Exergaming: A Fusion of Exercise and Video Gaming

Ahmad Wilson
Department of Computer Science
Brown University
Providence, RI 02912
awilson@cs.brown.edu

Abstract

Traditional interaction techniques for video games have been, for the most part, confined to sometimes subtle and sometimes not so subtle variations in button, directional-pad, and/or joystick placement as well as disparities in size and/or shape of gamepads. While the reasoning behind the stagnation of mainstream interactive techniques utilized in video games which characterized the gaming industry from its inception until fairly recently has more to do with applicability and accessibility factors rather than lack of creativity, the introduction of innovative technologies allowing for novel ways for players to interact with video games has generally demonstrated the desire of players to go beyond the use of increasingly dexterous controllers. One of the focuses of our project is to create decent quality low budget video games which make use of fairly novel interaction techniques, and, hopefully, enhance player involvement and experiences. To do this, we intend to utilize code bases and practices learned from CSCI1340 – Innovating Game Development [5], a course taught within the Brown University Computer Science Department to enable students enthusiastic about games, and, perhaps, game development to obtain not only some experience in the game developing process as well as background information and insight into existing game technologies but also engage in a medium through which ideas for new game concepts and interaction methods can pass and be analyzed.

1 Introduction

As we delve further into the twenty-first century, the use of traditional interaction techniques such as the aforementioned gamepad but also standalone joysticks and the pairing of mice and keyboards can no longer satiate the hunger for innovation of a more technologically savvy and intellectually as well as creatively evolving society. The use of more sophisticated and, seemingly, "natural", as evidenced by the incredible success of the Nintendo Wii game console and music-based games, such as the Dance Dance Revolution, Guitar Hero, and Rockband series, in addition to social gaming networks such as Second Life, have proven themselves to be, if not the future of video gaming, at the very least, a significant component of it.

Our project is based on Exergaming, a concept which fuses exercise and video games. While, as alluded to previously, we in no way claim to be the creators of this concept, we feel that our contribution and the main point of our Exergaming project is to expand the influence of this idea across multiple game genres, especially those which are typically considered to be incapable of being adequately represented in terms of being able to maintain a cogent simulation experience.

We believe that by extending the reach of this idea across a larger set of genres, we will be able to widen the target audience and assist in the facilitation of the usherance of this phenomenon into the mainstream.

Moreover, this paper not only describes the basis of our Exergaming project but also our first contribution to it, "Wii!!! Soccer". "Wii!!! Soccer" is a game which allows the player to perform natural soccer gestures and movements through foot tracking utilizing infrared emitters and infrared cameras contained in wiimotes. However, prior to this, we will provide a brief background of some of the most notable as well as prevalent existing interaction techniques/ input devices used for video games.

2 History of Interaction in Video Games

In order for a player to interact in any form with any type of device, whether it is a game console, computer, or what have you, an input device is necessary. An input device is basically any peripheral (a piece of computer hardware equipment) utilized to provide data as well as control signals to an information processing system like a computer. Most input devices can be classified according to three main characteristics: The first is the modality of input. This can either be in the form of mechanical motion, visual, audio, etc. The second characteristic corresponds to whether the input, itself, is discrete (i.e. keystrokes) or continuous (i.e. analog joystick). Typical input mechanisms generally combine the two. The third and last is based on the number of degrees of freedom involved (i.e. two-dimensional directional pads, joysticks, and mice and Cave Automatic Virtual Environment (CAVE) pointing devices which registers 6 degrees of freedom.

2.1 Joystick

The first electrical two-dimensional axis joystick is believed to have been invented around the year 1944 in Germany for the purpose of serving as a target system for the Herschel Hs 293. Joysticks were, and, in a sense, still are utilized mainly within aircrafts as controls for navigation. However, it is believed that Atari introduced the joystick to the gaming front with their Atari2600. This digital joystick operated on a two-dimensional axis and was connected via a DE-9 connector [6].

Prior to 1995, digital joysticks were the industry choice as analog joysticks were found to be both ungainly and unreliable. Most companies opted to use the digital directional pad or D-pad for short due to their ease of manipulation and high accuracy [7].

In the year 1995, however, Sony came to the realization that analog joysticks could be useful, despite the non-centering design which had caused their disfavor earlier, and ignited the idea of employing a potentiometer based analog stick for flight simulation games [7]. This joystick, commonly referred to as the "FlightStick", was the precursor to the playstation dual-analog controller and used in games such as "Descent". The use of analog joysticks eventually caught on as both Nintendo and Sega, two of game console's giants during the 90's utilized the design in their upcoming consoles, Nintendo 64 and Sega Dreamcast, respectively.

Figure 1: Sony "Flightstick"

Today, analog sticks, appropriately dubbed "thumbsticks" due to one's ability to control them with his/her thumbs have practically become standards for video game input devices.

2.2 Gamepads

Gamepads, also known as joypads or control pads, are the most prevalent mechanisms for input on modern video game consoles [8]. While joysticks as a standalone device, along with perhaps a few additional buttons, enjoyed significant popularity in the early stages of the video game industry, gamepads, most notably with the release of the Famicom and Nintendo Entertainment System (NES) Controller in 1983, eventually claimed the throne and have yet to fully relinquish it.

Figure 2: Famicom controllers

Basically, a gamepad is a game input device which is generally held in the hand and possesses a set of action buttons placed throughout its right-side for access by a user's right thumb, and, in more recent cases, right index and middle fingers as well as directional buttons usually in the form of a D-pad, analog joystick, or both on its left side [8]. This design, popularized by both the Famicom and NES controllers, differed from previous input devices in the sense that they placed directional control on the left. Although most arcade systems followed this design and positioned the directional control joystick on the left of the actions buttons, the majority of the home systems created

throughout that era were designed for directional right-handed operation [8].

Although certainly the most prevalent form of gamepad, the handheld device described previously is certainly not the only type. In 1986, Bandai released what became known as the "PowerPad" for the Famicom game console [8]. It was bundled within the "Family Trainer" pack in Japan and later released in the United States under the title "Family Fun Fitness". The controller, itself, is basically a gray mat with twelve pressure sensors embedded between two layers of a flexible type of plastic. The dancepad, otherwise known as the dance mat or dance platform, popularized by the rhythm and dance video game, Dance Dance Revolution, can trace its lineage back to the "PowerPad".

2.3 Augmented Reality

Dealing with the combination of real-world and computer generated data, augmented reality is a focus of computer science and computer engineering research in which computer graphics objects are integrated into displays in real time. In other words, live video imagery is digitally processed and "augmented" by the inclusion of computer-generated graphics.

Such research typically involves the use of motion-tracking data, fiducial marker recognition utilizing various computer vision techniques and algorithms, and the creation of controlled environments containing various sensors and actuators.

One of the most notable augmented reality setups is the ARQuake gaming system [1]. ARQuake is a first-person perspective game based on the first person shooter (FPS) series of games entitled "Quake". It is played in the physical world and enables the user to move about the world freely. The player wears a transparent Head-Mounted-Display (HMD) and his/her view in the game is adjusted based on his/her position and orientation in the real world. Game objects are dispersed throughout the environment based on the player's global position calculated using a TCM2 digital compass for orientation and a Garmin GPS navigation system for position.

Figure 3: Screenshot of ARQuake, the first-person perspective augmented reality gaming system

Another noteworthy augmented reality game is the interactive drama game called "Façade", developed by Michael Mateas, professor of artificial intelligence at Georgia Institute of Technology and Andrew Stern, creator of the Dogz, Catz, and Petz series from p.f. Magic [2]. The game incorporates natural language parsing as well as conversational interaction, natural language generation, emotional modeling, facial expressions real-time generation, and real-time body language simulation and generation.

Figure 4: Screenshot of the interactive drama, "Facade"

These are, of course, only a few of the augmented reality projects developed, but, it is safe to say that such an interaction technique is far from mainstream.

2.4 Virtual Reality

Allowing a user to either interact with a real or imagined computer-simulated environment, virtual reality is a technology which is immersive and takes place in highly visual three-dimensional environments. The visual experience can either be displayed on a computer screen or through

stereoscopic displays. Users interact with the virtual environment through the utilization of standard input devices such as a mouse and keyboard or through various multimodal devices [3].

The CAVE (Cave Automatic Virtual Environment), a type of virtual reality setup, is an environment where projectors are aimed at three to six walls of a cube about the size of a small room [4]. Wearing stereoscopic LCD shutter glasses, users are able to visualize three-dimensional representations of computer-generated images in three-dimensional space through the use of electromagnetic sensors. These sensors track the user's movements and the computer-generated image is adjusted according to the user's current position and orientation.

3 Exergaming

It is no mystery that the idea of exergaming works. As described in the previous section, the concept of integrating exercise and entertainment in the form of video games has been researched and implemented since the mid 1980's. The popularity of games such as "Dance Dance Revolution", Guitar Hero, and Rockband along with the incredible reception of the Nintendo Wii game console have more than demonstrated that society

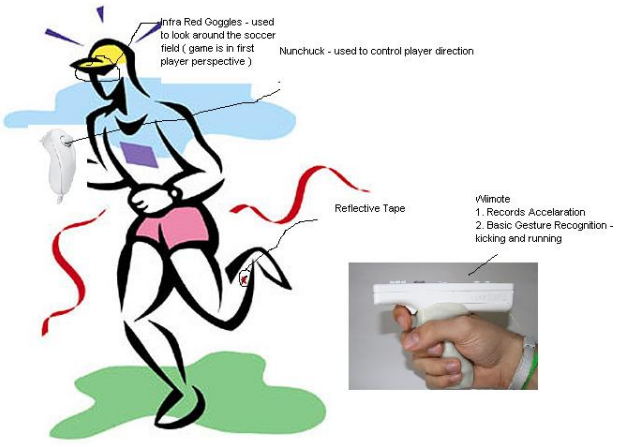

Figure 5: Wii!!! Soccer concept

is yearning for greater involvement in the video games which they play.

Therefore, with this said, providing a proof of concept for the idea is neither necessary nor the purpose of the project. The intent of our project is instead to expand the influence of this idea across multiple game genres while at the same time developing and implementing novel techniques for players to be able to interact with their games. We plan to do this by developing decent quality games and utilizing various technologies to alter the conventional methods of player interaction.

Of significant interest to us currently is hardware associated with the Nintendo Wii game console, specifically, the "Wii Remote". The "Wii Remote" or, as it is commonly referred to, "wiimote", utilizes a combination of built in accelerometers and infrared detection to calculate its position in three-dimensional space. This design allows for the system to detect physical gestures made by wielders of the wiimote. Such a feature has demonstrated its utility in many different applications but seemed ideal to us because it would allow us to mimic natural movements and gestures in our games. Furthermore, there is considerable support for the Wii Remote Communication API, which enables one to connect the wiimote through the Windows Human Interface Device (HID) [5].

Furthermore, we hope that by extending the influence of the idea of Exergaming across a more diverse set of video game genres, we can widen the target audience. Of course, the games themselves are indeed only proof of concept. The tools and engines which we use in the development process, while relatively advanced, are not quite sufficient enough to produce commercial quality games. Moreover, the members of the project lack any professional game development experience. Despite these factors, we feel that our first game, "Wii!!! Soccer" has progressed along pretty nicely and are encouraged by the initial feedback from our first playtests.

4 "Wii!!! Soccer" The Game

"Wii!!! Soccer" is a first person perspective soccer game which supports up to two players and allows players to perform natural soccer moves in the physical space, which are then translated into corresponding actions in the game. The game requires the use of a wiimote along with the nunchuk extension for navigation, an infrared emitter, reflective tape, and a second wiimote to track the reflected IR are used to track the player's

foot motion and gestures. This is somewhat different from previous applications of tracking as we are tracking motion of the foot rather than that of the head or hand. Moreover, in the same sense, our game differs from other gesture recognition systems in that we are detecting foot gestures rather than those performed by hand.

Our initial idea was to place reflective tape onto a player's foot and then allow infrared light

Figure 6: Players were required to wear infrared emitters attached to their legs in order for the wiimote to detect motion and gestures

emitted from the infrared emitter beneath the wiimote to reflect off of the tape on the player's foot back towards the wiimote's infrared camera. Unfortunately, we were unable to find reflective tape of sufficient grade and were thus forced to attach the infrared emitter directly onto the player's leg right above his/her ankle.

As expected, this turned out to be both uncomfortable and frustrating for players as it was somewhat difficult to keep the infrared emitter pointed towards the wiimote as the player moved.

It is also worth noting that we calibrated the gesture sensitivity thresholds based on the player being positioned between forty and forty-five inches away from the wiimote. As we will describe later, we found that players tended to move away or towards the wiimote as they played, which threw off the gesture responsiveness at times and caused some erratic behavior.

4.1 Controls on the Nunchuk

A player navigates by using the analog stick of the nunchuk. We had originally hoped to utilize the accelerometer data of the wiimote along with its orientation to control player navigation. However, we found that the movement of the player while running, passing, or kicking would unintentionally affect these values. In addition, holding the Z-button on the nunchuk down allows the player to move at a constant velocity in the direction he/she is looking. Again, we had planned to allow the player's velocity and acceleration to be controlled directly by the player's own pace. However, it became apparent to us that this translated into a considerable amount of work for players and caused them to tire out quickly. We, thus, decided to let the player's pace serve as bonus acceleration instead.

Lastly, by tapping the C-button on the nunchuk, a player is able to switch to a teammate closest to the ball. We found that this worked better than allowing the player to choose who he/she switched to by pressing a direction on the wiimote D-pad as, with the presence of AI, a player's focus is typically directed towards the ball.

4.2 Controls on the Foot Tracker

Designing and implementing the controls for the foot-tracker was by far the most challenging aspect of our development process due to factors related to gesture sensitivity thresholds and position. However, after considerable thought, we implemented a scheme which we feel is both "natural" and "intuitive". By holding down the Z-button on the nunchuk and running, a player can accelerate. The faster the player runs, the faster he/she moves in the game. Likewise, the slower a

Figure 7: Notice the small viewport on the upper right hand corner of the screen. This serves as the "dribble camera" for the player

Figure 8: Two Player Split-Screen

player runs, the slower he/she moves in the game.

Moreover, by performing a kick gesture to the player's left (away from the wiimote), the player passes the ball to a teammate in his/her direction. If there is no teammate in his/her direction, he/she just kicks the ball in the current direction. The force of the pass is proportional to the distance of the teammate. In the same sense, executing a kick gesture forward translates to a kick in the game. Like passing, the force applied to the ball is proportional to the velocity of the kick.

4.3 User-Interface Features

One of our biggest goals for this game was to maintain the traditional soccer game feel while making the player feel as though he is actually playing soccer with friends. In order to accomplish this, we designed a couple of user-interface features which should assist in the player's overall experience.

On the left side of the screen is an overlay used to maintain game information such as score, time remaining, current half, and an overhead view of the field. We found that the overhead view of the field was necessary as it could be difficult for players to keep track of their global position in the first-person perspective.

Additionally, one of the major problems we encountered developing a first-person soccer game was how to visualize the ball's position when the player is too close to see it. We experimented with tilting controls for the head of the player's avatar in game but found that given the pace of the game, this can turn out to be both frustrating and disorienting for players. Therefore, a foot camera is used to allow the player to look at the ball. If the player gets close to the ball, the foot camera pops up at the top right of his viewport.

4.4 Initial Playtests and Feedback

We recently conducted an initial play-test of our game and received very constructive feedback. We are planning to utilize this feedback to improve upon and add to our game for the next iteration.

In term of controls, we found that players had a penchant to hit the C-button while running, causing the player to accidentally switch from his current player. This was most likely due to the fact that while running, players were unable to

distinguish between the relatively close C and Z buttons on the nunchuk. We will most likely switch the "switch player" button to a button on the wiimote in our next iteration.

Furthermore, we found that the gesture sensitivity thresholds for discerning foot direction turned out to be too low for new/inexperienced players. Players would often initially bring their foot beyond the forward kick gesture recognition threshold while trying to pass. With better calibration and gesture detection algorithms, we feel that we can alleviate this problem.

Lastly, as for the dribble cam, it was not immediately clear to players what it was for. This can be attributed to the facts that it is relatively small compared to that of the player's head cam and it pops up without warning or any kind of indication. In the future, we plan to incorporate animated overlays to alert the player when he is close to the ball as well as to the position of the ball at any instant during play in addition to the foot cam. However, once players realized it was there and what it was for, they found it convenient and relatively easy to use.

5 Future Work

We believe that this first game will serve as a nice contribution to the Exergaming project. With more fine tuning of the foot-tracker parameters, a more consistent and responsive playing experienced can be obtained. Furthermore, we hope to be able to conduct future play-tests so that we may receive more feedback from players as to how we can improve our control scheme, user-interface, and/or add more gestures and motions to be performed by the player, which translates into various other in-game actions.

Lastly, we would like to be able to conduct a study on the extent to which players are willing to become involved in video games. We found that players enjoyed certain aspects of our game, such as running for extra acceleration, but not running for movement in general. It would be interesting to examine how close to real simulations gamers are willing to get in video games and what the factors are which determine this threshold.

6 References

[1] Pierkarsky, Wayne and Bruce Thomas, "ARQuake: The Outdoor Augmented Reality Gaming System", Commun. ACM, 2002.

[2] Mateas, Michael et al., "Presence and Engagement in an Interactive Drama", Conference on Computer-Human Interaction (CHI), 2007.

[3] Brooks Jr., F.P., "What's Real About Virtual Reality?", IEEE Computer Graphics and Applications, 1999.

[4] Cruz-Neira et al., "The CAVE: Audio Visual Experience Automatic Virtual Environment", Common ACM, 1992.

[5] Bircan, Korhan, "Making Next-Gen Video Games in Your Basement", Brown University Master's Project Report, 2008.

[6] http://electronics.howstuffworks.com/joystick.htm

[7] http://en.wikipedia.org/wiki/Joystick

[8] http://en.wikipedia.org/wiki/Gamepad