depending on the AR gaming scenario, appropriate functionality is assigned. For instance, for the Pile game (see next section) the pieces in the game can only be placed at right angles, it is reasonable to conclude that if a user wishes to rotate the pipe pieces in a certain direction, then they wish to do so in increments of 90 degrees. Similar gesture operation present a more comfortable way of playing the game when compared to carrying out the full rotations each time.

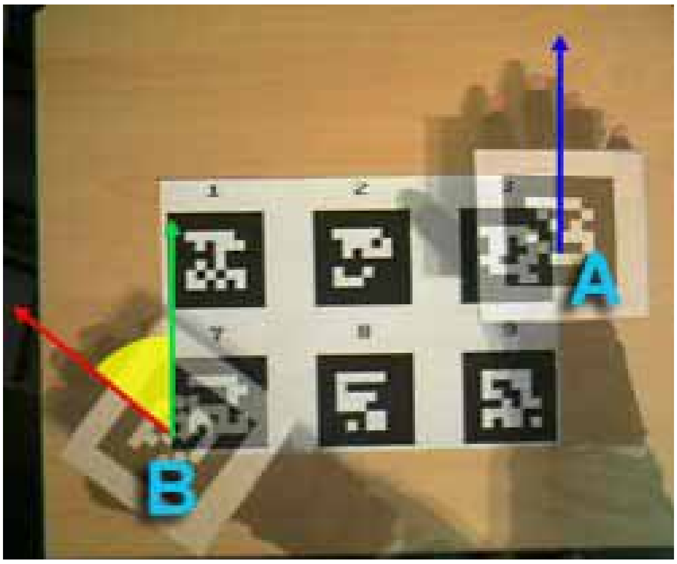

Figure 3 As the hand moves from position A to B, the unintentional anticlockwise rotation created is shown highlighted in yellow

There were, however, several issues that this functionality presented which needed to be addressed. Firstly, the speed and extent of the rotations that would trigger the function were very difficult to define. Different users would move at different speeds and have variable ranges of motion. Setting the speed that triggered the rotation function too high would prevent certain users from accessing it, but too low would cause it to be triggered when not required (i.e. by moving the hand to reach different parts of the board).

Tangible Racing AR Game

To illustrate the effectiveness of the multimodal interface, the interaction techniques presented above have been combined with a table-top AR car gaming application. It was decided to use a simple gaming scenario and focus more on the reaction of the players during interaction. The goal of the game is to start the car and move around the track without colliding with either the wall or the objects that exist in the gaming arena. In addition, the objects can be re-arranged in real-time by picking and dropping them anywhere in the arena. A screenshot of the starting stage of the car game is shown in Figure 4.

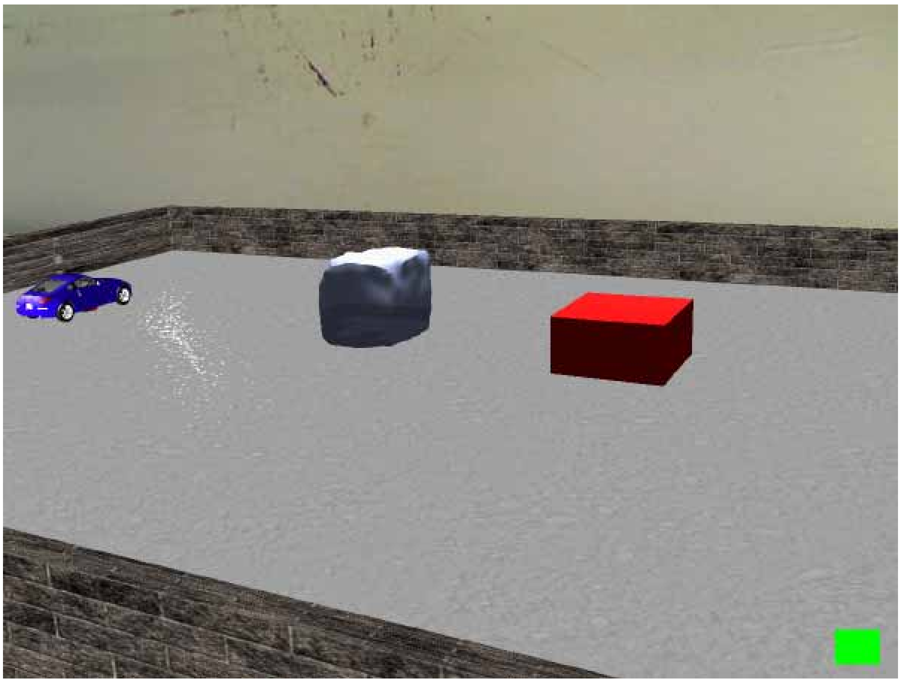

Figure 4 AR Racing Game

The main aim of the game is to move the car around the scene using the Wimote without colliding with the other objects or the fountain. However, alternative interactions techniques may be used such as picking using the pinch glove. Players can interactively change the sound levels (of the car engine as well as the collisions), the speed of the simulation, and finally the colour and the size of the car. In addition they can interact with the whole gaming arena in a tangible manner by just physically manipulating the multi-markers. Interaction is performed in a far more instinctive and tangible way than is possible using a convention control system (for example, keyboard and mouse or a video game controller). The pinch glove was used to move objects in the scene by grabbing them as illustrated in Figure 5.

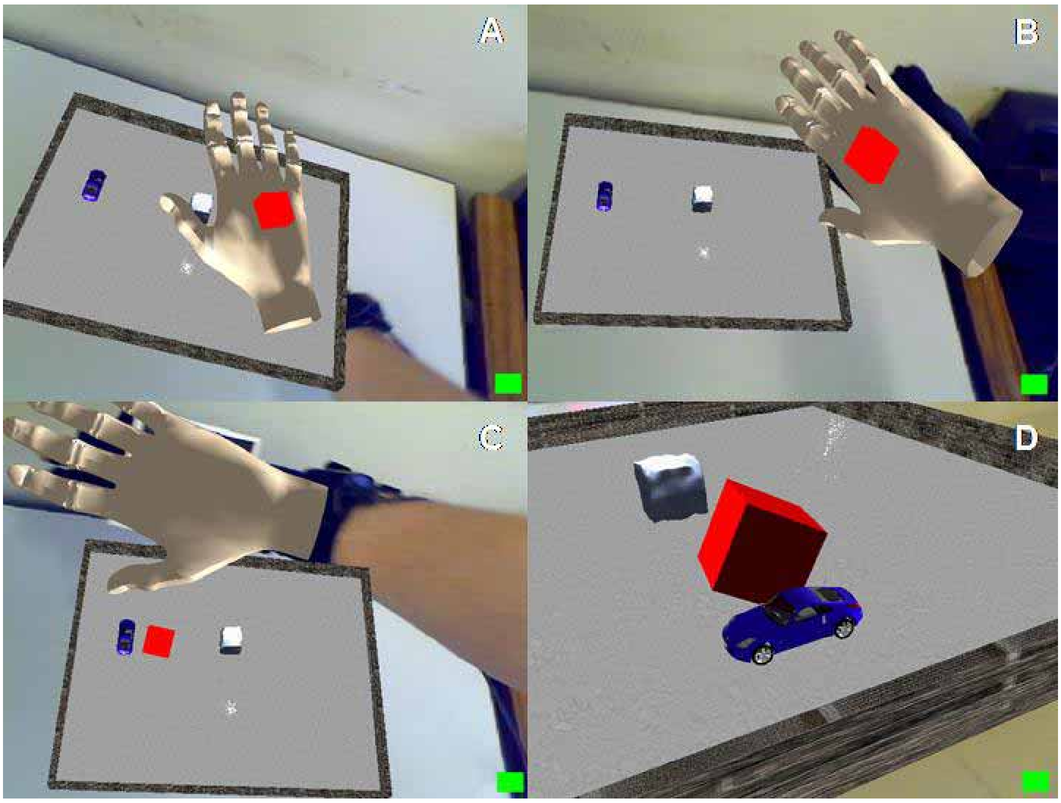

Figure 5 Pinch glove interaction scenarios (a) the user is picking up a 3D object (in this case a 3D cube) that exists in the AR game; (b) shows how the user can manipulate the 3D object in three-dimensions; (c) the user is dropping the 3D object in the gaming arena; (d) the object is placed in the gaming arena in a random position.

It is worth-mentioning that the game can be played in a collaborative environment by eliminating the use of the HMD. One player can be in charge of the Wiimote interaction and another for the pinch glove manipulation. Moreover, the game has only been qualitatively evaluated in two demonstrations at ‘Cogent Computing Applied Research Centre’ [32] and ‘Serious Games Institute’ (SGI) [33]. At Cogent the basic functionality of the game was tested based on ‘think aloud’ evaluation technique [34]. Think aloud is a form of observation that involves participants talking through the actions they are performing, and what they believe to be happening, whilst interacting with a system. Overall the feedback received was encouraging but certain aspects need to be improved in the future. The three tasks that were examined include: Wiimote interaction and pinch glove interaction. For the first task, a virtual sword was superimposed with a Wiimote placed next to it as shown in Figure 6 (a). It must be mentioned that Yaw detection can’t be detected as the motion sensor chip used in the Wiimote is sensitive to gravity, but rotation around the yaw axis is parallel to the earth.

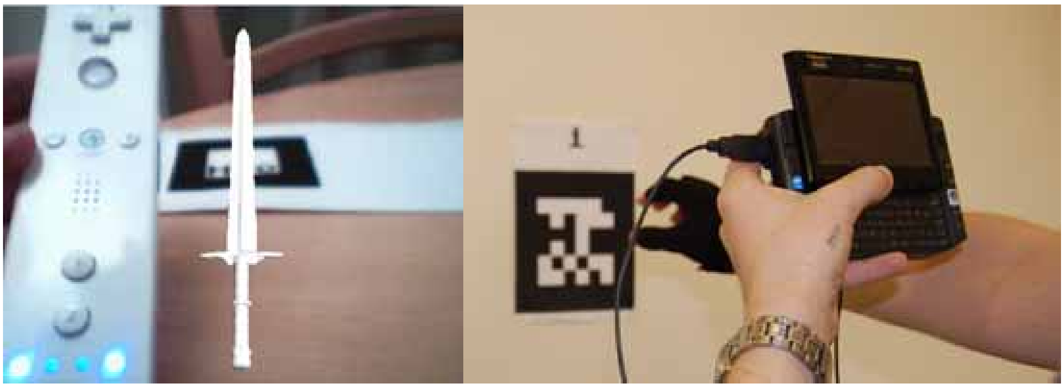

Figure 6 (a) Wiimote interaction test (b) Data glove interaction test

Users were asked to angle the sword upwards as if to point to an object in the sky. The feedback received was positive from four users. However, one user stated that although it is possible to detect the yaw rotation against one area, it is impossible to identify different IR sensors placed around the whole environment. As a result, interaction using the Wiimote would get confused as one IR sensor went out of site. For the second task, users were presented with the data glove placed on their right hand as illustrated in Figure 6 (a). Then they were asked to manipulate in 3D the virtual information in this case the virtual sword used in the previous task. Virtual manipulation included scaling, rotations and translations using the fingers of the pinch glove. All users managed to interact with the pinch glove without any problems as soon as they were briefed with its operations. Four users agreed that it is very intuitive to perform the pre-programmed operations. Two users mentioned that they would like to have more combinations such as change or color and activate/de-active the textual augmentations. One user stated that it can be tiring to control the UMPC with one hand only.

At the SGI the game was demonstrated in an internal event with 20 visitors. Initial feedback received stated that the game is very realistic in terms of interactions and enjoyable to play. Especially the idea of picking virtual objects and placing them in arbitral positions was very enthusiastic. Most visitors felt that tangible games presented potential for the next generation of gaming. On the negative side, they preferred to experience a more complete gaming scenario including a score indicating successful achievements. In addition, some users requested more objects in the scene (i.e. obstacles), multi-player capabilities (i.e. more racing cars) and more tracks with different levels of difficulty.

Pile AR Game

The game created for this project is based on a simple game from 1989, ‘Pipe Mania’ [35] with sales of over 4 million units in the past twenty years. The goal of the game is to complete a circuit of pipes from a starting point to an end point on a grid (Figure 7). While a player is laying these pipes, there is a liquid that is gradually flowing through the pipework. If a player does not connect the pipes quickly enough, and the liquid spills out, the game is lost. There were specific motivations behind using the template of a game already available. To begin with, it allowed for rapid development of the final product, which in itself was primarily a testing ground for the method of interaction that the project is proposing. In the version of ‘Pipe Mania’ created for this project, the interaction is entirely carried out through movements of a user's hand. They can reach over to pipe pieces, grip their hand into a fist to hold the piece, then move to a new position and open their hand to drop the piece. On the right hand side of the board, there is a supply point for pipe pieces, which is automatically replenished when the player picks a piece from there.

Crates are positioned over some of the game board's squares, preventing pipes from being placed in some areas and blocking certain paths from the starting pipe to the end pipe. If a user attempts to release the pipe piece on squares blocked by crate or another pipe piece, they will find the pipe will remain in their hand until they move over an unoccupied square. The pipe pieces can be rotated by turning the hand in relation to the game board or visa versa. The game automatically corrects the rotation to increments of 90 degrees when the piece is placed on the board. Using this technique, a player can change any curved pipe piece to make any turn, and straight pieces can be made to run either left to right or top to bottom. The goal of the game remains the same: place the pieces to complete the pipe from the fixed start to the end before the pipe fills with water.

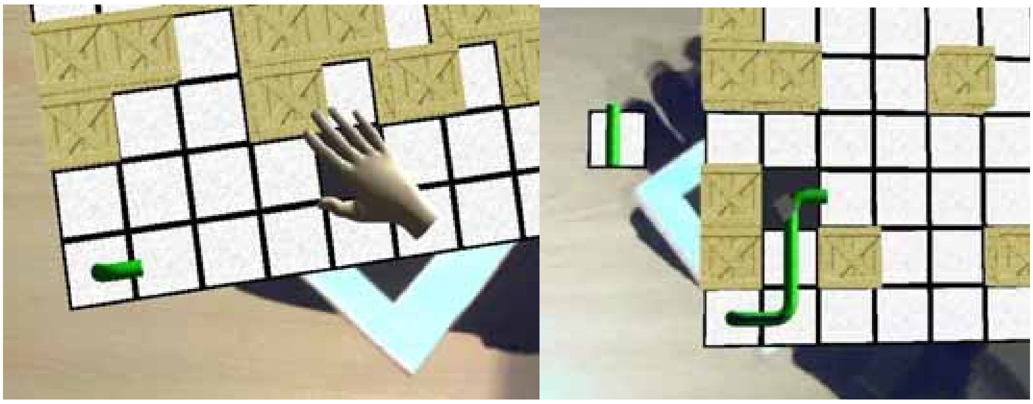

Figure 7 AR Pile game (a) initial setup of the game; (b) pile game in process.

To obtain their opinions on particular aspects of the game's functionality, users were asked to rate their agreement with certain statements on a Likert scale. For the purposes of this project, the most important aspects of the game were related to its controls, so many of the questions related to this. The set of questions relating to both the keyboard and the tangibly controlled versions of the game were exactly the same to attempt to find the different ways in which users perceived them. Specifically, the project aimed to discover which type of control the users found the most intuitive, the easiest to use and most enjoyable to interact with. The answers to the questionnaire, along with the observations from the tests and the notes from the post-test interview form the basis for the conclusions drawn about the effectiveness of the method of control, as well as the quality of the game developed. After playing the two versions of the pipe game, nine users were asked to indicate how strongly they agreed or disagreed with a number of statements, to gauge their enjoyment of the different types of game. The following graphs show their responses to some of the questions:

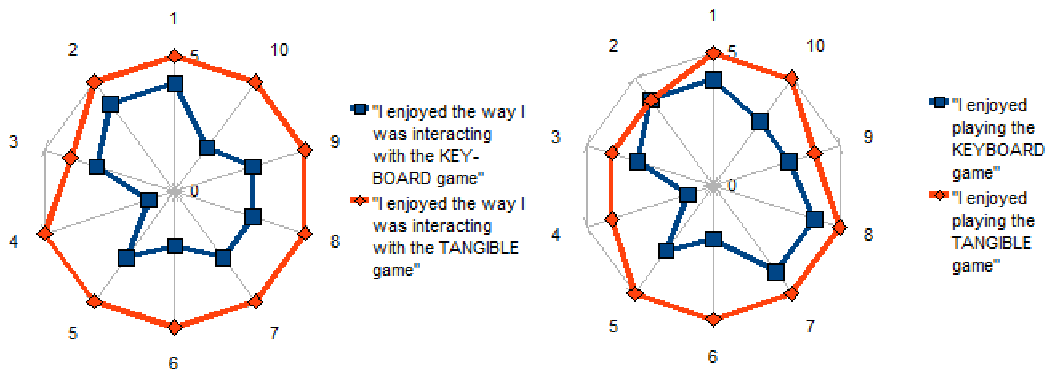

Figure 8 Interaction test (a) Graph showing users enjoyment of the tangible interaction method verses their enjoyment of the keyboard interaction; (b) Graph showing the user's level of enjoyment of the keyboard and tangibly controlled versions of the game.

By observing the players while playing the two versions of the game, there were several general points that were noted. Firstly, players with a background in gaming and particularly those with experience of PC games, were much faster to pick up the keyboard controls. People who had little experience of games or solely played console games were slower to understand the controls. Several people in this category were observed to forget the controls and move the hand in ways they did not intend, slowing down the game. They were also noticeably frustrated at times, rotating the hand in the wrong direction, then back pressing several keys to find the correct movement through trial and error. Whilst playing the tangible version, all players were able to quickly understand the nature of the controls, even after little to no explanation from me. The games were generally completed more slowly however, as the players became used to the interface and also explored the limits of the interaction. Several players had to be prompted to move the board to assist them with rotation, struggling to complete certain moves.

Conclusions and Future Work

Tangible AR gaming has the potential to change a number of applications that we perform in our day-to-day activities. This paper has presented a generic tangible augmented reality gaming environment that can be used to enhance entertainment using a multimodal tracking interface. The main objective of the research is to design and implement generic tangible interfaces that are user-friendly in terms of interaction and can be used by a wide range of players including the elderly or people with disabilities. Players can interact using different combinations between a pinch glove, a Wiimote, a six degrees-of-freedom tracker, through tangible ways as well as through I/O controls. Two tabletop augmented reality games have been designed and implemented including a racing game and a pile game. The goal of the augmented reality racing game is to start the car and move around the track without colliding with either the wall or the objects that exist in the gaming arena. Initial evaluation results showed that multimodal-based interaction games can be beneficial in gaming. Based on these results, an augmented reality pile game was implemented with goal of completing a circuit of pipes (from a starting point to an end point on a grid). Initial evaluation showed that tangible interaction is preferred to keyboard interaction and that tangible games are much more enjoyable. From the research proposed many potential gaming applications could be produced such as strategy, puzzles and action games.

Future development will include more work on the graphical user interface to make it more user-friendly and speech recognition is considered as an alternative option to enhance the usability of interactions. A potentially better solution that will be tested for the glove in the future on this system is to use a model for the hand that has separate sections for each finger, the position of which would be determined by the current readings on each of the finger sensors on the glove. This model could then use an alpha colour value of 1.0, meaning that it is entirely transparent in the scene. As a result the model would become an alpha mask for the live video of the users hand; the real world hand would then appear to be above any virtual objects that the depth testing determined were further away from the camera. Finally, a formal evaluation with 30 users is currently underway and results will be used to refine the architecture.

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