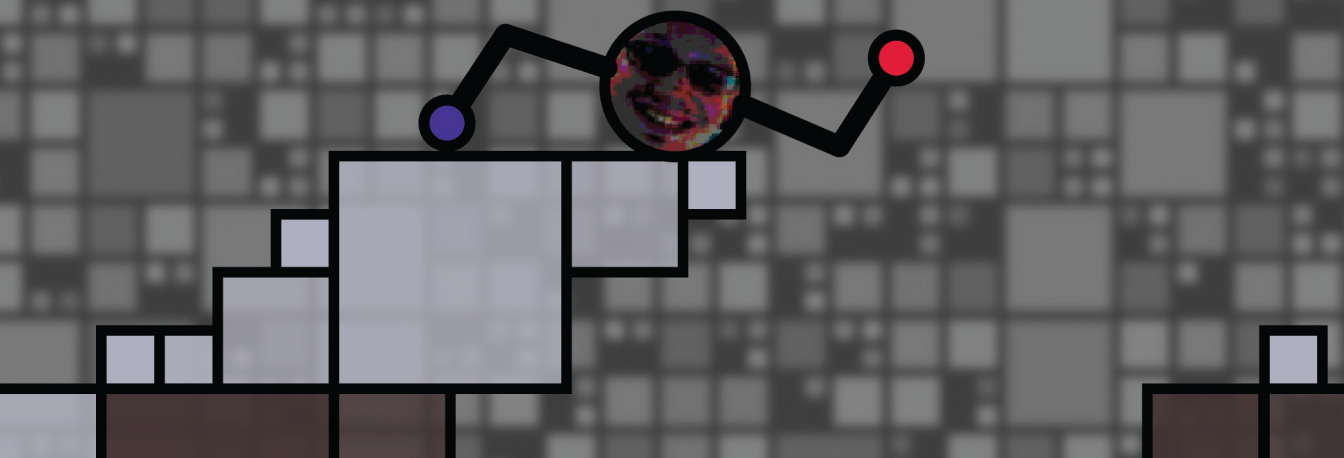
MIRROR

THE GAME THAT PLAYS YOU

A BFA Thesis Project by

Cory Hughart



Cory Hughart

Mirror: The Game That Plays You

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A Thesis
Presented to
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In Partial Fulfillme t
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by

Cory Hughart
Game Design Emphasis
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Acknowledgments

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Thanks also to Daniel Shiffman and the Processing community, who created the tools and tutorials I needed in order to integrate a physics engine into the game. They answered several of my naïve questions on the Processing forum as well.

Finally, I'd like to give a vague, general thanks to all of the game designers and game design theorists that have inspired me.

Dedicated to Denise and Tim, my parents.

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1 Artist's Statement

Long before writing this sentence, I[1] became fascinated with self-reference. I believe that, when something references itself (like using a phrase within parentheses to explain how things can reference themselves), the impact of its medium is compounded. The work is multiplied by itself like adding an exponent onto a number, creating a new dimension of the medium^{medium}. If the work contains a reference to itself (as this sentence does), its depth can extend infini ely as if gazing into two parallel mirrors. This technique can be clever or contrived, depending on its usage, but the paradoxical pattern it creates is interesting and pleasingly symmetrical. Self-reference is minimalism[2] taken to its most extreme conclusions: The most fundamental feature of any thing is what the thing itself is made of. I use this technique to provoke thought about the essence of things; after all, "the Medium is the Message."

Video games often exhibit self-reference as a matter of practicality; messages on screen usually give directions such as "Press A to jump," referring to the controller the player holds in his or her hand. Giving directions in this manner is nearly unavoidable, and this "break" of the fourth wall[3] often breaks the immersion of the player within the game world (just as the last footnote broke the fl w of the sentence, if you followed it). Most designers want the virtual game worlds they create to immerse the player, and so the controller is blamed for being crude and in the way. *Mirror* presents the controller as perfectly simple, and because of the symbolic nature of video games, the directness of pressed button to mapped action is not only satisfactory, but preferred.

Mirror's interactions aim to find new and unique meaningful inputs that expand our perceptions

1 Note: All instances of first person pronouns on this page refer to Cory Hughart, not to this statement itself.

2 "Minimalist" describes something as stripped down to its most basic characteristics.

3 "Fourth wall": the first three being the ones you can see on a traditional theatrical stage, the fourth being the invisible barrier that separates the audience from the fi tion; breaking the fourth wall is a form of self-reference wherein a fi tional character displays an awareness of his or her existence as being within a work of fi tion

to include the input device and game into an holistic experience. The game explores the use of self-reference as a practical technique for interaction with a video game, tying the physical interface directly to the game and the player as a unified system instead of separate entities. The game's content does not claim to be minimalistic or self-referential in itself (what does a game about playing a game look like?), but it employs self-reference in several layers to create immersion, rather than interrupt it. The title, *Mirror*, is itself a reference to the face capture that acts as a visual mirror for the player, the avatar's hand movements that mirror the player's own hand movements, and the left-hand mouse's functionality that mirrors the right-hand mouse. The game's goal is to escape the virtual mirror world, so that the player's identity is returned to reality.

2 Project Description

A paradigm shift is slowly and subtly occurring in terms of how we interact with our developing expanded reality, the virtual world. *Mirror* is a reaction to a current trend in the video game industry towards photorealism and controller-less interaction as brute-force methods for inducing an "immersive" experience. *Mirror* explores other techniques of immersion that allow for a tactile experience that is more than just button-pressing, but without the need to invent new hardware. Good games are enticing because they provide simple, symbolic experiences with well-defined goals and interactions that are quick to learn but challenging to master. This game intends to apply these guidelines to the very interactions between the player, the input device, and game. *Mirror* provides an innovative and practical immersive experience that is achieved by emphasizing and encouraging further exploration of existing, familiar devices and techniques with an emphasis in mapping physical action to similar virtual action.

Mirror consists of two separate but interconnected projects. First, it is an exploration of a familiar interface device, the computer mouse, as a competent though relatively unexplored video game interface. This project will explore the possibility of expanding a player's ability to interact with a virtual space by employing two USB mice simultaneously, augmented with tactile vibration feedback. This mirrors our ability to manipulate objects with two hands at once and understand them through the sense of touch. It will tap into the mouse's ability to translate positional data with little or no fatigue and its ergonomic design that fits comfortably as an extension of the human hand. Second, *Mirror* is an experiment in video game immersion through self-reference as a practical technique for interaction with a video game, tying the physical interface directly to the game and the player as a unifie , holistic system instead of separate entities. This is accomplished through an avatar, its system of interaction, and its storyline: 1) The avatar captures real-time video of the player's face, eliciting an automatic sympathetic response akin to recognizing one's self in a mirror, 2) the avatar's hand movement's mimic the player's own, and 3) the goal is to escape the virtual mirror world, so that the player's identity is returned to reality.

Mirror is a simple 2D physics game in which the player controls an avatar, trying to climb, swing, and roll to the goal. The interactions aim to find new and unique meaningful inputs that expand our perceptions to include the input device and game into an holistic experience. This unique input data can be translated into smooth, pleasurable control over a virtual avatar that sympathizes with the player as the player sympathizes with it. This experience will hopefully evolve into something greater than the sum of its parts, enticing its users to think about, create, and perhaps expect games that exhibit a greater depth of seamless interaction with the devices they manipulate.

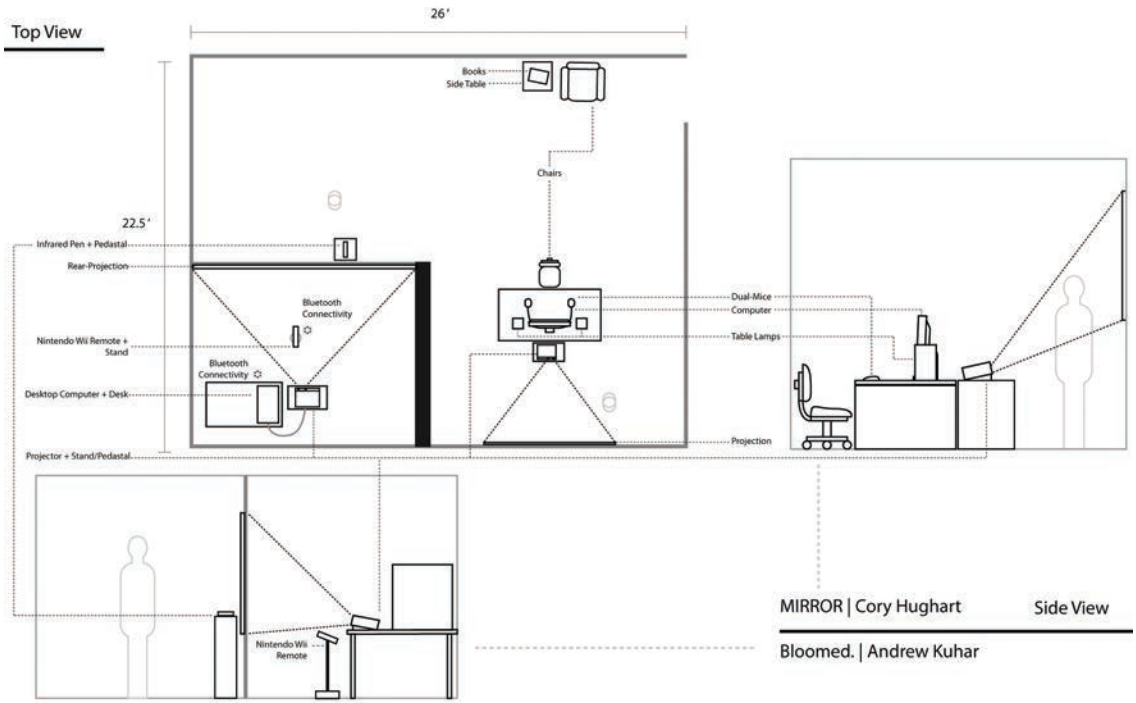


Figure 2.1.1 Installation Diagram (top and right side)

2.1 Media Overview

Mirror is a Java-based game developed to run only on Mac OS X due to technical limitations on Windows, though Java itself is cross platform (see section 2.5 Production Methods). The game and its source code will be available at coryhughart.com under a Creative Commons Attribution-Noncommercial-Share Alike 3.0 United States License[1]. This means that the work may be shared or adapted as long as the author is credited, and the resulting work is non-commercial and distributed under the same license.

The installation of *Mirror* shares a space with fellow game design student Andrew Kuhar's BFA Thesis project, *Bloomed* (Fig. 2.1.1). Both games hope to draw a similar audience, and both hope to achieve a certain level of conceptual complexity that entices players to think differently about video games.

Mirror exists as a computer station meant for one individual. An iMac rests on a simple black desk, offering two computer mice on large grey pads to the user. Two table lamps, one at each side of the monitor, illuminate the face of the user for the built-in iSight camera to capture. There is only sitting room for one, but a projector behind the desk displays the iMac's screen on the back wall for any observers. Near the entrance to the space, this book sits upon a small black side table next to a chair, for those who wish to learn more.

1 http://creativecommons.org/licenses/by-nc-sa/3.0/us/

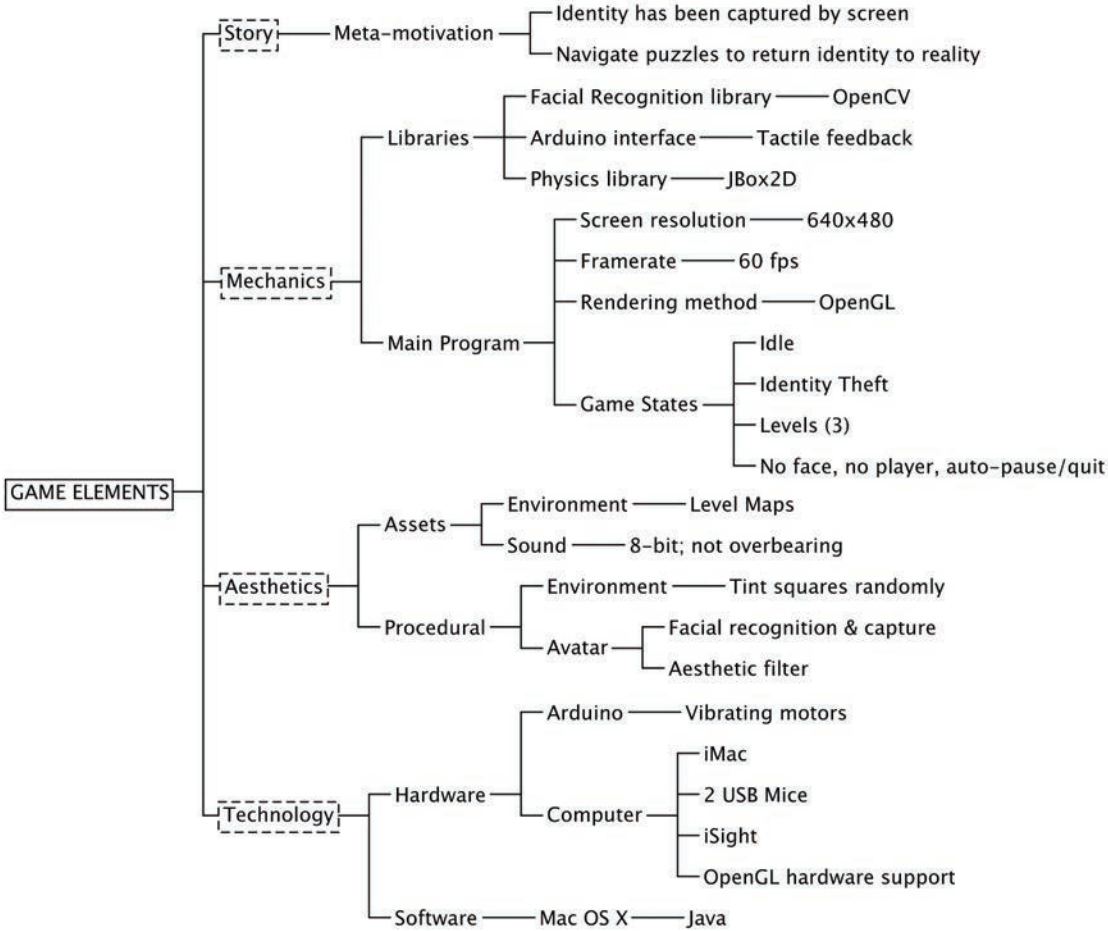


Figure 2.2.1 *Mirror* Program Outline

2.2 Program Outline

Every game can be split into four essential elements, described by Jesse Schell as the "elemental tetrad" (41). *Mechanics* are the rules of the game; how players interact and what the goals are (Fig. 2.2.2). *Story* involves the sequence of events that unfold, whether heavily scripted or abstract. *Aesthetics* are what affect the player's senses, such as visuals, sound, and feel. *Technology* is any material or mechanism that makes the game possible. *Mirror* is outlined in this way at left (Fig. 2.2.1).

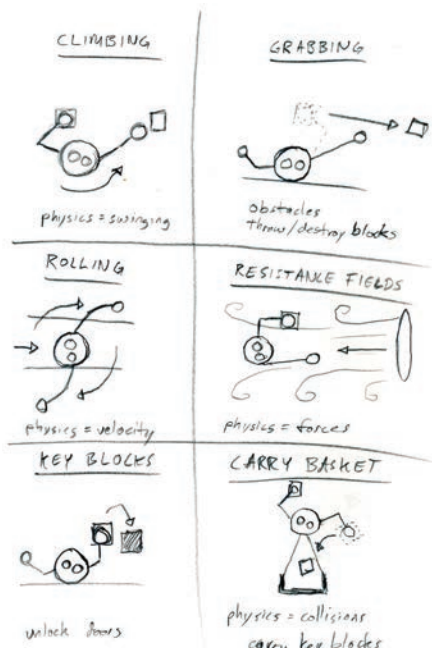


Figure 2.2.2 Avatar mechanics concept sketches

Figure 2.3.1 *World of Goo* (2D Boy, 2007)

2.3 Design Choices

The aesthetics of *Mirror* are deliberately and obviously non-photorealistic and low-resolution. This decision was influen ed by a number of factors, but mostly by successful games that did not require any level of traditional western realism to garner success, such as 2D Boy's World of Goo[1]. The emphasis is on simplicity; 2D, low resolution graphics are feasible within the time limits, but will also lend a unique identity to *Mirror* in a landscape of intensely detailed 3D shooters.

Several existing games have inspired *Mirror*'s aesthetics and design. *The Secret of Monkey Island* (Fig. 2.3.1), a point-and-click game for DOS, exemplifies the artistic quality of low-resolution imagery during a time of necessity, when graphics processing power was in its infancy.

"Old" games are not the only source of inspiration though; some recent indie flash games from fli el.org display similar levels of aesthetic beauty with pixel graphics. They are also inspirational due to their unique yet simple gameplay mechanics. Flixel game *Gravity Hook*[2] (Fig. 2.3.3) is designed with pixels in mind, and it had an influen e on *Mirror*'s gameplay design as well.

The medium of video games was once plagued by technological limitations that forced designers to create compelling visuals, sound, and gameplay with limited resources, but designers today face a different challenge: to create a compelling game with nearly unlimited potential, potential that grows with each passing year. Photorealism in video games is now feasible due to incredibly fast computing power and dedicated graphics hardware (Fig. 2.3.4). In the near future, graphics will hardly be the defining characteristic of video games. Other qualities must create uniqueness.

1 http://2dboy.com/games.php
2 http://www.adamatomic.com/gravity/

Figure 2.3.2 *The Secret of Monkey Island* (Lucasfilm ames, 1990)

Figure 2.3.3 *Gravity Hook* (Adam Atomic & Danny Baranowsky, 2008)

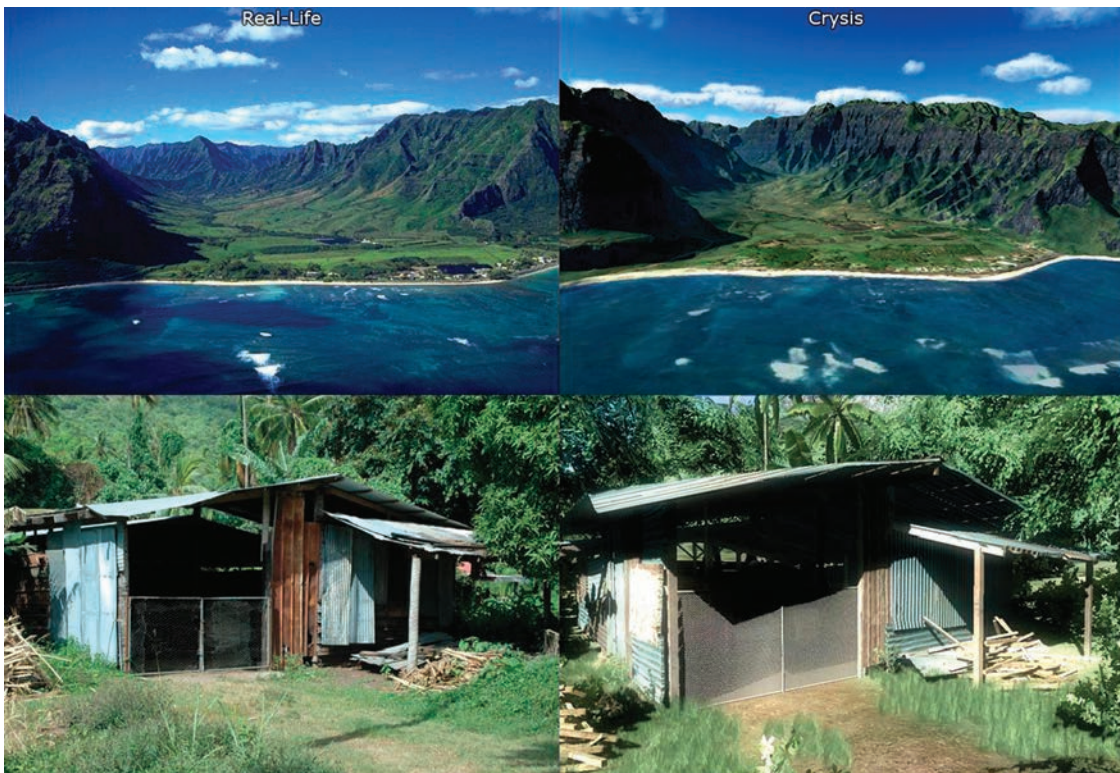


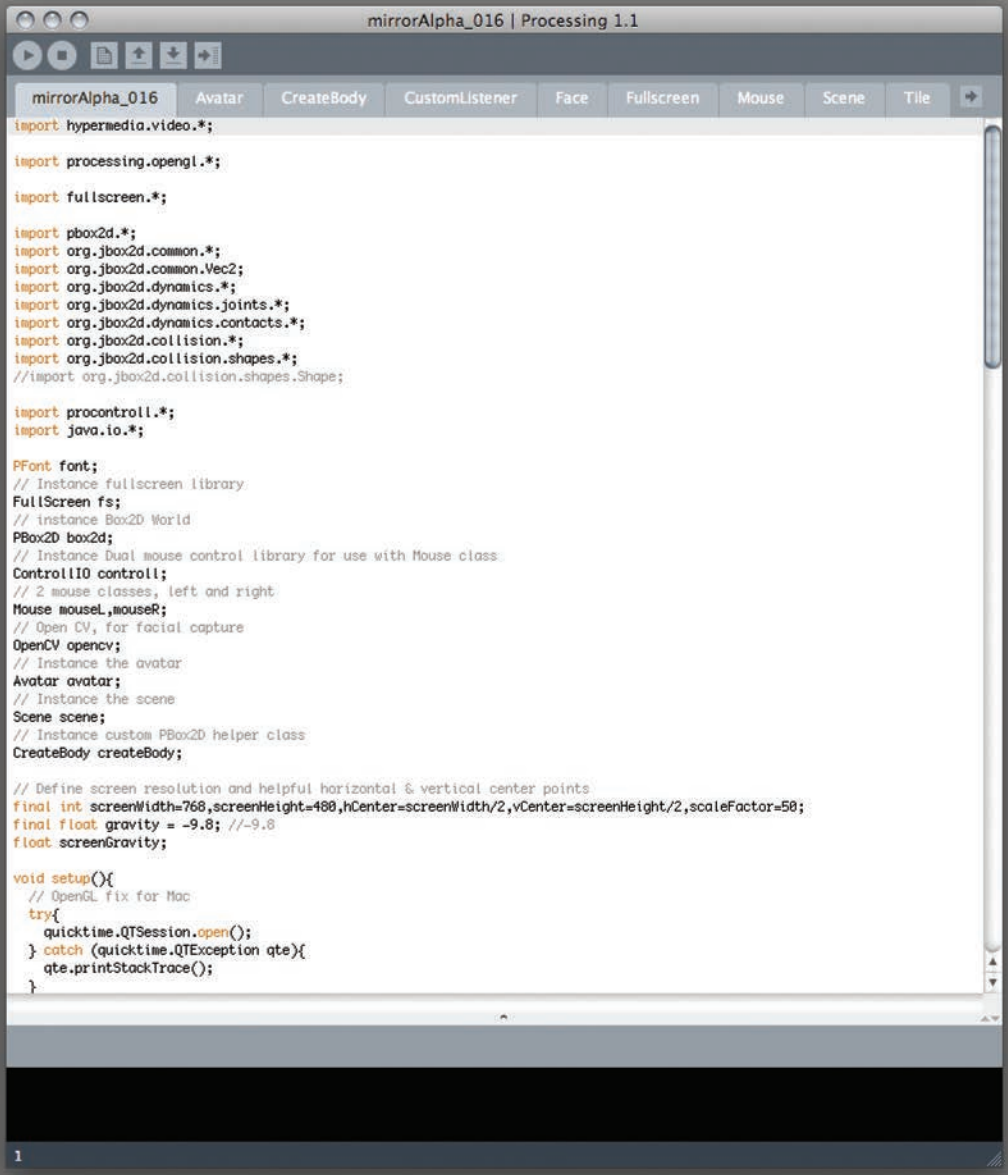
Figure 2.3.4 Comparison of photograph to *Crysis* (Crytek, 2007)

2.4 Target Audience

The target audience of *Mirror* is an "indie" (independent) gaming audience. Indie games are simply games that are made without the financial support of a publisher, usually relying on the strong personal interest of the designer (as well as his or her bank account). These games often exhibit a different sort of gameplay than mainstream, published video games because publishers are usually hesitant to fund a new and different idea that is not guaranteed to sell.

The indie game audience is made up of people looking for unique game mechanics and story-lines. These games usually don't fit easily into mainstream categories. Many of these games are made in Adobe Flash (such as *Gravity Hook* pictured in the last section) because it is accessible for individuals and easily published to the web. The age range for this project and its conceptual nuances falls approximately between teens and early 30s.

As stated in section 2.2 Program Outline, the audience is limited to the Mac OS X platform, but the game and its source code will be available under a Creative Commons license at coryhughart.com. Two USB computer mice and a webcam are also required.


mirrorAlpha_016 | Processing 1.1
mirrorAlpha_016
Avatar
CreateBody
CustomListener
Face
Fullscreen
Mouse
Scene
Tile
import hypermedia.video.*;
import processing.opengl.*;
import fullscreen.*;
import pbox2d.*;
import org.jbox2d.common.*;
import org.jbox2d.common.Vec2;
import org.jbox2d.dynamics.*;
import org.jbox2d.dynamics.joints.*;
import org.jbox2d.dynamics.contacts.*;
import org.jbox2d.collision.*;
import org.jbox2d.collision.shapes.*;
//import org.jbox2d.collision.shapes.Shape;
import procontroll.*;
import java.io.*;
PFont font;
// Instance fullscreen library
FullScreen fs;
// instance Box2D World
PBox2D box2d;
// Instance Dual mouse control library for use with Mouse class
ControllIO controll;
// 2 mouse classes, left and right
Mouse mouseL,mouseR;
// Open CV, for facial capture
OpenCV opencv;
// Instance the avatar
Avatar avatar;
// Instance the scene
Scene scene;
// Instance custom PBox2D helper class
CreateBody createBody;
// Define screen resolution and helpful horizontal & vertical center points
final int screenWidth=768,screenHeight=480,hCenter=screenWidth/2,vCenter=screenHeight/2,scaleFactor=50;
final float gravity = -9.8; //-9.8
float screenGravity;
void setup(){
// OpenGL fix for Mac
try{
quicktime.QTSession.open();
} catch (quicktime.QTException qte){
qte.printStackTrace();
}
1

2.5 Production Methods

(For project schedule, see Appendix A)

Mirror was developed in Processing[1], an open source programming language and environment for visually-based interactive web and desktop media. Processing is based on and produces Java desktop applications and web apps.

The gameplay utilizes the JBox2D Java physics library, which is based on Box2D, a physics library for C++. Daniel Shiffma 's tutorials and helper library at his website[2] were invaluable. The avatar is built from physics objects, joints, and springs, and the environment is made of stationary blocks. The hands of the avatar are simply attached with rigid springs to the invisible mouse cursor coordinates, and so the player acts as a sort of puppeteer.

Level design was quite a hassle at firs , as the coordinates and size for each block in the environment were put in manually. Eventually, a system was devised that greatly optimized the workfl w: Pixel maps, drawn by hand with Adobe Photoshop, are analyzed by the program, which places the appropriately sized and colored block at the appropriate coordinates in the virtual space. Three different sized GIF images, each exactly half the size of the last, are produced to coincide with the three different sizes of the blocks. See figu e 2.5.1 for the pixel map and figu e 2.5.2 for the resulting block placement.

Face-recognition is accomplished with OpenCV[3] (which stands for **O**pen Source **C**omputer **V**ision), originally for C and C++ but adapted for Java and Processing by Atelier Hypermédia. OpenCV analyzes real-time video capture and can run a number of algorithms to detect faces, bodies, or blobs of color.

1 http://www.processing.org
2 http://www.shiffman.ne
3 http://ubaa.net/shared/processing/opencv/

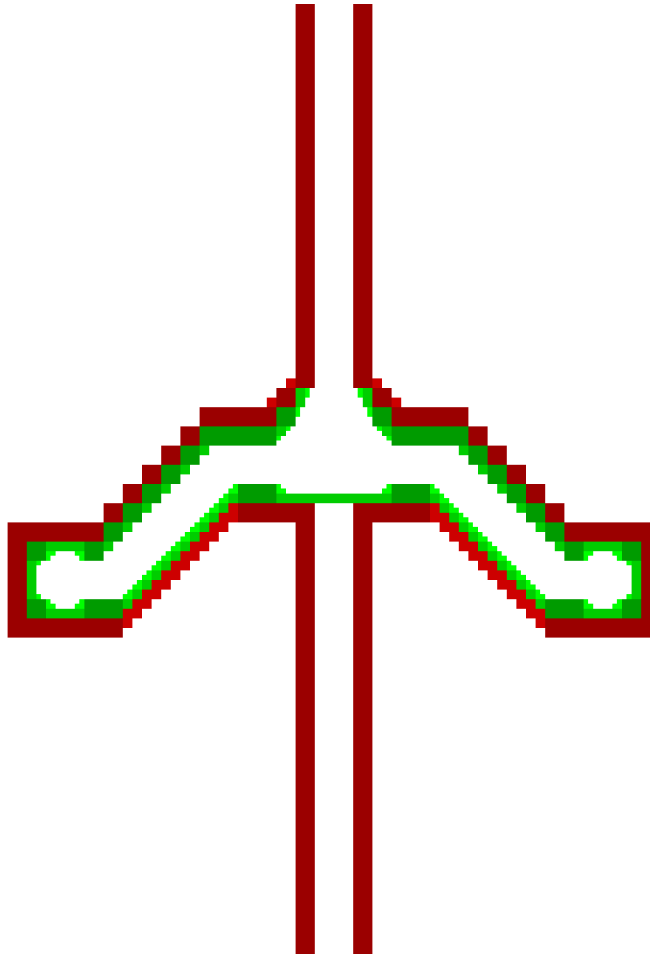


Figure 2.5.1 Pixel map of game hub

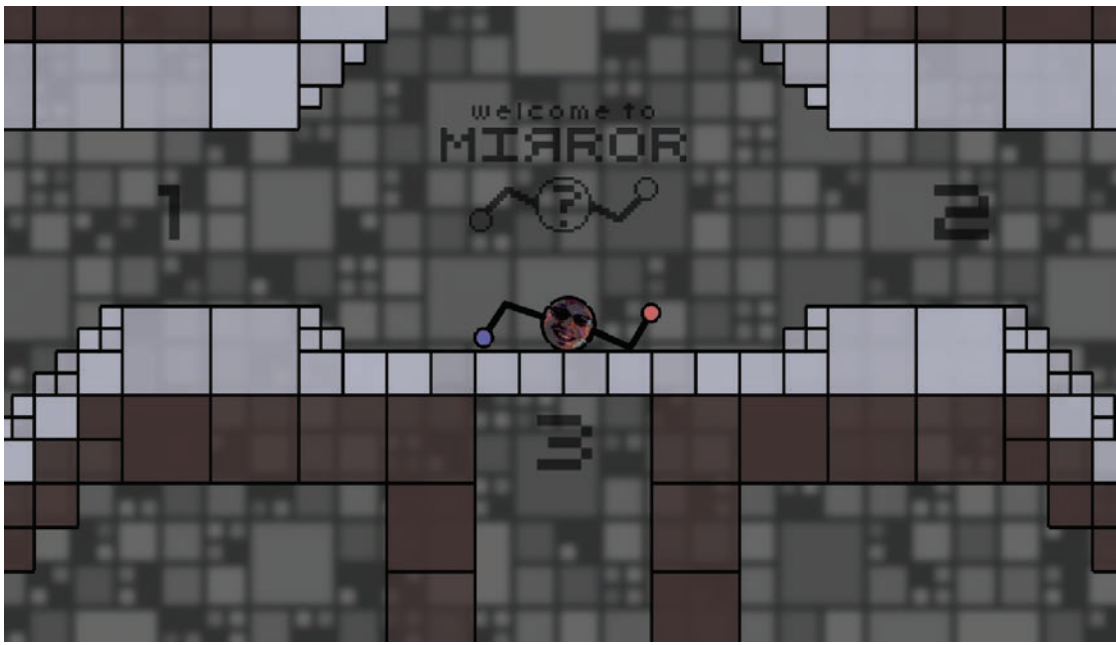


Figure 2.5.2 In-game screenshot of game hub

Figure 2.6.1 Fellow game design student (Andrew Kuhar) testing a *Mirror* prototype & mock installation

2.6 Outline of Resources

(For project budget, see Appendix B)

Hardware:

1. iMac, complete with built-in speakers and iSight webcam
2. USB computer mice (2)
3. Arduino microcontroller & misc. electronic components
4. Projector (for installation only)

Software:

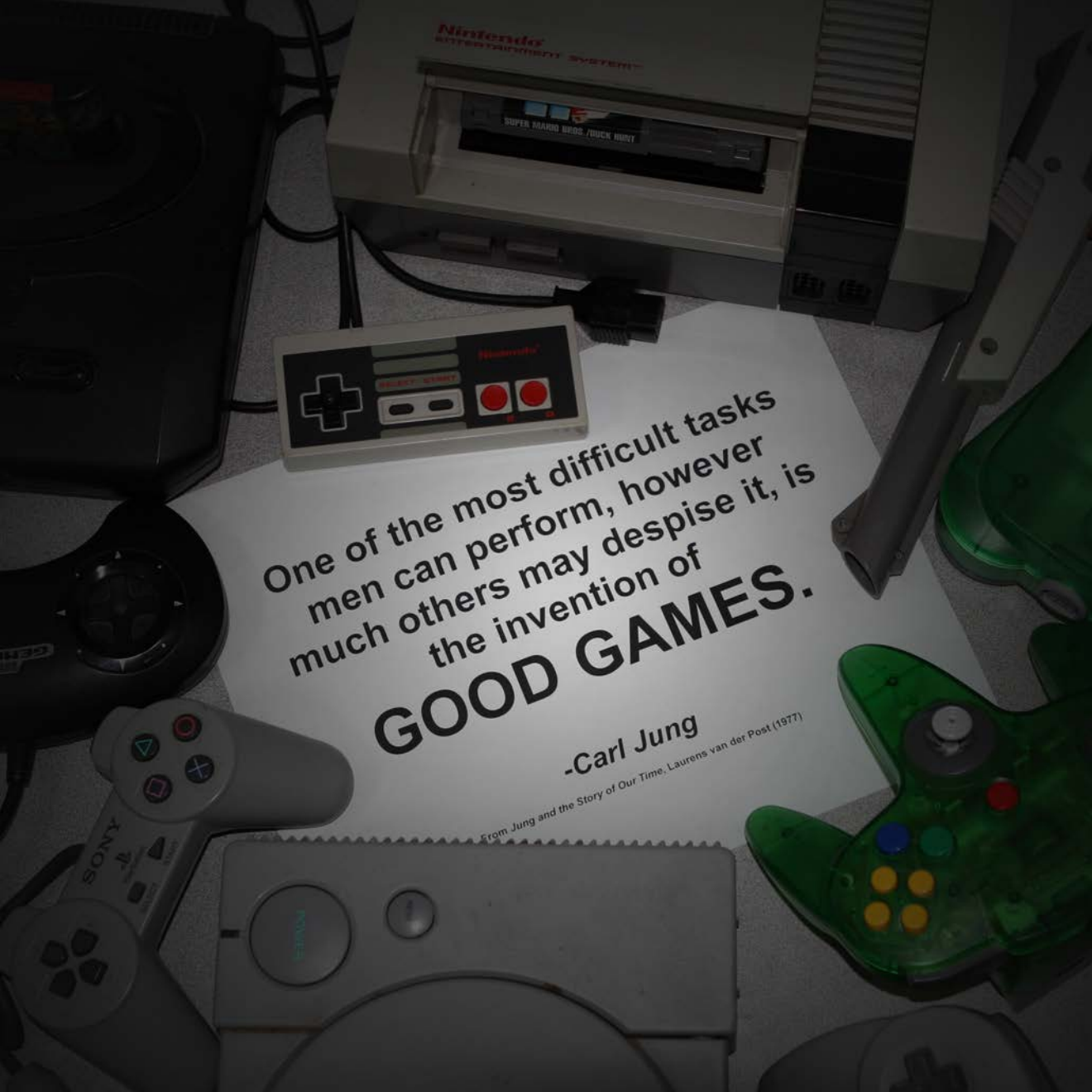
1. Processing IDE
2. Java Runtime Environment
3. Adobe Photoshop
4. Adobe Illustrator
5. Adobe InDesign (book)

Installation Materials:

1. Desk
2. Chairs (2, desk and recliner)
3. Frosted glass table lamps (2)
4. Side table
5. Desk lamp
6. Bound book of research & development
7. Wall decor and information

People:

1. Playtesters


Nintendo
SUPER MARIO BROS./DUCK HUNT
One of the most difficult tasks men can perform, however much others may despise it, is the invention of
GOOD GAMES.
-Carl Jung
From Jung and the Story of Our Time, Laurens van der Post (1977)

3 Research

A paradigm shift is slowly and subtly occurring in terms of how we interact with our developing expanded reality, the virtual world. *Mirror* is a reaction to a current trend in the video game industry towards photorealism and controller-less interaction as brute-force methods for inducing an "immersive" experience. *Mirror* explores other techniques of immersion that allow for a tactile experience that is more than just button-pressing, but without the need to invent new hardware. Good games are enticing because they provide simple, symbolic experiences with well-defined goals and interactions that are quick to learn but challenging to master. This game intends to apply these guidelines to the very interactions between the player, the input device, and game. *Mirror* provides an innovative and practical immersive experience that is achieved by emphasizing and encouraging further exploration of existing, familiar devices and techniques with an emphasis in mapping physical action to similar virtual action.

Figure 3.1.1 Frame from *Project Natal* Announcement Trailer (Microsoft, E3 2009)

3.1 Introduction

The current innovation trend in the video game industry rests upon gesture-based and controller-less interaction. The PlayStation Eye, Microsoft's Project Natal, and other "no controller required" initiatives utilize advanced computer vision technology, trying to provide for a "natural user interface" (NUI), or an interface that is or becomes effectively invisible to the user because the interaction is natural and intuitive. They have based their development of this form of NUI on the assumptions that video game players *want* controls that emulate "real life" as closely as possible; as the Project Natal announcement trailer (Fig. 3.1.1) matter-of-factly states, "The only experience you need is life experience." In this case, "real life" involves full- or at least partial-body movement, ignoring the fact that, in "real life," this is almost always accompanied by physical boundaries and natural touch-feedback. Microsoft and Sony will have their users flailing about in front of their televisions, attempting to translate all of that positional data into virtual action so accurately that the user doesn't need any physical feedback in order to feel immersed within the virtual space.

Figure 3.2.1 *Wii Fit* (Nintendo, 2008)

3.2 The Problem

The problem with this system in terms of video game control is stated eloquently by Steve Swink, author of *Game Feel: A Game Designer's Guide to Virtual Sensation*:

> In the apparent quest to make computer input mirror real-world interaction—to make it more "natural"—we may be ignoring the crucial fact that it feels good to control a complex system with simple inputs. This is what makes learning things in a game more fun than learning things in real life. Real life is complex, dirty and difficul to master. A game can be clean and simple to master. Through a simple input device with little bandwidth, we can truly interface with a highly complex system and experience the joy of manipulating it. (323)

This is not to say that one couldn't possibly enjoy a game designed for this system of interaction; rather, game designers would have to take precautions to ensure that enjoyment is not overshadowed by bodily fatigue, or else design their game as a means for exercise; the potential of this system as an exercise medium is certainly a driving force behind its development. As of the end of 2009, the "List of best-selling video games" on Wikipedia shows Wii Play (24.43 million sold) and Wii Fit (Fig. 3.2.1) (22.5 million sold) at first and second place, respectively, in the "Top 20 console games of all time," figu es backed by Nintendo's official financial iefing of 2009 (5)

3.2.1 Games vs. Simulations

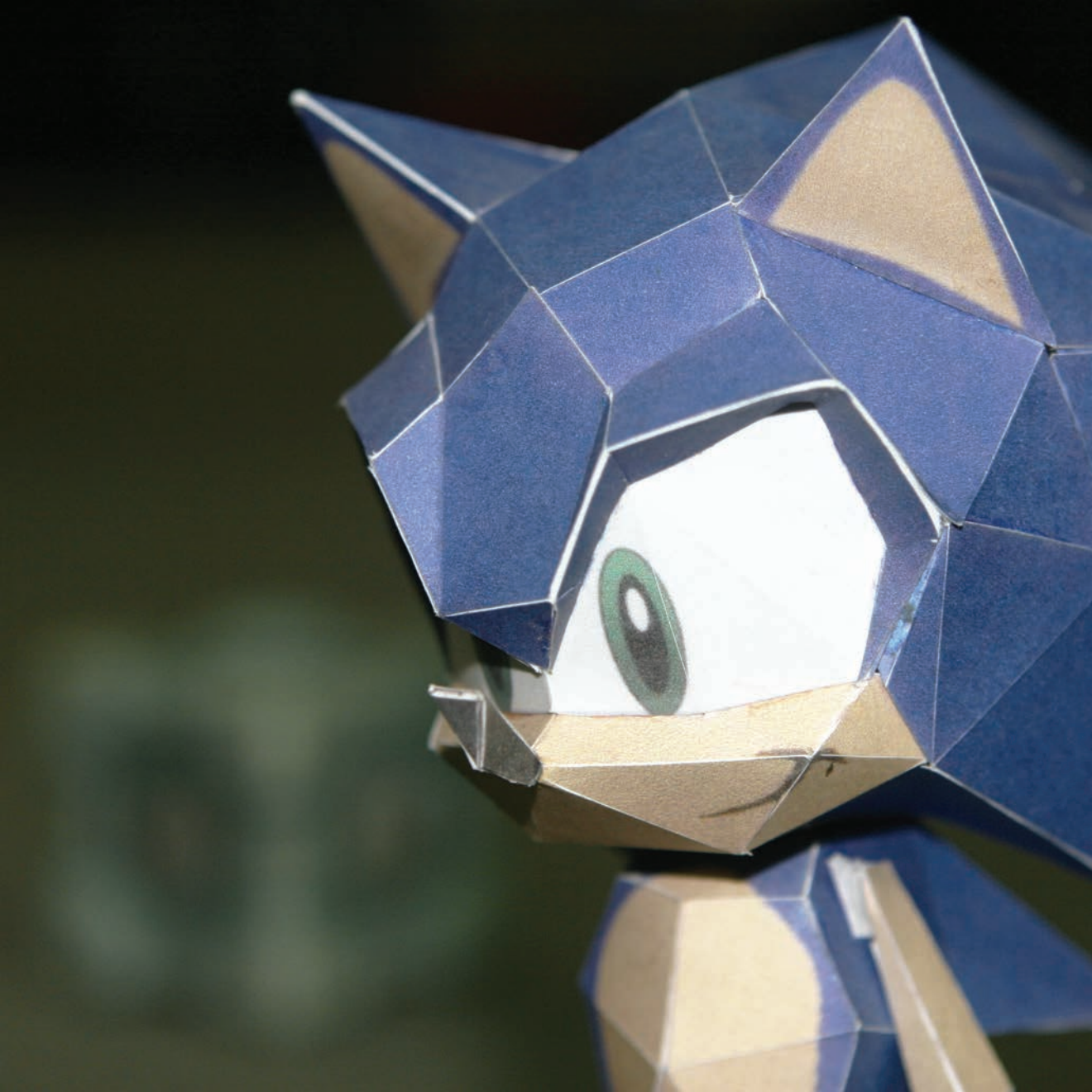
Full-body, motion-controlled, "realistic" input fits more appropriately in the realm of simulations, not games. In 1982, Chris Crawford authored *The Art of Computer Game Design*, a cornerstone work of game design theory, defining a simulation as "a serious attempt to accurately represent a real phenomenon in another, more malleable form" as opposed to a game, or "an artistically simplified representation of a phenomenon." He partially defines a game as a willing and necessary "subset of reality," being a focused design of a user's experience, whereas simulations only compromise when technological and intellectual limitations make it absolutely necessary (Chapter 1). The game designer tries to allow the user an inherent and intuitive mastery over a miniature reality, while simulation developers seek to emulate reality in all its gritty, complicated detail.

3.2.2 Intuitive vs. Realistic

Intuitive and realistic are not always the same as it is often assumed. Swink argues that intuitive controls do not necessarily follow from reality. The goal of intuitive interface design is the "amplific tion of input," where small, effortless motions illicit a powerful, complex, pleasing response (322). In reality, according to Newton's third law of motion, you only take away as much as you put in. Interaction with well-designed games is pleasurable because you put in less effort to achieve more control of a complex system. In an attempt to design a more intuitive system of interaction, the industry has developed methods for capturing raw, "realistic" motion that will simply fatigue the player due to the lack of physical support. The industry has known about these fatigue issues since at least 2002, according to a study from Germany on computer vision based gesture recognition (Lenman et al.), yet has forged ahead anyways.

3.2.3 The Importance of a Tactile Experience

A consumer report published in 2006 concluded that 72 percent of avid gamers in the U.S. agree that vibration-feedback is important for affecting a higher level of immersion in video games; it "makes the game more fun, involves the player more in the game, makes the game seem more real, helps the gamer play better." The report also accurately predicted the gain in sales over the PS3, which lacked the rumble feature in controllers at launch, by Microsoft's Xbox 360, which included the feature by default (Ipsos Insight).



3.3 Immersion Strategies

Immersion is a difficul word to defin , and an even more difficul thing to achieve. Ernest Adams, game designer and cofounder of the International Game Developers Association, defines immersion in three different ways. *Tactical* immersion is a level of intensity in concentration wherein a player is acting and reacting in a test of skill. *Strategic* immersion occurs when a player's involvement is highly "cerebral," planning and puzzling over the next move. *Narrative* immersion is a sense of care for a character or characters and an investment into seeing a story play out in its entirety. Michael Nitsche's definition of "presence" helps clarify this idea of immersion: "Presence ... is understood as the mental state where a user subjectively feels present within a video game space as the result of an immersion into the content of the fi tional world ... It is a mental phenomenon based on a perceptual illusion" (203). The following subsections will look at immersion from three perspectives, slightly different from but related to Adams'; *Proprioception, Sympathetic Projection, and the Holistic Experience*.

3.3.1 Proprioception

Proprioception is a sense that most people are unaware of, yet without it they would be nearly helpless. It is the sense of the physical self in space, drawn from the relation of individual parts of the body to each other. It is physically perceived through tightness and slackness in muscles and joints, noting the degree of bend in an arm in concert with the strain of the biceps and other surrounding muscles. The sense of proprioception is what allows a person to touch his nose with his eyes closed (Blakeslee 1-2).

This general sense of positioning in space extends into tools and devices, demonstrated by the ability to hit a ball with a bat or parallel park (4). This is where proprioception begins to serve the goals of immersion; just as a person understands how to bring a fork swiftly to his mouth, this sense can be manipulated to allow a player to literally feel like they are physically manipulating a virtual object. As a simple experiment to increase the reader's own awareness of his or her proprioception, Sandra and Matthew Blakeslee, in their book *The Body Has a Mind of Its Own*, describe the following: Obtain a fake hand or borrow a friend's, and place it on a table. Rest your hand somehow out of sight, but in the same orientation and position. Have the friend touch both hands the same way simultaneously while you watch the fake hand. Eventually, you will feel as if the sensations are coming from the fake hand (36). This is their explanation: "Visual and tactile stimulation converge in combined vision and touch maps in your posterior parietal lobe, and because they are well correlated in time, those maps will accept the interpretation that the tactile sensations are actually coming from the inanimate thing you are watching" (36). This is an important aspect of Swink's "game feel," the quality of a video game that measures the tactile, kinesthetic sense of manipulating a virtual object. Along with the principle of the amplific tion of input, a player receives visual, tactile, and aural impressions that combine to from a "virtual proprioception."

One loophole may get in the way of absolute success in immersing a player. Proprioception, though so essential to affecting immersion in video games, is not equal in all people:

> Interestingly, people show different degrees of ability to experience [the substitute hand] illusion. Some people feel it vividly and almost instantly, while others take a long time to start experiencing it and may "lose the feel" for it. Neuroscientists are just starting to search for the basis of these individual differences, which may end up having practical implications for prosthetics, virtual reality, neurotherapy and rehabilitation, and anorexia treatment; anorexics are immune to the rubber-hand illusion. (Blakeslee 36)

There is a possibility that the inclination to play video games in general may have something to do with a person's level of proprioceptive extension.

3.3.2 Sympathetic Projection

The extension of a user's proprioception is necessarily dependent on an object with which to anchor. This is usually accomplished through an *avatar*, or the embodiment of the player's will in the virtual space; one might refer to this phenomenon as "sympathetic projection." The last chapter of *Video Game Spaces* by Michael Nitsche, entitled "Players 'in' the Video Game Space," considers the player's position in relation to virtual environments:

> "You" are not directly projected into the fi tional world of a video game space. Instead, you get access to distinct elements (e.g., an avatar) within it and from that a feeling of presence can emerge. (209)

The physical input system and the software must coexist and interact in real time, so that the player's will is immediately transferred into the virtual space, in the form of an avatar.

An avatar can be as complex as a fully rendered 3D approximation of a human being or as simple as a cursor on a computer screen. The player may control this avatar from a third-person perspective or inhabit the avatar and see through its "eyes." It is important to note that a common miscon-

Figure 3.3.2.1 *Assassin's Creed* (Ubisoft, 2007)

ception has been perpetuated, a belief that the firs -person view is always the most immersive kind of virtual interaction, harkening back to VR research projects from the '80s (214). Brandon Sheffie , editor-in-chief of Game Developer magazine, believes that no player truly believes he or she is actually inhabiting a virtual avatar; rather, developers should focus on allowing the player to *identify* with the avatar. In an article entitled "The First-Person Immersion Myth," he asks, "how can you identify with a character you can't see, a character who usually doesn't even talk or have any opinions about the ... things going on around him?" (4). Sympathetic projection, or projection of one's identity into an object that one easily relates to and identifies with, may benefit from a 3rd person perspective. Viewing your avatar from a third-person perspective allows your proprioceptive sense to perceive the character object as an extension of your hands. In Assassin's Creed, a third-person perspective emphasizes the climbing skill of the avatar, and also a sense of sheer

height (Fig. 3.3.1).

The notion of extending one's own identity into an object outside of one's self is not as foreign and farfetched as it sounds. Human beings universally perform this feat of identity acrobatics every time they glance into a mirror anytime after 24 months of age (Nielsen and Dissanayake "Mirror self-recognition"). Infants tend to manifest this capacity after 24 months in other areas as well, most notably through "synchronic imitation," a "characteristic of play which emerges ... whereby infants show a preference for engaging with objects that are similar to ones chosen by their play partner, and use the common object in a similar postural, motoric, and symbolic way" ("Synchronic imitation"). In other words, human minds develop early on to sympathize with an *other* who exists outside of the body, essentially understanding that *other* as an extension of the *self*.

3.3.3 The Holistic Experience

Another piece of the immersion puzzle to consider, aside from tricking the senses into extending you perception, is tricking the frontal lobe, which contains the seat of consciousness. That logical, reasoning part of the brain is more likely to *hinder* immersion than help it, being able to distinguish between self and other, or self and refle tion. A player can make a logical connection between input and output, cause and effect, lending credit to Brandon Sheffie 's assertion that no player truly believes that they inhabit an avatar (unless a brain disorder is involved). This can possibly be circumvented by a more abstract approach that appeals to those higher brain functions: to conceptually connect input to output, to link the physical device and its related interactions to the game world by more than just cause and effect.

This concept is well theorized in the form of the "fourth wall" of theater. This fourth wall originally referenced the imaginary wall between the audience and the fi tional world on stage, the other three walls being at the back and sides. In film, this term came to be represented by the screen, since camera angles frequently change. *Breaking* the fourth wall occurs when the self-contained fi tional world suddenly is able to peer through this wall, as if through a window, and acknowl-

edge the presence of the audience or the technological apparatus that is creating and containing the fi tion. This separation between the fi tional and real world is a problematic concept for video games, in which the player acts as audience and performer. This allows for nearly limitless potential for positioning the player in, around, over, under... (insert any number of other prepositions)... the fi tional game world.

In an article titled "A Circular Wall? Reformulating the Fourth Wall for Video Games," Steve Conway examines a number of ways that video games have used the concept of the fourth wall to their advantage. Some games classically *break* the fourth wall, directly addressing the player or displaying awareness of the apparatus that contains them; others seem to *relocate* the wall, such as many *Alternate Reality Games*, where players seem to play in a fi tional world while keeping their identities; they utilize real life media, such as websites, email, and phone calls to band together with other players and solve puzzles, actively participating in the creation of the storyline.

The fourth wall in games is strongly tied to the concept of the "magic circle," the mental space in which a game occurs as a subset of reality. This circle can be contracted, essentially throwing the player from the fi tion world, sometimes as an assertion of the game's autonomy; it can also be expanded to include the device by which the player interacts with the game (1-2). Steve Swink gives the example of *The Legend of Zelda: Phantom Hourglass* for the Nintendo DS; in order to "stamp" a piece of paper on the bottom screen with an image on the top screen, the player must close and open the device so that the two screens literally come together and separate. He acknowledges that the industry tends to avoid the complete exploration of current input devices, purporting that the unique and unusual use of familiar devices is often perceived as gimmicky (331). However, as Conway puts it:

> By encompassing the technical features of the video game console, and in doing so creating a new, novel form of interaction with the game, the developers again are not breaking the fourth wall, but instead expanding the magic circle to include the hardware features of the console. (3)

> ... to *break* the fourth wall is normally to *break* the suspension of disbelief, to remind the audience it is just a [game] ... many of these so-called fourth wall breaks actually serve to further immerse the player, extending the immersion beyond the screen. (4)

If done properly, these types of interactions allow the physical interface device to have meaning within the game space instead of making it invisible, rendering it unnecessary, as NUIs seek to achieve.

3.3.4 A Note on Photorealism

The medium of video games was once plagued by technological limitations that forced designers to create compelling games with limited graphical resources, but designers today face a different challenge: create compelling games with practically unlimited graphical potential, potential that grows exponentially each year. Photorealism in video games is nearly possible (see fi . 2.3.4 in section 2.3 Design Choices), along with incredibly fast computing power and dedicated graphics hardware.

In an article for Gamasutra.com, David Hayward analyzes the push towards photorealism in video games, noting that a push towards realism has occurred in most forms of visual art, usually signifying a coming age of wider visual experimentation (1). In order to reach that point, designers would have to push through an area of human likeness called the "uncanny valley" (Fig. 4), theorized by roboticist Masahiro Mori. This is a sudden decrease in a viewer's positive response as an object nears human likeness; when a moving image that looks human but doesn't act with the level of complexity that a human is used to, a viewer will elicit a similar response to running into a moving corpse.

At this point, total photorealism in all aspects of a game is absolutely impractical, as the cost of development is enormous (3). But even if it were possible, an environment that appears real will be expected to act real as well. This level of complexity in interaction is simply not possible, and, at that point, one might as well not bother with such a virtual construct, being the same, theoreti-

cally, as reality itself. A photorealistic environment, then, may ultimately detract from a player's feeling of presence, since a less-real interaction with the environment contrasts sharply with its visual realism, ultimately pushing the limitations of the interactivity to the forefront.

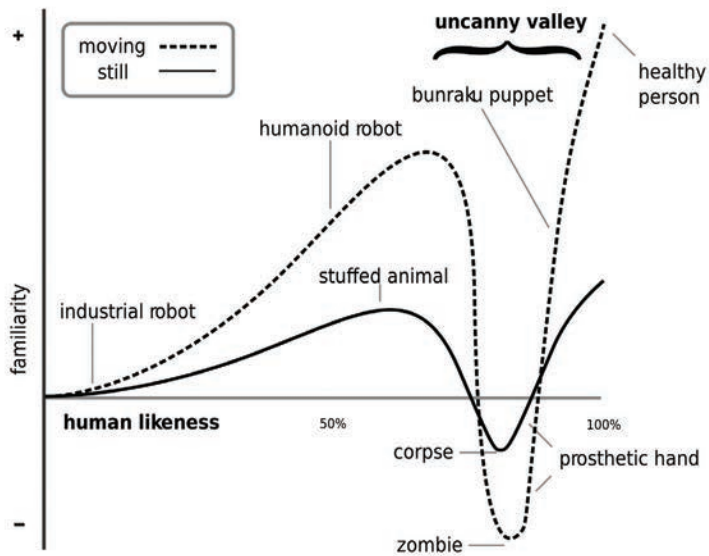


Figure 3.3.4.1 *Uncanny Valley Chart* (Masahiro Mori, androidscience.com, 1970)

3.4 The Solution

The proposed solution to these issues about the latest and upcoming NUIs is to take a step back and build upon familiar, preexisting interface device technologies, instead of scrapping tried-and-true devices. As Ian Bogost states, "Perhaps the souls of our games are not to be found in ever-better accelerometers and infrared sensors, but in the way they invite players to respond to them." This statement was geared towards devices like the *wiimote*, but it applies equally well to more experienced technology such as classic button controllers and the computer mouse.

This solution takes the form of a video game entitled *Mirror: The Game That Plays You*. The title refle ts the project's goal of developing a game that does not so much rely on the player alone, but emphasizes the dual nature of experiencing a video game. Not only does the player provide input to the game system as it reacts; the game system provides its own set of possibilities that the player must react to in turn.

3.4.1 The Tactile Device

Mirror is an exploration of a familiar interface device, the computer mouse, as a competent though relatively unexplored video game interface. The project explores the possibility of expanding a player's ability to interact with a virtual space by employing two USB mice simultaneously, augmented with tactile vibration feedback. This refle ts and utilizes our ability to manipulate objects with two hands at once and understand them through the sense of touch. Since the largest area of proprioceptive sensation happens to be the hands (Blakeslee 21-22), it makes sense to design a form of interaction that allows the most positionally-sensitive area of the body to experience the amplific tion of input.

3.4.2 The Amplification of Input

The game is designed with a primary focus on game feel and tweaking the system of interaction so as to provide for an intuitive and responsive environment. Utilizing computer mice as the input method, the system feels similar to how a computer vision system might react, but with the added benefits of a physical device that can be moved with ease as the player's hands and arms are supported by the table top. The availability of buttons is also beneficia , allowing simple clicks to perform such possible complex tasks as grasping virtual objects or flic ing them away.

3.4.3 The Avatar

The avatar in *Mirror* is defined by the player in a individual and personal way. A camera captures real-time footage of the player's face and maps that image onto the virtual avatar. This induces what one might call a "mirror effect," where, as humans automatically identify themselves in a mirror, the player identifies the avatar as an automatic extension of his or her identity. This effect reduces the necessity for a lengthy plot-driven narrative to flesh out character attributes for a player to sympathize with.

3.4.4 The Story

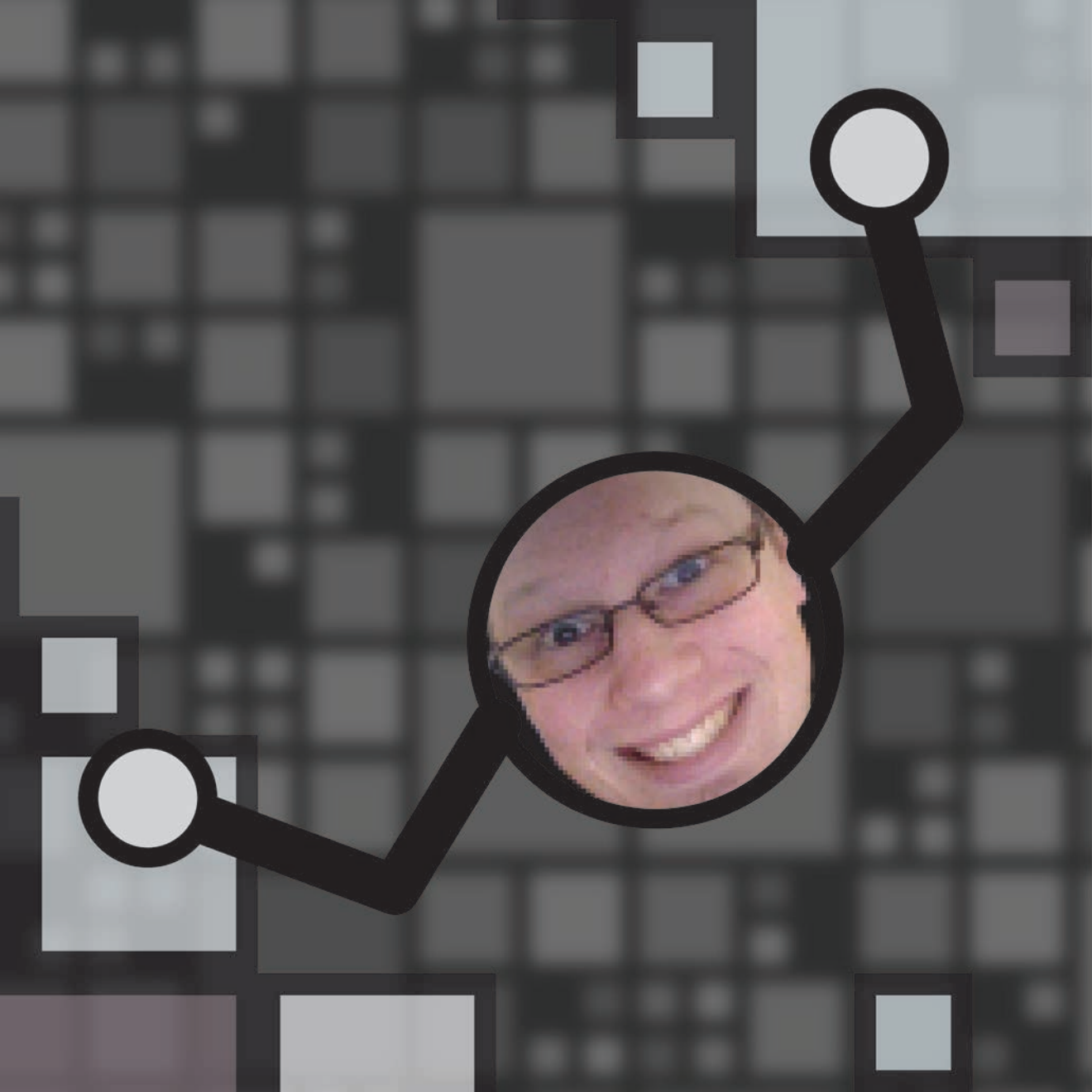
The story relies heavily on the manipulation of the fourth wall. This powerful conceptual framework is the point of cohesion for each of the other parts, connecting hardware with software, player with avatar, fi tion with reality. Only by blurring the line between real and virtual can the player walk freely and comfortably between the two.

The setting is decidedly non-photorealistic, low-resolution, and 2-dimensional. This is as much of a conceptual requirement as a technical one; producing 2D graphics as opposed to 3D within the time limitations is feasible and practical. A player would not necessarily expect a pixelated representation of a tree to sway and shimmer, and respond to light and water, as they may in a game touting "realism."

3.5 Conclusion

One does not need to require full-body participation of a player in order to artificially induce a feeling of immersion. Through careful consideration and implementation of tactile interaction, the amplific tion of input, sympathetic projection, and fourth wall relocation, a game can immerse players without resorting to overly complex and expensive technology.

Mirror aims to find new and unique meaningful inputs that expand our perceptions to include the input device and game into an holistic experience. This unique input data can be translated into smooth, pleasurable control over a virtual avatar that sympathizes with the player as the player sympathizes with it. This experience will hopefully evolve into something greater than the sum of its parts, enticing its users to think about, create, and perhaps expect games that exhibit a greater depth of seamless interaction with the devices they manipulate.



4 Artist's Bio

Cory Hughart is T.I.M.E. - Digital Arts Major at the Cleveland Institute of Art, with an emphasis in Game Design. He focuses mainly on the technical aspect of creating digital art, aspiring to bridge the gap between artists and engineers as a Technical Artist at a game production studio. Projects he has worked on have utilized Valve's Source Engine, Epic Games' Unreal 3 Engine, and Torque, and he worked with teams to produce games on the XBox 360 and the iPhone. Recently he helped develop *ChromaWaves*, an ambient color-mixing game on the iPhone, with other students at CIA and CWRU. A recent collaboration produced an interactive learning tool for embryology students at Case Western Reserve University. He also taught at a technology camp for kids in 2008, which involved programming games, building computers, and robotics. His conceptual work involves writing his own programs that invite users to examine their perceptions, such as *Pixel_People* (2008) in which live video was procedurally altered so that only people appeared heavily pixelated, and *HeadRoller* (2009) in which the user's head was shown rolling along a procedural landscape, moved along by noise the user makes. His portfolio and open source programs can be found on his website at coryhughart.com.

Appendix A: Schedule

(summary)

Note: hour totals are approximate

Aug. - Oct. 2009	
Concept Development & Research	40
Nov. - Dec. 2009	
Technical Research & Pre-Production	60
Jan. - Feb. 2010	
Prototyping & Testing	60
Mar. - April 2010	
Production & Post-production	150
Total Hours of Production	
	270
Total Hours Spent	
	310

Appendix B: Budget

Note: * = owned before project; cost totals are approximate

Hardware:

Macbook Pro 17" (development computer)*	$3,000
Arduino Decimila*	$30
USB computer mouse (2, + 2 extra)	$25
1 Terabyte external USB HDD	$130
iMac	(school loan)
Projector	(school loan)

Software:

Mac OS X Leopard*	$100
Processing 1.1	(open source)
OpenOffice.org	(open source)
Adobe Photoshop CS4	(school facilities)
Adobe Illustrator CS4	(school facilities)
Adobe InDesign CS4	(school facilities)
Cfxr (audio)	(open source)

Materials:

Misc. electronic equipment/components*	$50
Vibrating motors (4)	$15
Desk	$50
Chair	$20
Lighting (3)	$20
Side Table	$8

Materials (cont.):

Paint (white)	(school loan)
Mirrors & mat board	$20
Logo Print	(school credit)
Mini Business Cards (250)	$30
Postcards (100)	$35
Book	$35

Total Cost of Project Purchases

$390

Total Cost of All Equipment

$3,570

Annotated Works Cited

(in alphabetical order)

Adams, Ernest. "Postmodernism and the Three Types of Immersion." *Gamasutra.com*. 9 July 2004. Web. 20 Nov. 2009.

Ernest Adams splits the definition of immersion into three categories, each affecting a player in a different way to achieve similar results. They are: tactical immersion, strategic immersion, and narrative immersion.

Blakeslee, Sandra, and Matthew Blakeslee. *The Body Has a Mind of Its Own: how body maps in your brain help you do (almost) everything better*. New York: Random House, 2007. Print.

Along with the science and history behind the sense of proprioception and "mind maps," this book describes several experiments that the reader can perform to become aware of their proprioception. One experiment, called the "rubber-hand illusion," illustrates clearly the link between immersion in a virtual space and proprioception. When an object (in our case, a virtual object) responds accurately to a user's will according to his/her sense of sight and touch, the user's sense of self in space is extended into that object. This is immersion in a physical, measurable sense. It is interesting to note that different people respond more or less strongly to this illusion; perhaps the inclination towards video game usage can be related to a person's ability to extend their proprioception.

Bogost, Ian. "Persuasive Games: Gestures as Meaning." *Gamasutra.com*. 30 June 2009. Web. 08 Oct. 2009.

In this thoughtful article, Ian Bogost challenges the notion of better technology, better games. He takes a look at the latest developments in motion capture technology for game consoles that translate gestures into actions, and then points out that Train, a board game by designer Brenda

Brathwaite, goes a step further with simpler technology. Train does not focus on gestures as action, but more deeply on gestures as meaning. This illustrates that, in the rush for better technology, designers are allowing the novel appeal of these systems to carry their games, as opposed to fully exploring the new meanings one might create with tools already at our disposal.

Conway, Steven. "A Circular Wall? Reformulating the Fourth Wall for Video Games." *Gamasutra.com*. 22 July 2009. Web. 05 Nov. 2009.

Steven Conway briefly describes the history of the "fourth wall" and its evolution through various media, and how our notion of a break in the fourth wall does not accurately portray the interactions that video games provide. Rather, it is more precise to discuss a "relocation"of the wall, from in front to behind the player, placing the player directly into the fi tional experience. He also relates the concept of the fourth wall to the idea of the "magic circle," the mental space that players inhabit when entering a game-world, noting how they relate and how relocating or breaking the fourth wall can also affect the magic circle.

Crawford, Chris. *The Art of Computer Game Design*. Berkeley, Calif: Osborne/McGraw-Hill, 1984. Vancouver.wsu.edu. WSUV, 1997. Web. 10 Sept. 2009. <http://www.vancouver.wsu.edu/fac/peabody/game-book/Coverpage.html>.

This work, originally composed in 1982, can be said to be a cornerstone of game design theory. Chris Crawford discusses various topics, including what games are and why people play them. Most relevant to this paper are his definition of games and simulations, and the differences between the two. Also relevant is one of his design precepts about designing for the input/output system, instead of designing gameplay with input/output as an afterthought. This is a strong argument against reformatting a classic game to utilize the dual-mouse system.

Hayward, David. "Videogame Aesthetics: The Future!" *Gamasutra.com*. 14 Oct. 2005. Web. 05 Nov. 2009.

David Hayward examines the trend towards photorealism in video games, positing that the industry is nearing a plateau that other art forms have usually shown to be a precursor to wider experimentation. He claims that we are not quite there yet, but this article, written in 2005, does not take into account more recent computer games that push the limitations of rapidly developing graphical technology, such as Crysis (2007). He also mentions that the "Uncanny Valley" is a hurdle to pure photorealism when it comes to depictions of human beings; when a moving depiction approaches realism, there is a point of significa t negative response when we subconsciously compare the depiction to an animated corpse because of its not-quite-human quality.

Ipsos Insight. "Consumer Study Shows Video Game Console Purchasing Behavior May Be Influen ed by Vibration Feedback Technology." *Immersion.com*. Immersion Corporation, 25 Sept. 2006. Web. 05 Nov. 2009. <http://ir.immersion.com/releasedetail.cfm?ReleaseID=212029>.

A 2006 report by Ipsos Insight for Immersion Corporation follows the statistics of PS3 sales before Sony released a controller with rumble-feedback, and consumer surveys indicated a demand for vibration-feedback to enhance gameplay. The report indicated that Microsoft would likely gain market share at the expense of Sony solely because of this lacking feature.

Lenman, Sören, Lars Bretzner, and Björn Thuresson. "Computer Vision Based Hand Gesture Interfaces for Human-Computer Interaction." CID, Centre for User Oriented IT Design 172 (2002). *CID, Centre for User Oriented IT Design*. KTH (Royal Institute of Technology), June 2002. Web. 28 Nov. 2009.

A journal article (originally from Germany) reporting findings from experiments in computer vision

and gesture recognition. Though possible even in 2002, the most oft-cited issue with a non-physical system is the fatigue it generates due to lack of support from physical objects.

Nielsen, Mark, and Cheryl Dissanayake. "Pretend play, mirror self-recognition and imitation: a longitudinal investigation through the second year." *Infant Behavior and Development* 27.3 (2004): 342-365. ScienceDirect.com. Elsevier Inc., 22 July 2004. Web. 28 Nov. 2009.

This article reports on an investigation into mirror self-recognition, among other behaviors of imitation, in normally developing infants between 12 and 24 months of age.

Nintendo. "Financial Results Briefing for the Six-Month Period Ended September 2009." *Nintendo.co.jp*. Nintendo Co., Ltd., 30 Oct. 2009. Web. 20 Nov. 2009. <http://www.nintendo.co.jp/ir/pdf/2009/091030e.pdf>.

This Nintendo Corporation financial briefing for 2009 reports, among other things, on the sales of Nintendo game titles. Wii Play and Wii Fit, exercise-oriented games, are top sellers, having sold over 20 million copies. A currently maintained compiled list of top selling titles of all time on Wikipedia.com, citing other companies' financial reports, places these two games at number one and two, respectively.

Nitsche, Michael. *Video Game Spaces: image, play, and structure in 3D worlds*. MIT, 2008. Print.

In the section entitled "Players 'in' the Video Game Space," Michael Nitsche analyses different forms of presence, a mental phenomenon based on perceptual illusions, generally referring to a sense of immersion. He also discusses the notion of the "fourth wall" in relation to video games, and how it can be conceptually positioned to place the player in different spacial roles.

"Project Natal Announcement Trailer." *Xbox.com*. Microsoft, 2009. Web. 05 Oct. 2009. <http://www.xbox.com/en-US/live/projectnatal>.

The teaser trailer for the upcoming motion-control interface device, code-named "Project Natal," portrays people of various ages interacting with possible (though as of yet nonexistent) games, utilizing natural motions to affect in-game responses. A driving game involves the player holding her hands out in front of her, moving her hands as if positioned on an invisible steering wheel. A boy plays a skateboarding game by standing in place, leaning to turn, and jumping in precise ways to do virtual tricks. The skill level portrayed in-game appears to be necessary in real life, which is a mistake according to Steve Swink, author of Game Feel.

Schell, Jesse. *The Art of Game Design: A Book of Lenses*. Burlington, MA: Morgan Kaufmann, 2009. Print.

A very recent addition to the landscape of game design how-to's and references, Jesse Schell's 2009 book breaks game design down into its essential components and provides 100 tips in the form of "lenses." These prompt the reader to view their projects from the perspectives of many various disciplines and instill the reader with one overall perspective; that the process behind the design of good games involves more than just art and programming.

Sheffie , Brandon. "The First-Person Immersion Myth." *Game Developer* Aug. 2009. Gamasutra.com. 3 Sept. 2009. Web. 10 Oct. 2009. <http://www.gamasutra.com/php-bin/news_index.php?story=24513>.

Brandon Sheffie , editor-in-chief of Game Developer magazine, analyzes the misconception that firs -person perspective in video games is automatically more immersive than other perspectives. He argues that no one truly believes that they are the character, but there are better ways of linking the player to the avatar, such as through empathy for an avatar that is clearly visible and has strong,

relatable characteristics.

Swink, Steve. *Game Feel: A Game Designer's Guide to Virtual Sensation*. Burlington, MA: Morgan Kaufmann, 2009. Print.

Steve Swink explores the unexplored theory and application of "game feel," the quality of a video game that measures the tactile, kinesthetic sense of manipulating a virtual object. This relates strongly to proprioception, the sense of self in space, which can be extended to include identity as something that can expand to accommodate things outside of the self that are controlled by the self. He also examines some control devices and how they relate to game feel, criticizing new motion-control technologies for obfuscating player intention and overcomplicating the user's control of a system.

Notes

Notes