SEARCHING FOR THE ALCHEMIST

A Multimedia Graduate Thesis Project

A University Thesis Presented to the Faculty

of

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Master of Arts in Multimedia

By

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ABSTRACT

Multi-touch interface technology will require new styles of interacting within a multimedia environment. Traditional navigational frameworks typically follow one of three paradigms, i.e. free navigation, automated tours, and limited multi-user navigation such as those found in chat facilitated applications where users essentially navigate independently while also being able to maintain some conversation with other players [1]. Each of these paradigms presupposes that individual users act through separate interfaces and are free to make individual choices without regard to the actions of others. Multi-touch technology allows multiple users to interact simultaneously within the same interface in complex ways. If this technology is to be used effectively to promote collaboration between users, then the navigational paradigm needs to be reconceived to facilitate effective interactions between users in a single environment. Our thesis project attempts to answer the question: "What kind of interface will best facilitate deliberate, constructive interactions between multiple users working within a single, multi-touch interface to provide an immersive experience for up to three players?

PROJECT DESCRIPTION

Searching For The Alchemist is a multimedia installation project that uses a nonlinear narrative and the latest in immersive multimedia technology to allow users ages 12 to 16 to explore core concepts in physical science through inquiry based exploration. Learners, guided by a magic spell book, seek to reconstruct a set of experiments that interlock to form a puzzle. As the pieces are solved, learners gain knowledge about physical science and discover the fate of the missing alchemist. Through the development of this project, we explored how a novel interface can be implemented to facilitate collaborative interaction using a multi-touch table interface.

Audience

Searching For the Alchemist is designed primarily for adolescents between the ages of 12 and 16 and the learning environment is designed for children in Piaget's formal operations stage of psychological development [2]. It employs a constructivist style of instruction [3] where learners are able to explore the environment in a nonlinear sequence while making meaning as they fit pieces together to complete the challenges. Searching For the Alchemist also supports the latest theory of learning styles by combining visual, auditory, and kinesthetic modalities [3]. Visual learning styles are supported through the use of the alchemist's magic spell book where learners read notes and view diagrams to gain information about how each experiment works. Kinesthetic learners are supported as students move around the viewing table and use their hands to directly interact with the environment and assemble the components of each experiment. Assessment of learning outcomes is tightly integrated into the game play by requiring learners to solve each portion and then correctly assemble them into a larger structure.

Overview of User Experience

Searching For the Alchemist is an installation piece designed to have a 25 to 30 minute run time with five separate challenges that must be met to complete the game, each one taking approximately three to five minutes. The underlying theme of the project is one of transformation. Upon entering the installation, users discover a table with a touch sensitive screen. After touching the screen, an animation sequence tells the story of missing Alchemist and users discover that they must visit the four realms of Air, Water, Fire, and Earth in order to save the day. A table surface scattered with alchemist tools and a mysterious compass is then revealed. Using a magic spell book and the table objects to uncover clues, users must first unlock the portal in order to visit one of the four realms. As the learners transition through the portal to a different realm, they first pass through an introductory intermediate experience that is thematically linked to the final destination. The purpose of this experience is to act as an anticipatory set, heightening interest in the subject and providing a clue as to the nature of the mystery to be solved. Each realm then contains a game or puzzle based on a different aspect of transformation and an underlying physical science concept. Users must collaborate in order to successfully solve each of the puzzles and restore each realm back to its original state. Upon completing each of the game challenges within the allotted time, the spirit of the realm is released and players receive a piece of the Philosopher's stone. As the individual puzzles are completed, a sense of urgency is created as sounds of approaching destruction echo through the lab. When all the pieces of the stone are assembled on the cover of the Spellbook, the missing alchemist is released and order is restored to the universe. Users are appointed "master alchemists" for helping save the day.

HARDWARE AND SOFTWARE CONFIGURATION

Building the Multi-touch Table

We began our project by researching and building a multi-touch table. Searching For the Alchemist uses a multi-touch table employing frustrated total internal reflection (FTIR). Plans for the construction of the table were available from various sources including the natural user interface group (www.nuigroup.com) though the technology owes most of its current interest to the activities of Jeff Hann of NYU.

Table Design and Hardware

An FTIR Frustrated Total Internal Reflection multi-touch interface consists of a clear screen with good transmission characteristics for infra-red, a diffuser to capture the image, an illuminator to project the IR into the screen, a projection system, and a camera system sensitive to infra-red and capable of filtering out visual light. Ideally, the camera and video projector should have the same field of vision but this is rarely the case. Cameras can be easily purchased with a wide field of vision but short throw projectors with good (preferably xVGA) capabilities are expensive so we used a mirror to increase the effective distance to the screen. Figure 1 shows the basic table set-up.

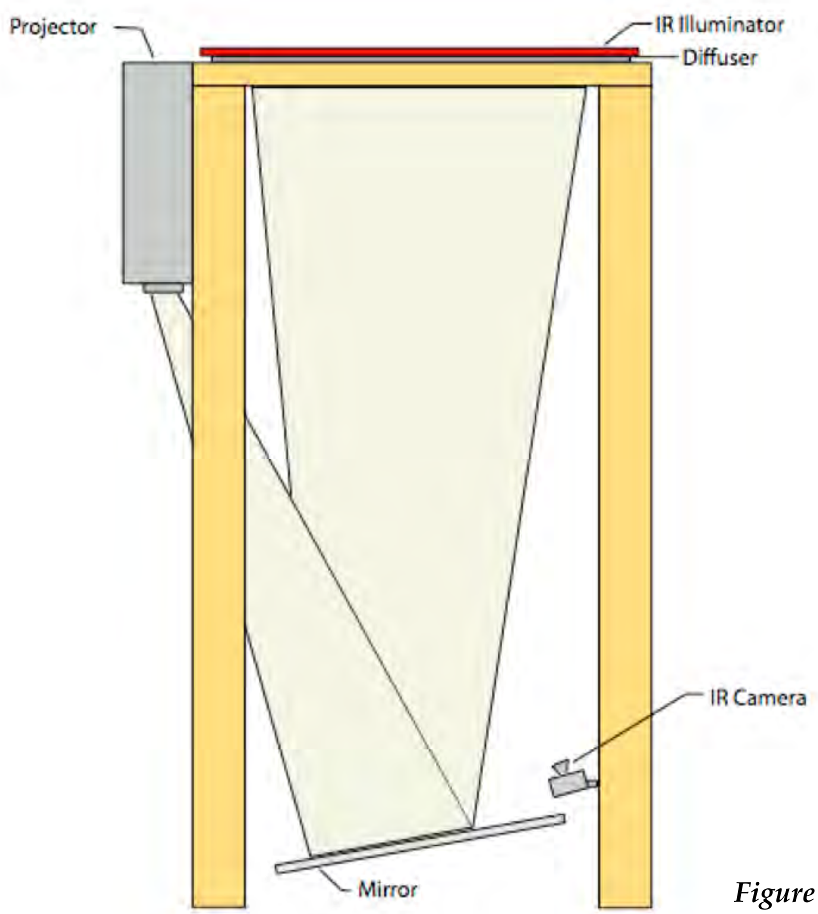


Figure 1: Table set-up

The Touch Screen

The first item built in the construction of the touch table was the touch screen. The touch surface consists of a clear 5/8 in. clear acrylic sheet with 5mm holes drilled in along the edges to hold their LEDs. The illuminator is built of banks of 6-8 high current IR LEDs connected in a series placed around the entire edge of the sheet with approximately 5cm between them. Aluminum L channels were used to construct the frame and provide a shelf for the screen. Figure 2 shows the touch screen design and fiqure two shows construction images of the table.

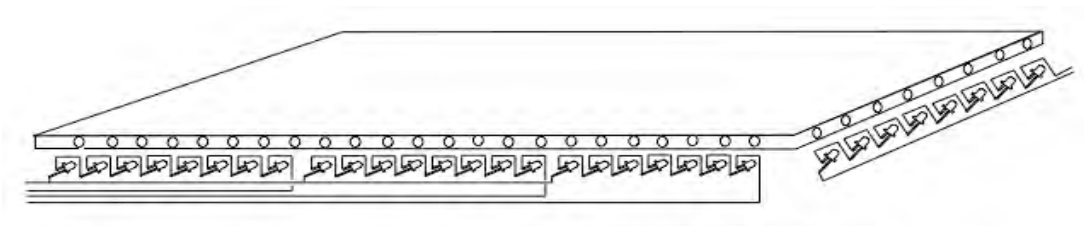


Figure 2: Touch Screen design

Users interact with the system by placing their fingertips directly on the touch surface. To minimize skipping in the finger image pickup, a light oil (typically vitamin E oil) was added to the surface of the table with each use.

Figure 3: Table construction. Left shows table frame with acrylic sheet and right shows aluminum L channel with LEDs inserted in 5mm holes drilled along edge

Software Configuration

Interface between the Flash application and the table interface was initially set-up via the TUOI protocol calls in the Touchlib open source library for multi-touch tables. *(see fig 4)* This application communicates with CS3 Flash games using a special Open Source Communication patch called flosc ("Flash Open Source Communication"). Thanks to the active support of members of the Natural Users Interface (NUI) group, Touchlib is constantly being added to and improved as an interface for touch applications. Using TUOI, most mouse events can be captured from touch interactions. Coordinating multiple touch events can be done directly. However, Touchlib also includes a number of base classes that can be used to inherit complex responses including drag, rotate, and scale. To use them, the class path must be set within each FLA and the security changed to allow the programs to communicate. Issues and challenges we encountered with Touchlib and flosc are discussed in the Project History section, page.

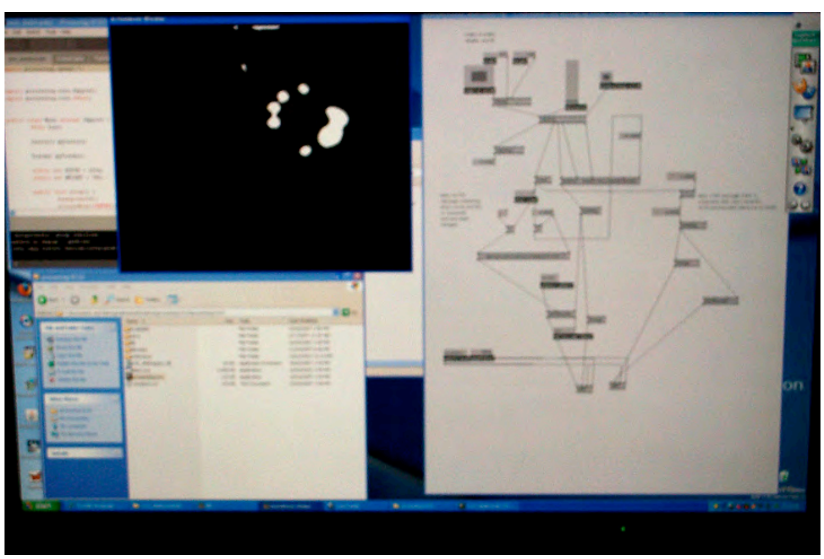


Figure 4: Touchlib open source library for multi-touch tables.

INTERFACE DESIGN

Multi-user Concerns

Originally all applications were designed from a single user perspective allowing either free navigation or a guided experience such as through a wizard. Beginning with text based interfaces that employed a branching navigational scheme such as William Crowther's *Adventure Game* 1975-80 [5] and later using the now familiar point-and-click mouse action, these interactive styles were restricted to precisely defined cause and effect. More recently, fast, asynchronous communication between computers have made possible the development of virtual worlds that allowed multiple users to interact nearly simultaneously using a central server to maintain a single, unified world view.

This was important and potentially problematic as situations where more than one player attempted to pick up or interact with an object at the same time could cause incongruities in each player's local representation of the environment. Dealing with such problems creates a message handling strain for the server. [6] The most expedient way of dealing with this problem was to enforce a sufficiently large personal space such that only one player could actually interact with an object at any given moment using either a regional or an Aura based approach. Because these classic, server based approaches do not work when multiple users are free to interact simultaneously using the same interface, this problem of overlapping user interactions is now compounded. To investigate solutions to this problem, we examined various methods of controlling user interaction that attempted to promote collaboration between users while maintaining a necessary level of control.

Key Interface Considerations

The unique aspects of a tabletop, multi-touch, multi-user interface made designing the content one of the most challenging aspects of our project. Bill Nye, a former CSU East Bay graduate whose current project deals with interactive multi-player games in a physical environment [7], was helpful with defining some of the important considerations for collaborative, simultaneous game play. Some of the key objectives that were identified:

1) Game patterns should be easy enough to recognize so that players can quickly learn how to play the game [8] and solve it within the allotted time frame, yet challenging enough to promote verbal dialog among users within the physical game space.
2) In some instances, users might be "forced" to collaborate. For example, two or more touches spaced far apart on the table might be needed to accomplish a game task such as moving an object.
3) Being able to test typical touch screen interactions (drawing with a finger, moving virtual objects) against more goal-oriented game play designed to encourage more collaborative-type interactions (completing tasks together, solving puzzles together, searching for clues, etc).
4) The need to satisfy user feedback with each touch (visual or sound)
5) Allowing for some non-linear exploration of the game environment.

Navigational Design and Architecture

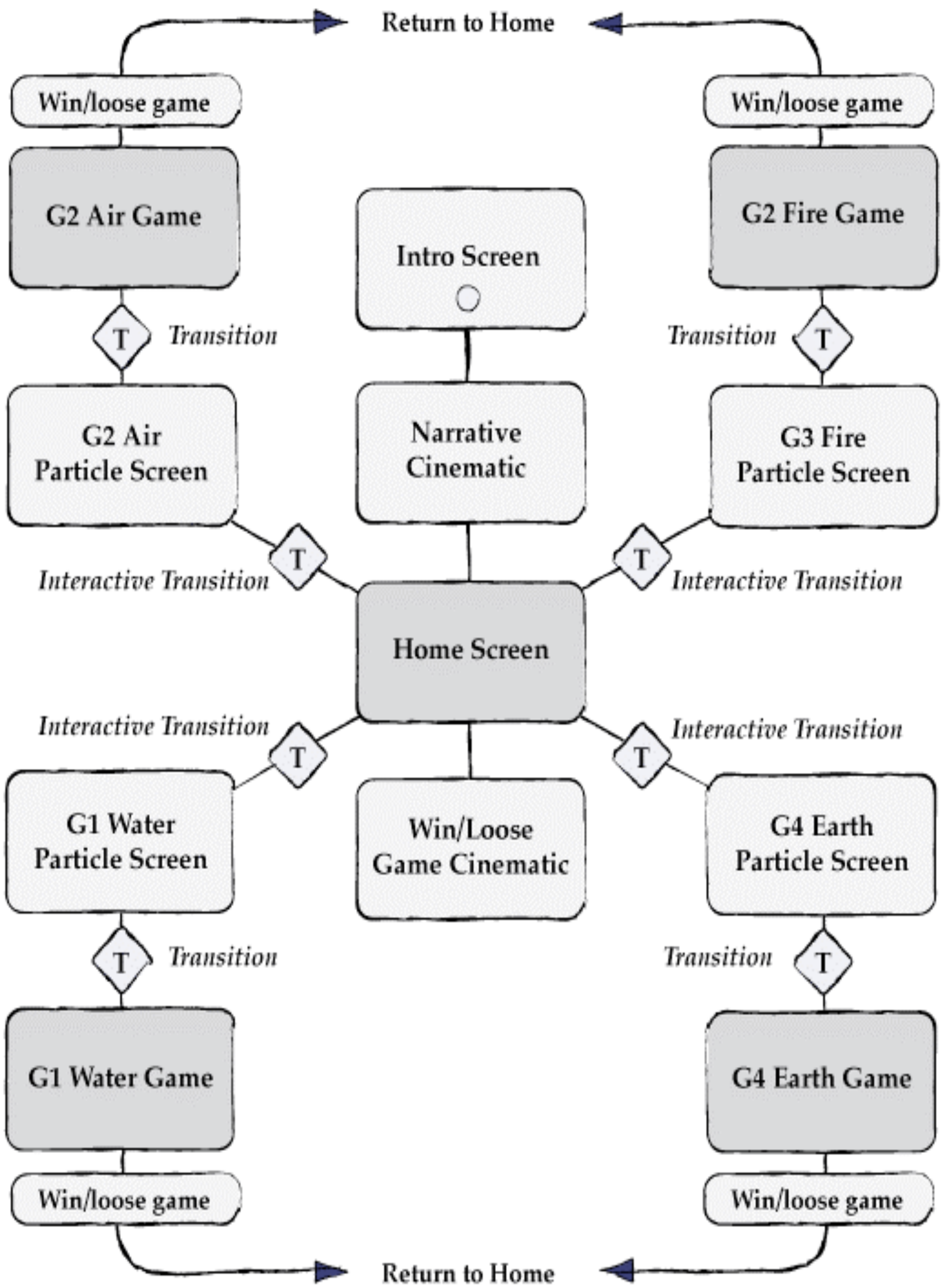
The interactive visual environment for Searching for the Alchemist was created in Flash CS3. This allowed game programming to be accomplished using Actionscript 3- a core competency for our group. The elemental subject matter lent itself to a richer visual approach than is typically found in most vector-based Flash environments. To this end, highly textural and multi-layered bitmap illustrations were created using Adobe CS3 creative suite and then imported into the Flash environment. Particle effects were added using various Flash Plug-ins to help convey the elemental themes of water, earth, fire and air. Final cut pro and Adobe After effects were used to create the cinematic sequences. The desire for a more three dimensional visual approach than could be realized in Flash alone led to the use of Swift 3D, a modeling software compatible with Flash CS3. Image sequences of modeled objects were imported into flash so game objects could be turned and seen from different angles.

The top-down viewing environment of the multi-touch table created it's own set of challenges when designing the interface and games. Alchemist tools such as pots and beakers viewed from this angle might not be distinguished adequately for some puzzle challenges to be solved. To accommodate different types of game interactions and enhance the illusion of depth, a "turning cube" navigational structure *(see figure 5)* was conceived so that the environment could change and be viewed from both top-down and side angles. To navigate to a new realm from the home screen, users must "pull" two knobs that emerge from the table surface and turn the face to another side of the cube. Animated transitions between game screens were added to support the underlying theme of elemental change and transformation.

The overall game structure and user flow for Searching for the alchemist is is shown in fiqure 6. After watching (or skipping) through the intro cinematic, players land on the home screen as represented by the alchemist's lab table. Users must search for clues and solve a puzzle to unlock the compass. By turning the cube and navigating to one of the four realms, they arrive at one of the intermediate particale screens which provide simple, short multi-touch interactions before entering the one of the realms.

Figure 5: Turning Cube Interface

Figure 6: Map of User Flow/Navigation



CONTENT DEVELOPMENT

The First Experimental Science

Figure 7: Aristotle's elemental diagram of the universe. Image courtesy of http://reich-chemistry.wikispaces.com

The medieval scientific, philosophical and spiritual discipline known as alchemy provided a rich subject matter with which to develop engaging content and an immersive visual environment. A diverse and complex practice, alchemy combined aspects of chemistry, metallurgy, physics, mysticism, astrology, spiritualism and art. Alchemists believed that all matter had a common origin and sought to find a complete and unified order of things in which the physical, natural and spritual all fit into place. The practice spanned over 2000 years and had a role in many cultures starting with the Greeks, then Egyptians, Bablonians, Chinese, Persians and finally spreading throughout the rest of the Europe. [9}

One aspect of alchemy that is often referenced in popular culture today was the practice of trying to transmute cheap metals into gold using a mysterious tool called the "Philosophers Stone". Another was their intent to discover the "fountain of youth" or a way to prolong life indefinitely. A third was the alchemists desire to cure all sickness by discovering the "Elixir of Life". Alchemists were a varied lot. Some were doctors or pharmacists, some priests or wizards, and others were just plain charlatons.

Figure 8: Etching of Nicolas Flamel. Image courtesy of http://reich-chemistry.wikispaces.com

Perhaps the greatest influence on the alchemists was the work of Aristotle who lived around 320 BC. Along with Greeks, he believed that the universe was comprised of four primal elements; earth, fire, water, and air. *(see figure 7)* He also believed that the circle and gold were examples of perfection in nature. Among the more famous alchemists were Democritus, Copernicus, Galileo, Kepler, Brahe, and Newton, although there were many lesser-known alchemists who practiced throughout history. One French alchemist in particular, Nicolas Flamel, was cast a role in our narrative. Flamel, who lived during the 15th century, was supposed to have received a mysterious book the deciphering of which he made his life's work. It was said that Flamel was the only alchemist to ever accomplish two of the alchemist's main goals: he created a Philosopher's stone enabling him to turn lead into gold, and along with his wife, achieved immortality. [10]

Today, ancient alchemists are credited with three main contributions to science: 1) Lab techniques and chemical procedures that are still used today like distillation, filtration, crystallization, evaporation and extraction. 2) Medicines through their exploration of minerals and their properties and 3) Lab tools.

Our Narrative - Why Alchemy?

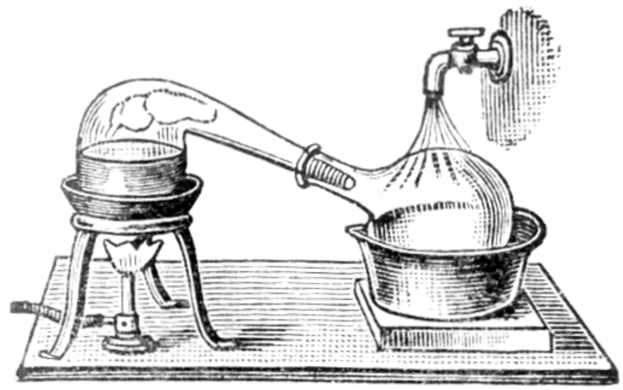


Figure 9: Distillation Apparatus. Image courtesy of: http://www.thepaganpath.net/what-is-alchemy/.

Early iterations of the project were designed to employ technology to teach core concepts of physical science to high school students. Since alchemy was the precursor to modern chemistry there was a logical connection between the two. However, the recent popularity of fantasy and wizardry in popular culture cast alchemy as an ideal way to create content that would engage students and encourage investigation outside the classroom. As the focus of our project moved away from primarily that of a teaching tool to one exploring multi-touch and multi-user interactions, we felt the topic was still a compelling one for our narrative and game themes. The elemental and transformative themes of alchemy, along with it's mystical aspects made it a topic that would invite exploration and constructive colloboration between users.

When writing the narrative, one objective was to engage users in the experience by encouraging them to become part of the story. With this in mind, players were cast in the role of apprentice alchemists studying at the Academy of Alchemy and Magic. The installation is meant to represent the missing alchemist's laboratory and his magic table that the apprentices have stumbled upon. The idea for the four elemental realms gave us an opportunity to give users different areas to explore in the game environment, as well as different types of collaborative game play/multi-touch interaction that could be tested.

Visual Themes

Since alchemy was practiced in many different cultures spanning over 2000 years, visual inspiration was taken from various Middle Eastern and European design motifs including Celtic, Indian and Islamic alchemist symbols. To create a unique sense of place, inspiration was also taken from the work of the Spanish Architect Antoni Gaudi. With the four elemental realms to navigate to, a conceptual theme of the table serving as a portal or window into other dimensions was conceived. This portal is suggested through the use of a window during the introductory and conclusion sequences of the game. *(see figure 10)*

Audio Content

Audio content was added in the fall and summer of 2008. A rich soundscape was desired to enhance the immersive nature of the experience and sound effects to provide users with more satisfying touch feedback. The voice over for the opening cinematic was recorded in the theater space at the Multimedia Graduate building to achieve the effect of the narrator's voice echoing though a large chamber. Sound was modified in Final Cut Pro. Other sound effects and foley were recorded using a dynamic microphone and a lap top computer, edited in Audacity/Adobe Soundbooth, then imported into the flash environment. Additional music, sound effects and foley provided courtesy of Sound-Dogs.

USER EXPERIENCE: GAME WALK-THROUGH

Idle Screen and Introductory Cinematic

Figure 10: Idle Screen

When the table is idle an animated sequence will continue to play. The surface of the table is shown as a portal through which slowly transitioning animations of earth, fire, water, air and strange alchemic symbols are seen to be morphing. Upon touching the table, a narrative cinematic sequence will be triggered. A video sequence is played in the portal, while Chronos the caretaker narrates the story of the Academy and the missing alchemist. At the end of his story, he beckons the "apprentices" to help find the missing alchemist if disaster is to be averted. Users can skip this narrative cinematic if desired. The full version of the script can be found in Appendix A: Game Script.

Game Objects

Spell book: Users must refer to the spell book for hints on how to solve puzzles or play games. It is represented as a full-sized object on the home screen *(figure 14)* and as a smaller icon in the corner of all other game screens. To open the book, users must touch it twice in rapid succession. The spellbook is a fantastical object in a sense, but it also references the ancient manuscripts that many alchemists kept. Physical science principles are embedded into the information revealed in it's pages. When each game challenge is completed, another piece of the philosopher's stone will appear in the crest on the cover of the book.

Figure 11: The spell book opened

Compass: In the home screen, the compass is used to navigate to one of the four realms by turning the pointer to a quadrant. *(see figure 18).* Users then must touch the elemental symbol twice to reveal knobs that allow them to navigate to that realm. While playing a game in one of the four realms, touching the compass icon allows players to quit the game and return to the home screen. (*see figure 18*)

Figure 12: Compass navigation

Hourglass: The hourglass times each of the game challenges- as the sands run out, a chime sounds and the screen flashes. If the game is not completed before time runs out, the game is lost. (*see figure 18*)

Alchemist tools: Various alchemist tools are scattered about on the home screen (*see figure 14*) and later in the air realm challenge where users must build a distillation apparatus (*see figure 19*). In addition to serving as game assets, many of the objects represent tools that were used by the actual alchemists. Descriptions provided on the home screen give users a chance to learn more about early chemistry and alchemy. (*see figure 13*) Detailed descriptions of these objects can be found in Appendix A: Game Script.

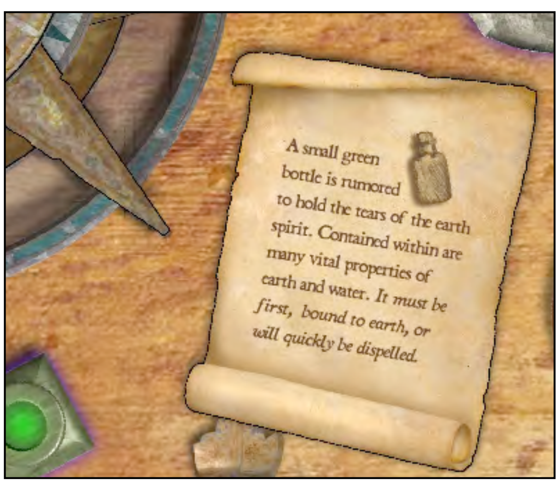


Figure 13 : Object Descriptions

Home Screen - The Alchemist's Table

A wood surfaced table that is scattered with various alchemist tools, a spell book and a large rusty compass at the center represents the home screen.

Figure 14: The Home Screen

When an object is touched, a description of the item is displayed on the scroll. By collectively exploring table objects and gathering clues from the spell book, users find that they must mix the right combination of chemicals in the mortar and pestle and pour it over the compass to get it functioning again. If the wrong combination is mixed it will explode or make the compass even rustier.

Once the compass is functioning, the pointer can be moved to a quadrant by pressing the elemental symbol. A second press will take them to a transition screen that leads to one of the intermediate particle screens. Users return to the home screen after each challenge is completed. Estimated Time: 4-6 minutes.

Intermediate Particle Screens

Just before entering each of the four realms, users encounter an intermediate screen containing a simple interactive activity. These anticipatory screens serve as the final gateway and are thematically linked to the realm users are about to enter. These activities are designed to give us an opportunity to test simple, intuitive touch interactions against the more goal-driven game play designed specifically to encourage collaboration.

Figure 15: Water Realm Particle screen. Users ripple surface with finger tips

The particle screen for the water realm simulates ripples on the surface of a pool of water when the table screen is touched. *(see figure 15)* In the fire realm, touches emit bouncing sparks which bounce around a metal surface. In the earth realm, users find a cracked-earth surface covered by large insects. When the screen is touched, animated insects chase the hand movements and appear to bite. *(see* *figure 16)* The air realm allows users to draw lines on the screen. Touching a blotter in the corner or the screen will then erase lines. *(see figure 17)* Particle screens can be exited by touching the elemental symbol representing the realm, which transports users into the game screen for the realm.

Figure 16: Earth Realm Particle screen. Insects chase users touch

Figure 17: Air Realm Particle screen. Users draw with fingertips.

The Four Realms - Game Challenges

Water Realm

Figure 18: The water realm game

As users enter the water realm, the table surface morphs into a solid sheet of ice covered with crystals and a rusty thermometer gauge in the center. Players must collaborate by moving the ice crystals with their hands to get enough of them bouncing around and breaking apart crystal formations. When enough energy is created, the temperature gauge reaches melting point and the surface returns to a liquid state. Once completed, users receive a piece of the Philosopher's Stone and are returned to the home screen. The physical science concepts explored are movement, temperature, and state. Time allotted: 3 minutes.

Air Realm

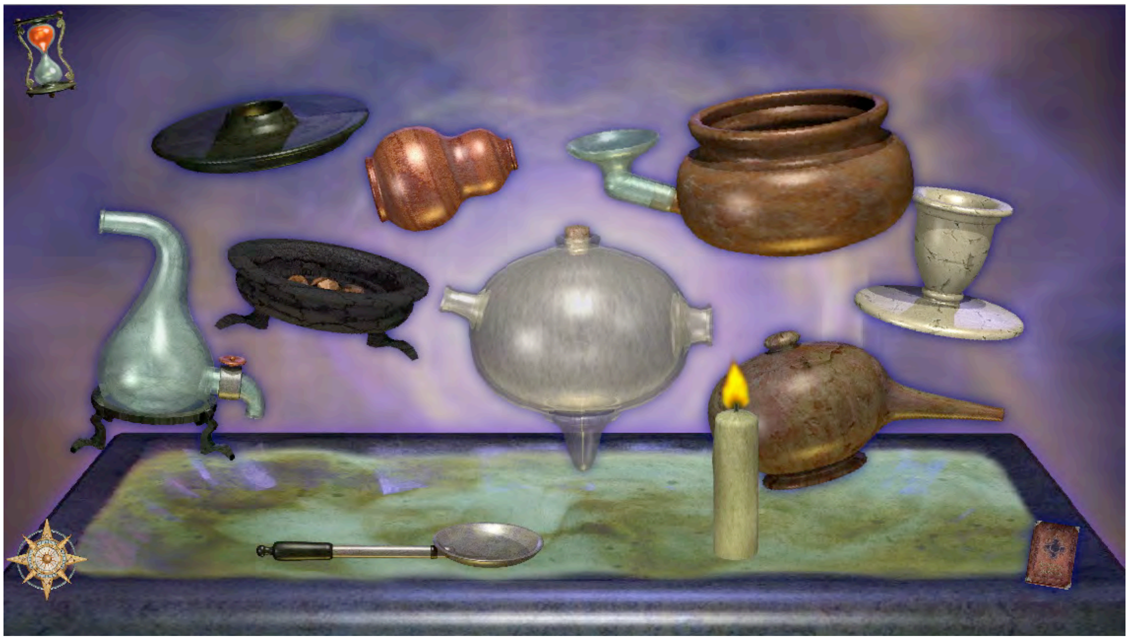


Figure 19: The air realm game

This game is viewed from a side perspective rather than top down. The surface of the cube melts into a murky yellow-green pool and alchemist pots and tools appear floating above the surface. Using clues and a diagram in the spell book, players must assemble a distillation apparatus by stacking and connecting the objects on the surface in the right order. After it is assembled correctly, the coals must be lit and water scooped into the pot. Once this is completed, all the putrid water is evaporated from the table surface and users receive another piece of the Philosopher's Stone. They are then returned to the home screen. This realm explores the science concept of distillation using traditional alchemist tools. Time allotted: 4 minutes.

Fire Realm

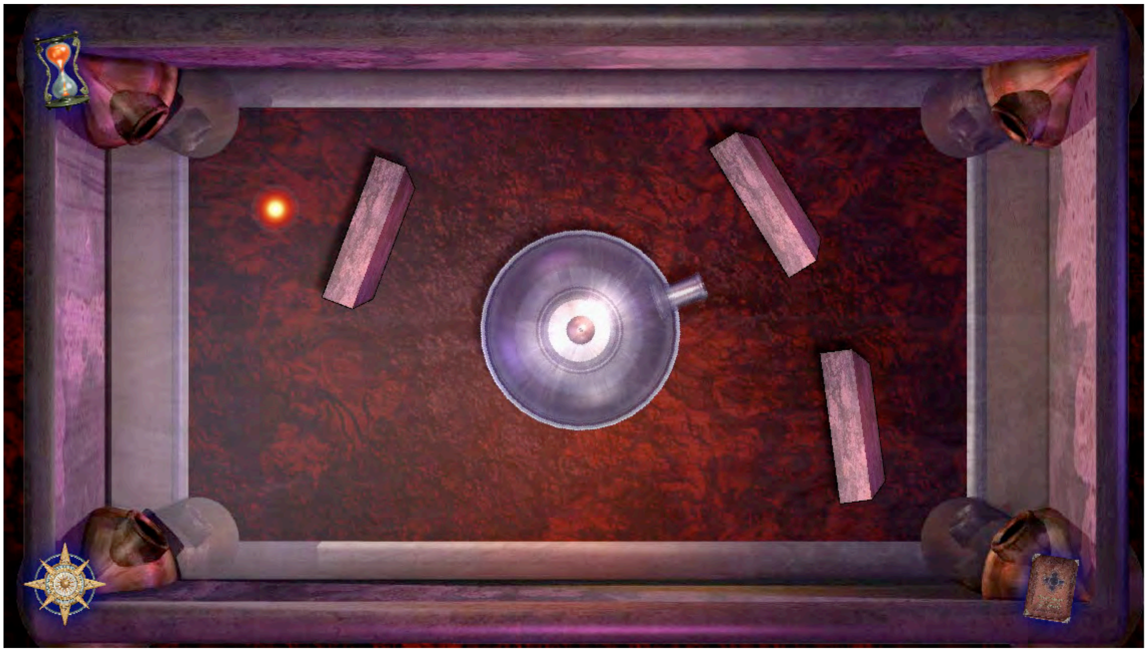


Figure 20: The Fire Realm

Large metal doors open revealing a pit with a large glass orb in the center and three metal shields. The center orb shoots fireballs every few seconds. By turning the center orb to aim the cannon and positioning shields in the playfield, players attempt ricochet fireballs into the corner pockets. Moving or turning a shield requires two touches. When all four corner pockets are sealed, the glass surface melts in a fiery explosion and users receive another piece of the Philosopher's Stone. Time allotted: 3 minutes.

Earth Realm

Figure 21: The Earth Realm

A large rock island is suspended in the center of the screen by thin, rock channels that divide it into 5 sections. A crucible sits in the center of the table. From the spellbook, users learn they must collect same colored pieces of ore in the correct order and move them into the crucible to melt them down to a molten state. When melted into liquid material, users manipulate the liquid through the channels by tilting the table surface and guiding the material into the correct area where it will solidify. Three touch inputs at an edge are required to tilt the surface. If any rocks were left in the area, the lava will dissipate and the procedure must be repeated. Once the entire screen is a solid surface, the center crucible hardens into the face of the earth spirit who presents users with a piece of the Philosopher's stone. Time: 4-5 minutes

DESCRIPTION OF FINAL INSTALLATION

During Fall 2008, a work-in-progress installation was set-up for the CSUEB multimedia graduate night. At this time, the multi-touch table was not yet functioning with our interface and the programming of all our content not yet complete. Our installation consisted of the multi-touch table, a video wall and five individual Mac computer stations.

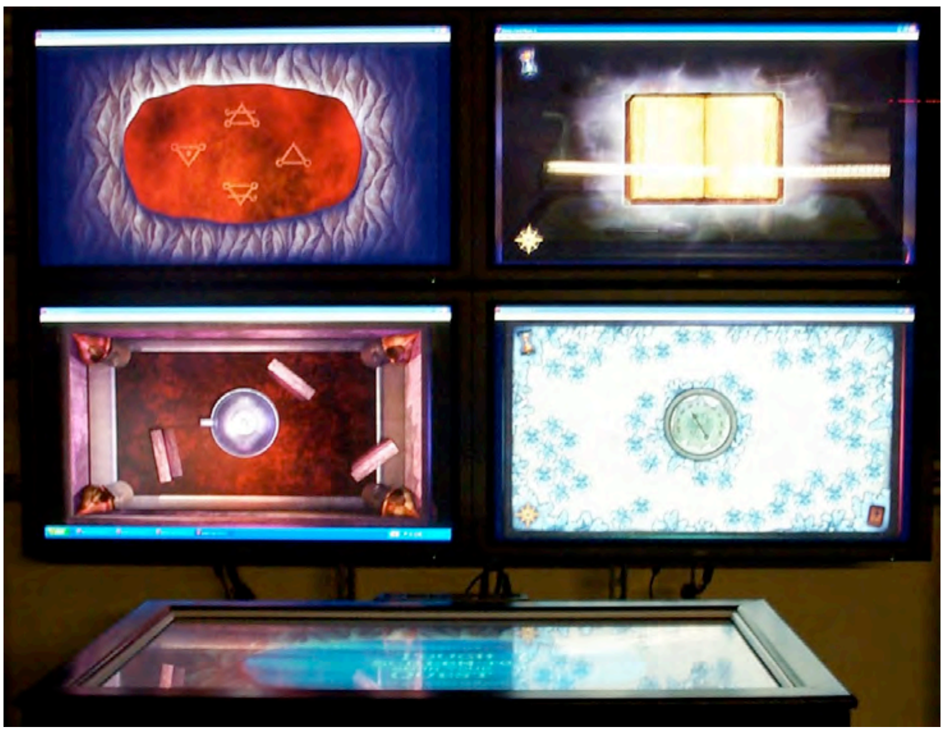


Figure 22: Back wall of the installation featuring the video wall.

A platform was built so that users could step up to view/interact with the table, and demonstrations were given on how the multi-touch table functioned. Behind the table, the video wall showcased animations of our content that were created for the event. To help set the tone for our project, music from our content was played using the video wall. On four computer stations set up across from the table, participants were able to try out some of the games that were coded as mouse-only versions. On the fifth computer station, the Searching for the Alchemist project web site was displayed so that visitors could read more about the project. Other marketing materials included hanging banners and postcards that were designed to help promote the project. During Fall 2009 thesis presentations, a second SFTA demonstration was given. This time, our fully functional table was demonstrating the Searching for the Alchemist Content.

Figure 23: Various game interactions on the multi-touch table.

PROJECT HISTORY

Concept Development

Originally, Searching For The Alchemist was conceived as a teaching tool to introduce learners ages 12 to 16 to core concepts in chemistry through a "virtual" laboratory experience. It employed the use of the alchemist storyline and immersive technology such a virtual reality headgear and motion sensor glove, to help immerse students in the experience. Users were also able to interact with each other remotely while logged into the virtual lab. The main focus of this first

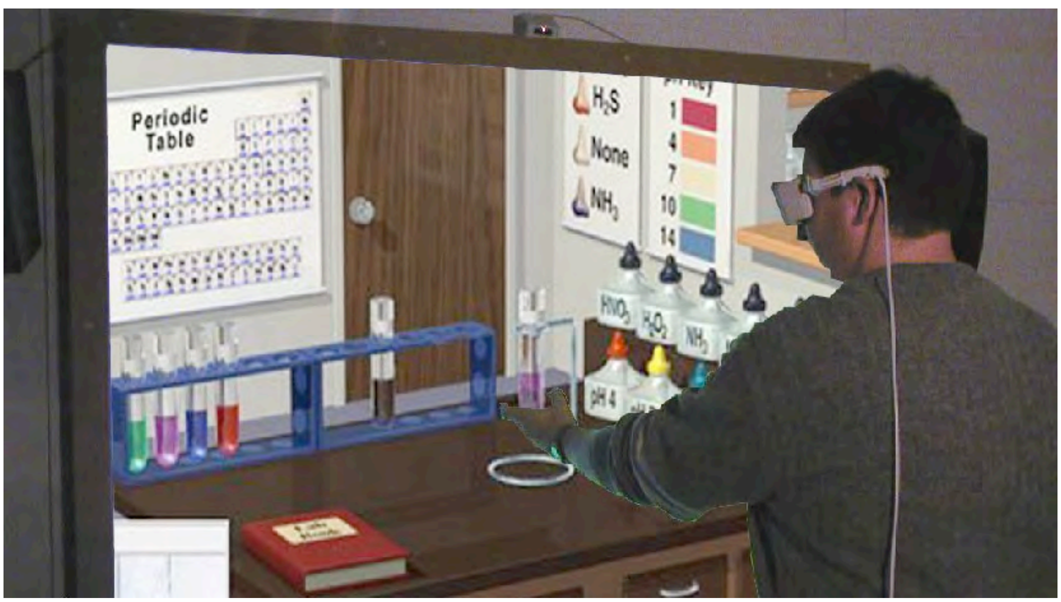


Figure 24: Early Rendition of SFTA featuring a virtual chemistry lab.

concept was to simplify chemistry instruction for middle and high school students while improving learning outcomes and test scores. As our group thesis members changed and the project evolved, the focus of the project shifted from that of an educational tool designed to help improve test scores into more of an “edutainment” style immersive, multimedia experience. The interface itself also evolved from individual workstations into a museum-style installation featuring a large, multi-touch table as its interface. *(see figure 25)*

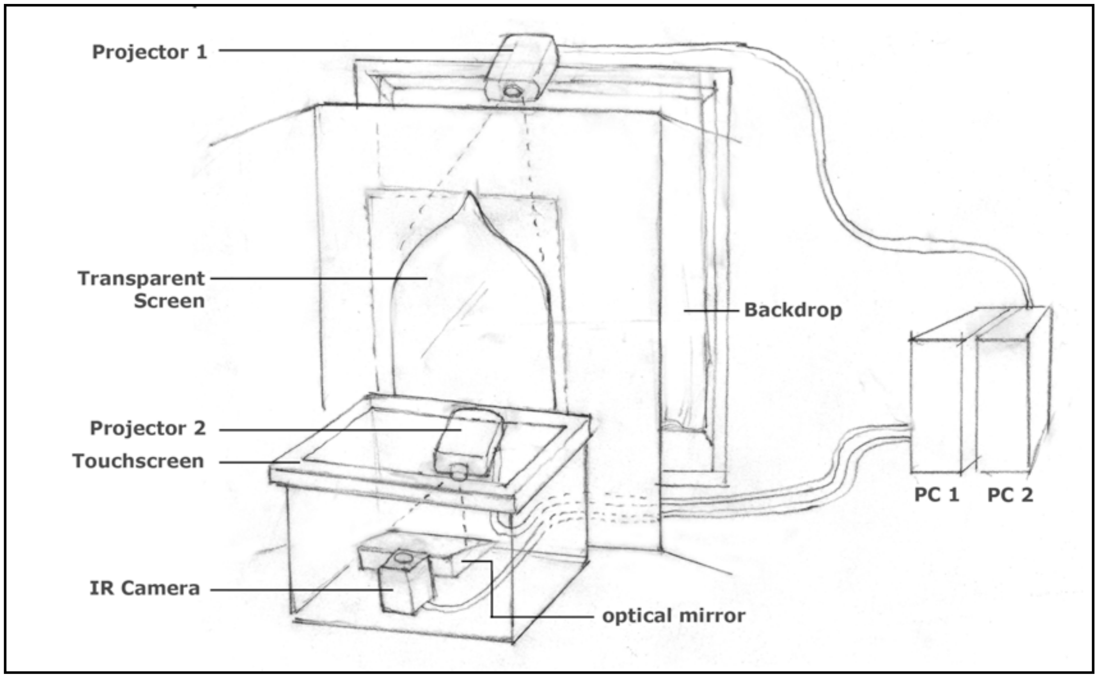
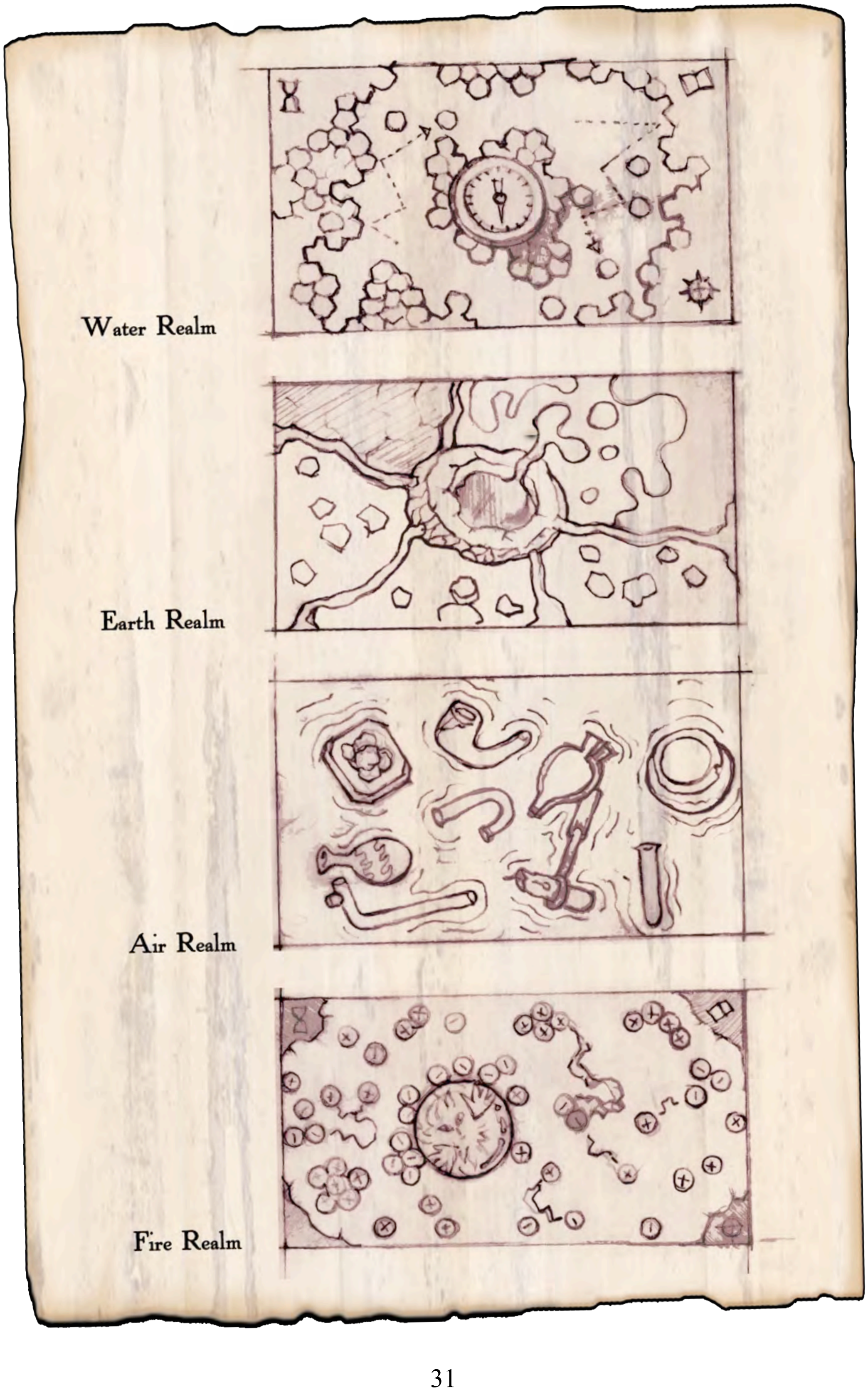


Figure 25: Early sketch of the project featuring a single mult-touch table for the interface and a transparent rear projection screen.

Early installation plans were significantly more involved in scope. To enhance the immersive nature of the experience, the project included a themed set design representing the missing alchemists lab and a transparent rear projection screen. The transparent screen was intended to project “holographic” animated characters on the screen at different points during the game experience. These characters, one representing each of the four realms, would help guide users through the experience along with the magic spell book. Characters were to be modeled in 3D software and animated using motion capture. *(see figure 26)*

Figure 26: Character studies (top) and detailed digital illustration of the installation and set design (bottom).

Figure 27: Early sketch depicting the different game challenges



Although these theatrical components may have enhanced the immersive nature of the experience, after building the actual multi-touch table and developing some of our content, it became clear that what we were really exploring was the use of multi-touch itself and collaboration between multiple users within a single interface.

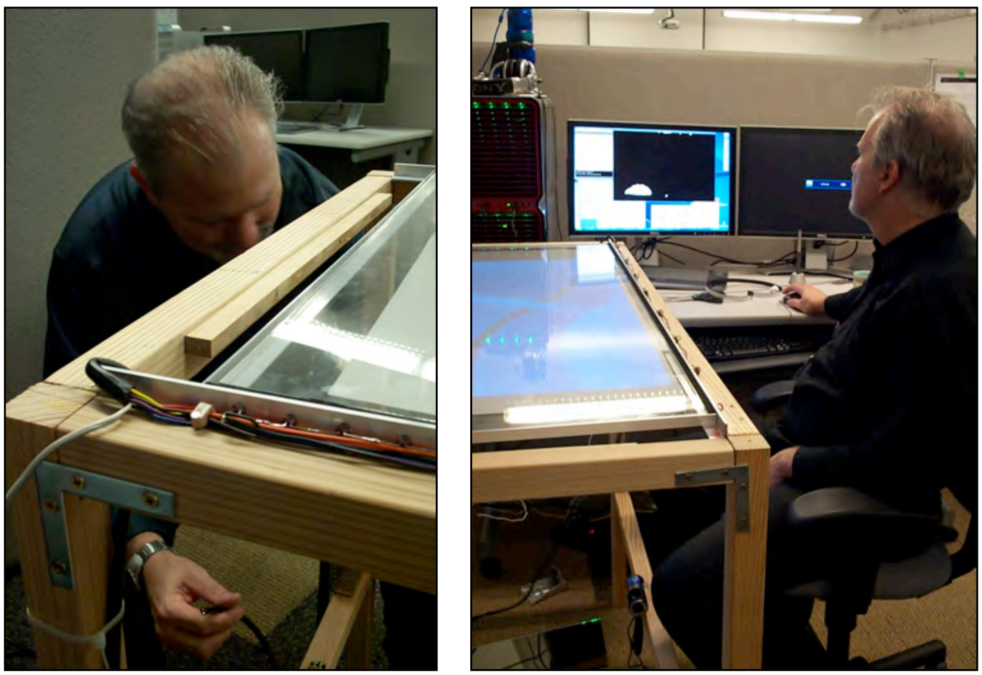


Figure 28: Building and testing the multi-touch table interface.

Additionally, technical setbacks during the first production year and the sheer demands of the project on our two-person team, necessitated that the final installation be pared down to its more essential elements; the content itself and the multi-touch interface. Although many aspects of the project changed and evolved throughout the process, one constant throughout was the Alchemist theme and the underlying science subject matter.

Technical Issues and Challenges

Initial construction was of the multi-touch table was complete in mid November of 2008. During winter quarter, a delay in receiving a widescreen format projector and camera resulted in a considerable amount of redesigning. The delay was exacerbated by the inability to get the camera to detect the reflected infrared "blobs." The camera was sensitive enough but the latency too great for acceptable game performance. A Firefly MV camera, a machine vision quality camera that has been tested by others (see NUI group forum) was ordered and received during the summer in mid July. Unfortunately, SFTA was delayed in it's first year of development due to problems getting Flash and Touchlib to connect. Thanks to the invaluable support of Prof. Rafael Hernandez and Prof. Theibald, this problem was identified as resulting from an incompatibility between Touchlib and the 64bit processor on the computers assigned to us. Changing the computers allowed the interface to function and development was reinitialized in spring 2009.

PROJECT MARKETING

To help create a strong presence for Searching for the Alchemist, a logo was designed during the early stages of the project. The SFTA project web site was also developed to capture interest and the visual style of the project, including the desired theme of a entering through a portal into different realms. A short 2-minute video highlighting the key aspects of the project was embedded into the web page. The site was designed in Adobe Flash to create more dynamic transitions and animations. *(see figure 29)*. Additional promotional materials included banners that were hung above the installation and postcards handed out during presentation night. *(see figure 30)*.

Figure 29: SFTA web site-home page and Team page

Figure 30: Project logo. Banners (left) were hung as part of the presentation, and postcards (right, bottom) describing the project were distributed.

BACKGROUND RESEARCH

Rise Of The Touch Screen

There is a fundamental disconnect in the way people interact with standard computers that have a Graphic User Interface (GUI). In a GUI environment, users receive and attempt to manipulate information that is presented visually on a video display device. Unfortunately video displays are strictly output devices. That is, they only output information - they do not receive it. To input data, the user makes selections using a steering device such as a mouse, trackball, or joystick often with one or more decision buttons.

Figure 31: Input and output are separated in normal computer interactions.

After the appropriate GUI object is selected and activated, detailed information can be input using a keyboard *(figure 31).* Thus complete interactions that consist of both an input and a response require the use of up to three independent devices – the display device, the selector, and the text input. Moreover, these three devices are not contiguous and there is no intuitive connection between objects that appear on the display and the expected method of interaction. Users must continuously shift their attention between each device in turn and in the proper order. Designers have attempted to overcome this limitation through consistent interface design and carefully crafted paradigms.

Consistent design together with well-planned decision trees facilitates user interactions by providing a familiar interface. Learning and usability are further improved by using simple paradigms that make interactions more intuitive. However, these do not address the fundamental problem of separating feedback from response. In the late 1960s, engineers began to address this problem with the first touch screens. With a touch screen, the selector and the video output are combined to make interactions more natural. Decision trees can still be implemented by including selector icons on objects so that "touching" the object in different places produces different responses. An early example of using touch screen technology in a learning context was the PLATO project *(see figure 32).* PLATO or Programmed Logic for Automated Teaching Operations was built originally by the University of Illinois as a system for offering programmed course material to schools and included several innovations including a voice synthesizer and a 16x16 grid infrared touch screen that allowed students to choose answers by directly touching points on the screen.

Figure 32: PLATO IV introduced a touch screen interface

Commercial Applications

Commercial applications also quickly began to appear. In the 1980s many controls companies started to use touch screen technology as part of the design of Man-Machine interfaces for process control and data acquisition. Touch screen controls for industrial applications however soon fell out of favor due to the "Gorilla Arm" problem. Gorilla arm is the fatigue caused when operators controlling equipment were forced to hold up their arms for extended periods. In most factory floor applications, this problem cannot be improved by dropping the screen into a horizontal position either because of environmental conditions. These systems were typically built around one of three sensor technologies. The first and most widespread was the resistive film technology *(see figure 33).* In this method a grid work of conductive material is laid over a thin resistive film. Touching the screen firmly makes a connection between the surfaces that is sensed with the surrounding bevel plate and relayed to the computer as x and y coordinates. Capacitive systems produced similar results with greater sensitivity. In a capacitive system, a thin coating of a capacitive material such as indium tin oxide is applied to the glass. This layer is affected by the electrical field in a users finger causing a touch event to be detected.

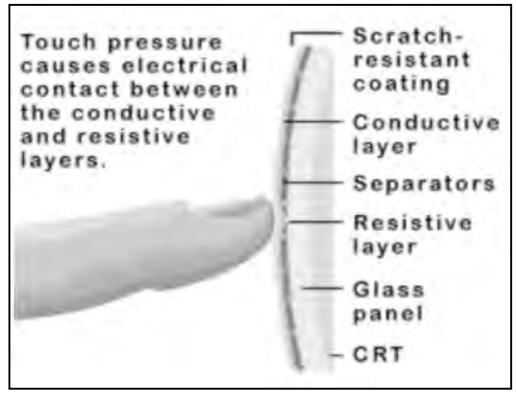


Figure 33: Transparent resistive film under a conducting grid creates a coordinate feedback of touch location.

All of these methods however suffer form the draw back of requiring a specialized surface coating to be applied over the top of the display device. These coatings interfere with the image and are susceptible to being damaged. A more durable method of touch detection uses SAW or surface acoustic wave technology. In this method ultrasonic waves are transmitted over the surface from one side and detected on the other. A touch on the screen absorbs a portion of the wave and again the x and y positions are reported to the computer interface. A similar technology uses infrared light that is transmitted over the surface. The draw back of these two methods is that they can be interfered by material being streaked or deposited onto the touch surface. All of these technologies are limited to one or two touch points. This is because the sensing

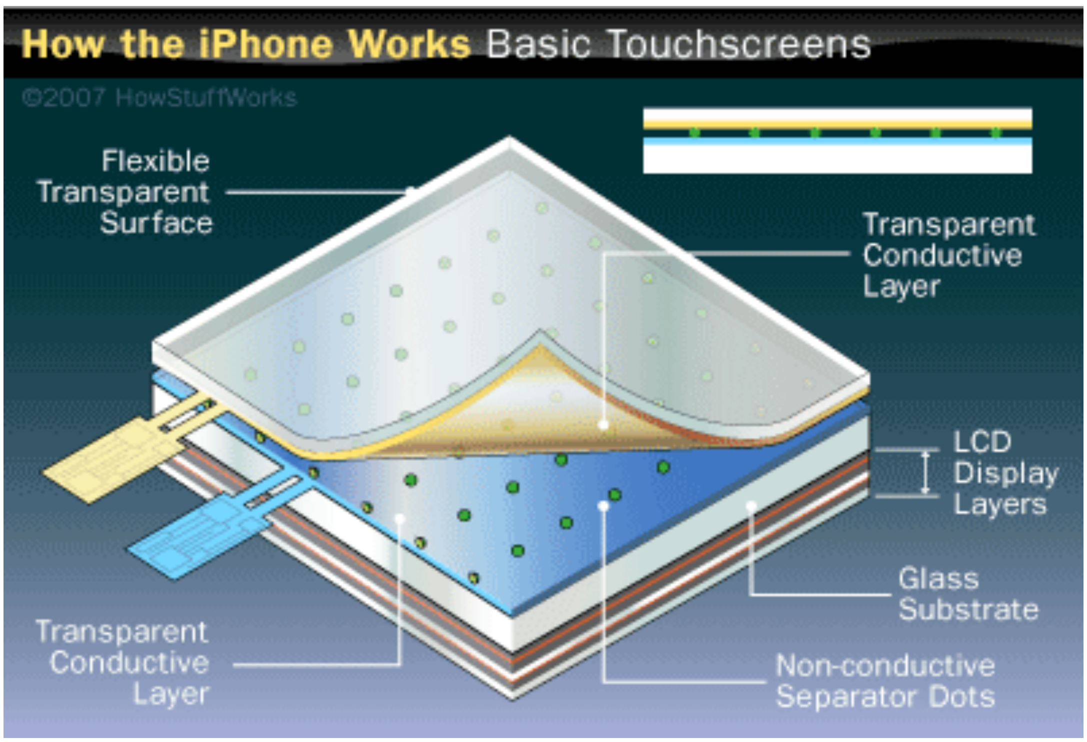


Figure 34: Capacitive screens work using two conductive layers separated by a thin insulator. courstesty of How Stuff Works - http://electronics.howstuffworks.com/iphone.htm/printable

occurs along the display edges and overlapping points in either the x or y coordinates cannot be separated. Nevertheless, these methods have been widely exploited particularly in ATM style and kiosk environments. Palm was the first to introduce touch screens to a wide consumer market. These were small, hand held devices designed to store and retrieve personal information quickly and easily. To facilitate the data entry process, Palm introduced the public to the use of stylus pointers and gesture characters. Gesture characters were important because the Palm device interpreted the lifting of the stylus as the completion of the character so all characters had to be easily written in a single stroke *(figure 35)*

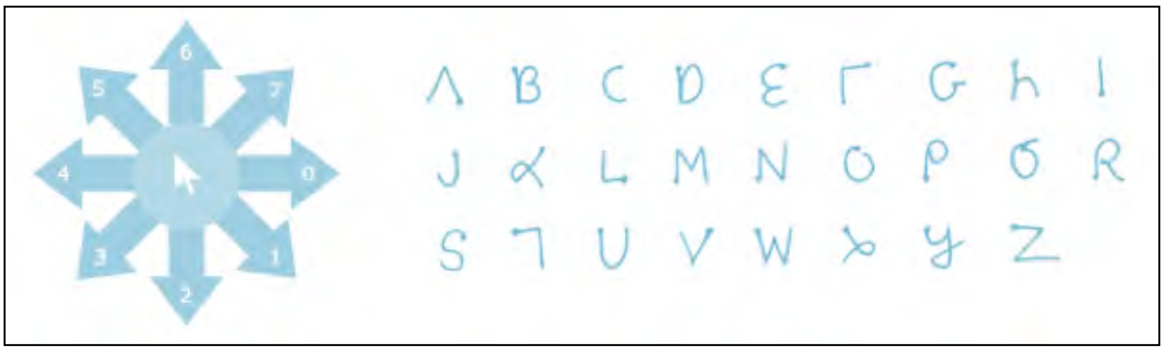


Figure 35: Gesture writing allowed characters to be entered into a Palm device with stylus using a single continuous stroke.

To make the Palm PDA work with a capacitive touch screen, the stylus needed to be conductive but not able to scratch the screen. As a consequence, if a user lost a stylus it had to be replaced or the information could no longer be directly entered or retrieved. Modern devices such as Apple's iPhone and iPod touch, Sony Walkman and others use capacitive technology and are designed specifically to be used with bare fingers.

Multi Touch – The New Touch Interface

Older touch screen technologies relied on sensor arrays built into the display surface. These applications are expensive when applied to large areas and are limited in the number of simultaneous touch events that can be used (typically no more than two). The next step in touch screen technology was made possible by improvements in optical imaging. In optical imaging, one or more optical sensors are mounted below the display surface to detect objects that come in contact with the surface from above. In order to work, optical imaging requires the ability to resolve a complex video signal into usable data about discreet objects in the visual field. This ability was developed by researchers working in computer vision.

Three main types of feature resolving are used – edge detection, corner detection, and blob detection. Edge detection is a method of searching through video data to find strong gradients in intensity or color.

One of the earliest and still most widely used algorithms is the Canny edge detector algorithm developed by U.C. Berkeley Computer Science professor John F. Canny in 1986. *(see figure 36)*

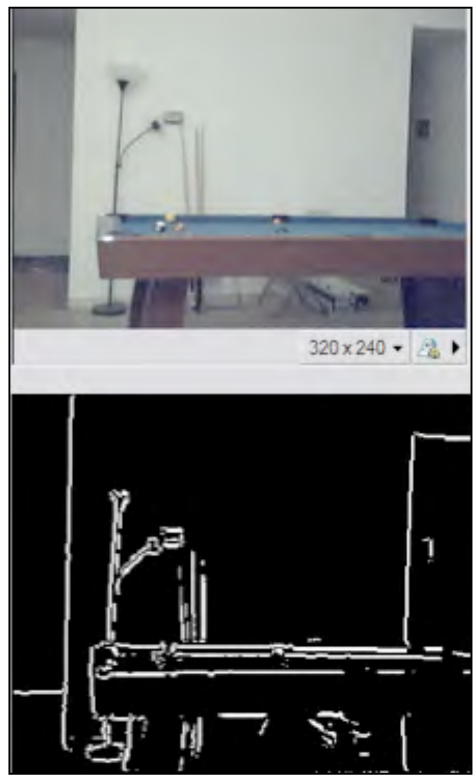


Figure 36: Image before and after being subjected to processing using a Canny edge detector algorithm. Image courtesy of Noah Kuntz www.pages.drexel.edu

Corner detection, also known as interest point detection, is commonly used in motion detection and object recognition. Originally, corner detection was defined as the intersection of two edges but interest point detection as it came to be known means more generally any well defined area that can be robustly detected including corners, edges, ends of lines, or points on a curve. One of the earliest corner detection algorithms was developed by Hans Moravec, an adjunct professor at the Robotics Institute at Carnegie Mellon University in 1977. The Moravec corner detection algorithm works by analyzing localized "patches" of pixels comparing their overall brightness to other patches close by. If a patch lies along a visual edge, than the intensity of the patch will be distinct from the

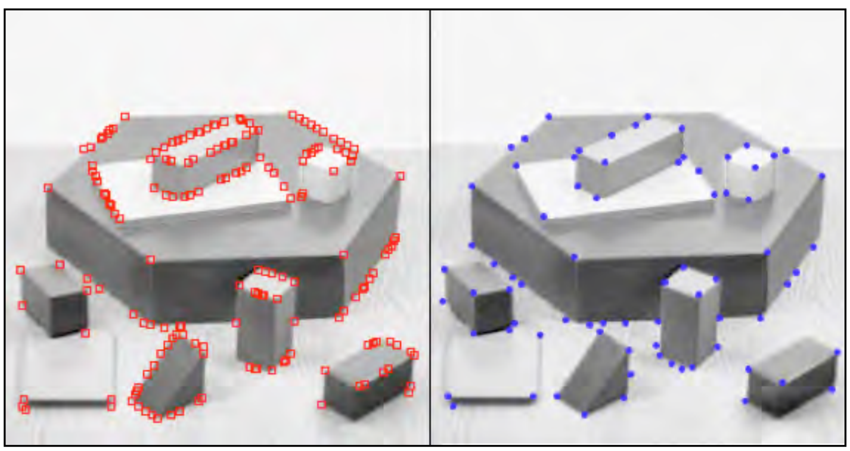


Figure 37: Image of blocks processed using the Moravec operator (left) and Plessey operator (right). Image courtesy of Moravec Operator- www.cim.mcgill.ca

intensity of other patches around it. *(figure 37)* Once isolated, other patches with similar intensity are searched for that are nearby. Unfortunately, if other patches are not detected nearby that are properly aligned, the patch will fail to be recognized as belonging to an edge. Also, the Moravec algorithm requires too many computations to accomplish the patch matching. The Harris, Stephens, and Plessy corner detector improves on the Moravec algorithm by looking for internal alignments within a patch. Although the mathematics are complex, the basic idea is that interest patches should possess strong alignment values. Blob detection or connected component labeling as it is also known, combines corner and edge detection to isolate and discreet objects. During blob extraction, an image graph is constructed of identified corners and edges. Each area is then examined in comparison to the areas around it and scores are assigned according to a preset Heuristic. From this analysis, a line is drawn around a blob or area of interest and the center point and radius of the resulting "blob" is registered.

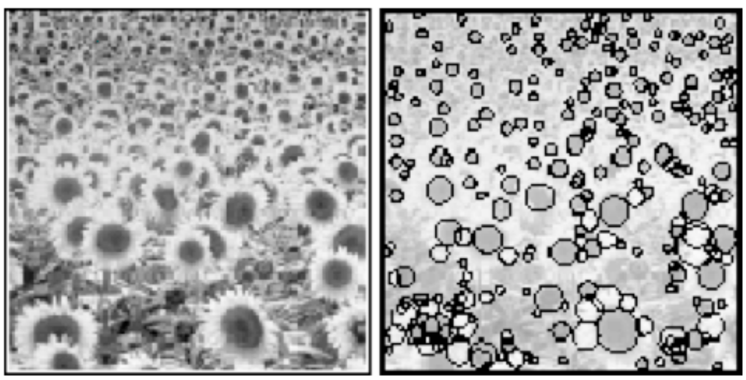


Figure 38: Image of daisies processed using blob detection. Notice how all the strong visual gradients are now circled. Image courtesy of Tony Lindeberg www.nada.kth.se

Reactable Project Uses a Multi Touch Interface

One of the first uses of new technology to implement optical processing was the Tangible User Interface developed in 2003 by the Music Technology Group at the Pompeu Fabra University in Barcelona Spain. This technology was developed and distributed as an open source software library called reacTIVision which was developed by Ross Bencina and Martin Kaltenbrunner as part of the project.

Figure 39: Reactable table with tangible objects added. Image Courtesy of S. Jorda Music Technology Group Universitat Pompeu Fabra

In the Reactable project, objects called tangibles are placed directly on the screen. On the bottom of each tangible object is a pattern of black and white circles and dots called a fiducial. The reacTIVision software operating as part of a computer vision system decodes the pattern of the fiducial using blob detection and communicates to the running application the identity of the object on the screen. *(see figure 40)* More important, the reacTIVision system is also capable of multi-touch fingertip tracking. To communicate with the Tangible User Interface, reacTIVision applications use OpenSound Control, an interface for device interface designed to replace

Figure 40: Sample of a fiducial pattern. Strong circles and dots are easily detected as points of interest and decoded by the reacTIVsion library. Image courtesy of Jannis Leidel, Python library for reactables TUIO protocol

MIDI, and a custom network protocol called Touch User Input Output (TUIO). TUIO forms the basis of TouchLib to be discussed later.

Jeff Han Introduces FTIR Multi Touch at TED.

In 2006 Jeff Han, a research scientist for New York University's Courrant Institute of Mathematical Sciences, presented a new type of multi touch display at the Technology Entertainment Design (TED) conference in Monterey California using a method of detection called Frustrated Total Internal Reflection (FTIR). *(see figure 41)* FTIR is a method for creating finger imprints on a display surface that a video camera can easily detect and subject to blob detection.

In Jeff Han's device, a sheet of polyacrylic plastic highly transparent to near infrared energy (IR-A: 700 nm – 1400 nm). Light from an array of IR LEDs, either Gallium arsenide or Aluminum gallium arsenide, is directed inward from the edge along the plane of the sheet. Due to the effect known as Total Internal Reflection, the light from the LEDs will be trapped within the sheet until it reaches the far edge. This is because the poly acrylic has a very high refractive index in comparison to the air above it.

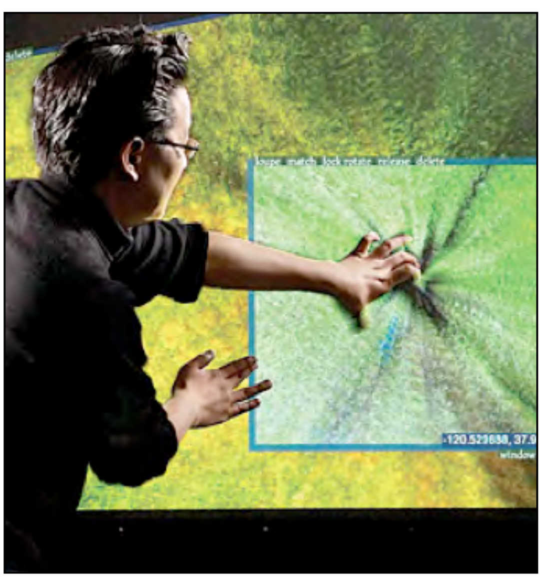


Figure 41: Jeff Han demonstrating FTIR multi touch. Image courtesy of Scientific American July 2008, "Hands-On Computing: How Multi-Touch Screens

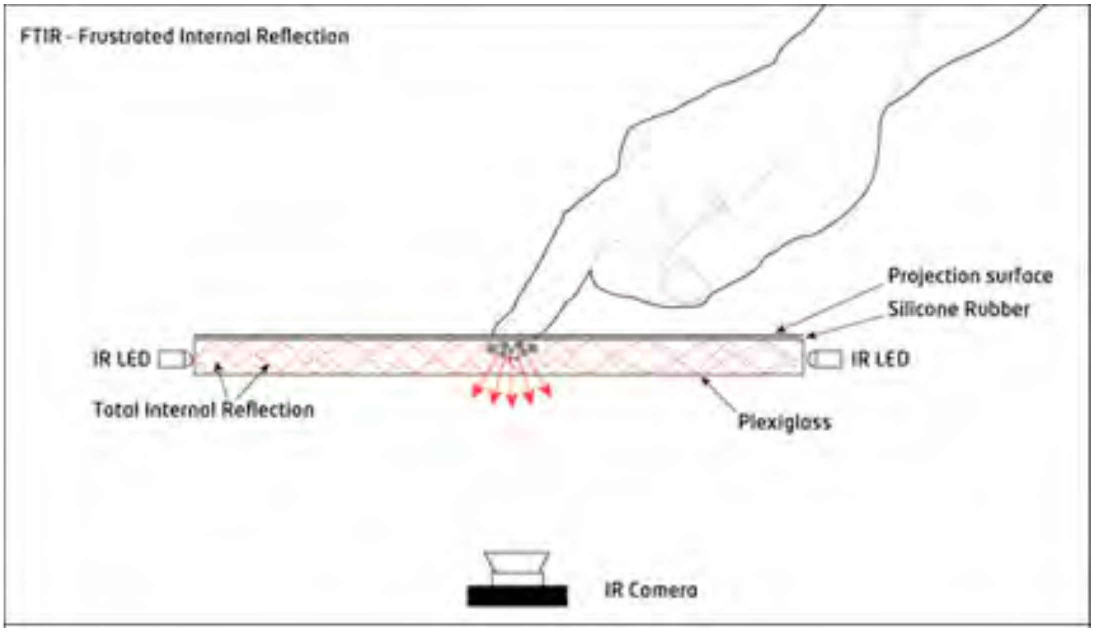


Figure 42: Differences in refractive index between the surface and the plexiglass traps light inside the plexiglass screen. Touching the screen causes some of the light to be reflected down and out of the screen. Image courtesy of the Natural Users Interface Group wiki.nuigroup.com/FTIR

When light strikes a boundary, if the refractive index of the material on the other side of the boundary is lower, then the angle at which the light strikes the boundary must be greater than a critical angle in order to cross the boundary. Otherwise all the energy of the light is reflected back along the angle of incidence and none escapes. The critical angle is a function of the optical density (OD) of the two materials ?c=arcsin(ODLow÷ ODHigh) where OD or transmission loss rate is the negative log of the transmittance OD = -log10(T) expressed in decibels. In the case of FTIR, all the light is very nearly parallel to the upper and lower surfaces so the angle of incidence is very low and well below the critical angle. The "frustration' comes in when a user places their finger tips on the surface of the sheet. Now the upper medium is no longer air but skin which has an extremely high refractive index in relation to the table. In this case the light is not refracted but instead is reflected downward so that it strikes the lower surface at an angle greater than the critical angle and passes through. This happens because, even before touching the surface, some light escapes due to the properties of an evanescent wave. This allows a phenomenon called evanescent wave coupling to occur if the surface of the skin comes within a few wavelengths of the plastic surface. By this effect, trapped light is reflected by the fingertips which appear to a camera sensitive to infrared as bright points in a dark field. *(see figure 43)*

Figure 43: Using FTIR, touch points appear bright to an infrared sensitive camera. Image courtesy of the Natural User Interface Group wiki.nuigroup.com/FTIR

FTIR – Not The Only Way To Multi Touch

FTIR screens suffer from a number of problems not least among them is the requirement that the fingertips must press close to the surface of the screen. Near infrared LEDs emit light with a wavelength of about 760 nanometers. This means that the fingertips must contact the surface at no more than 5 x 760 nm or less than 4 micrometers. Small air gaps which open up particularly as fingers rub along the table surface cause images of fingertips to be attenuated and to skip in and out of existence making detection problematic. To improve performance, an FTIR table must be coated with a light oil with a transmittance for infrared similar to air. Typically vitamin E oil is used for this purpose. The oil displaces air gaps between the fingertips and the surface creating a closer coupling between the low transmittance fingers and the high transmittance poly-acrylic surface. Another problem with FTIR screens is that they are susceptible to interference from other infrared sources outside of the table particularly overhead lights which can create false touch points. As a consequence, these tables are usually seen operating in darkened rooms. Other means of generating detectable blobs have been developed including Diffused Illumination (DI), Laser Light Plane (LLP), and Diffused Surface Illumination (DSI).

Diffuse Interface Principles

In DI surfaces, infrared light is projected at the display screen from outside above or below. In rear DI screens the light is projected from below so that when the user touches the screen, more light is reflected downward and can be picked up by the camera as bright spots. *(see figure 44)* In front DI systems the IR light is projected downward from above and the fingertips produce dark spots. *(See figure 45)* The advantage of DI systems is that the need for tight coupling between the fingers and the surface are reduced so oil is not necessary. The disadvantage is that DI systems are susceptible to local hot or dark spots caused by surface defects.

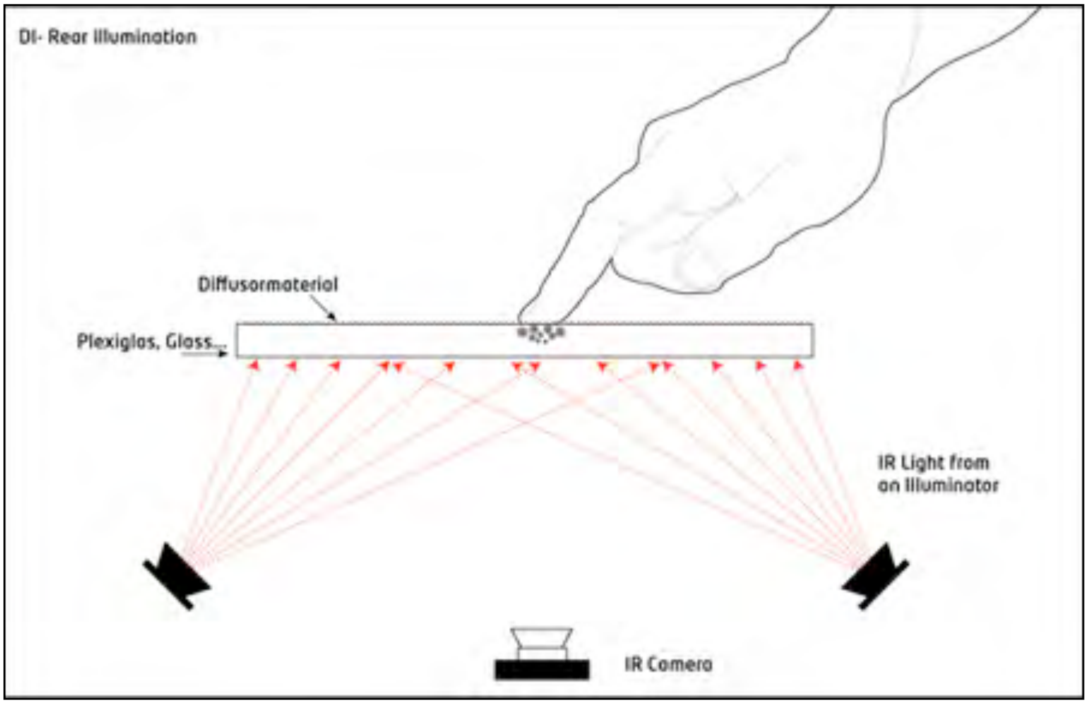


Figure 44: Rear DI systems use Infrared light pointing up from below the touch surface.Image courtesy of the Natural Users Interface Group wiki.nuigroup.com/DI

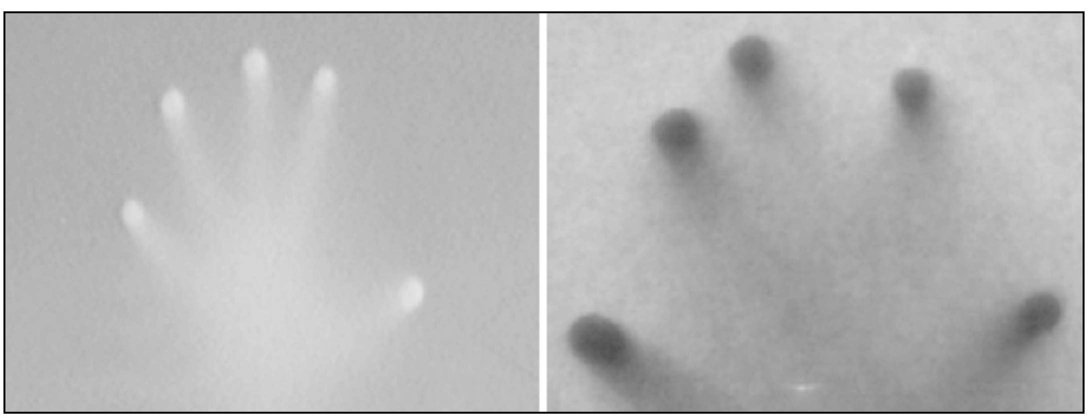


Figure 45: Image using rear DI illumination (left). Image using front DI illumination (right). images courtesy of the Natural Users Interface Group wiki.nuigroup.com/DI

Laser Light Plane Systems

In LLP systems, an infrared laser is used to pass a beam of light just above the surface. *(see figure 46)* Touching the surface than scatters a portion of the light downward. The principle advantages of LLP is that a wider array of materials can be used for the touch surface including glass and, like DI systems, the coupling between the surface and the fingertips does not need to be as tight eliminating the need for messy oils. The disadvantages of LLP are the expense of the laser systems and the inherent danger of working with strong laser light. This particularly true with infrared lasers as the IR light does not produce a blink response and the eye can be easily damaged.

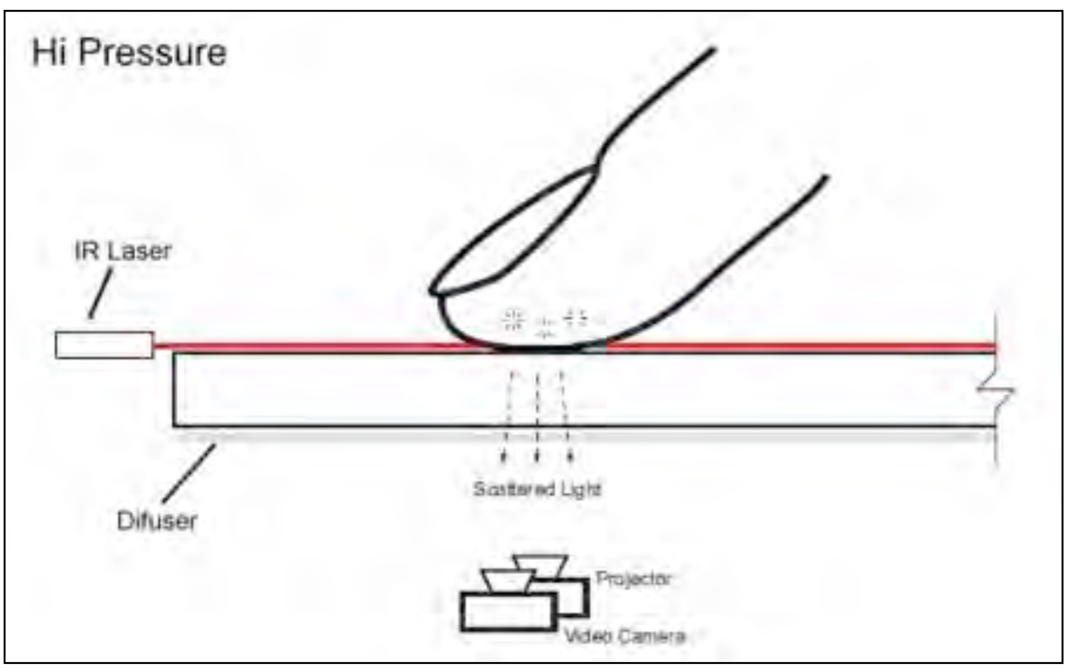


Figure 44: LLP systems use laser light scanned across the touch surface. Image courtesy of the Natural Users Interface Group wiki.nuigroup.com/LLP

Diffused Surface Illumination

Diffused Surface Illumination works essentially the same as regular FTIR but with DSI a special acrylic containing small reflective particles are used to improve evanescent wave coupling and to reduce the problem of hotspots.

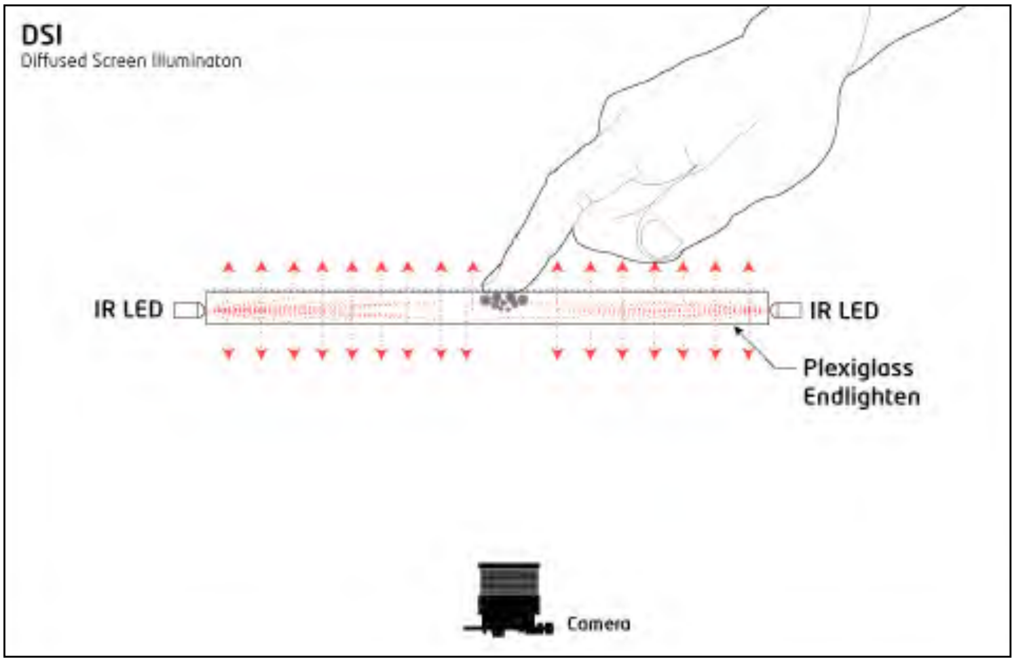


Figure 45: DSI systems use embedded particles to improve the distribution of the evanescent wave. Image courtesy of Natural Users Interface Group wiki.nuigroup.com/DSI

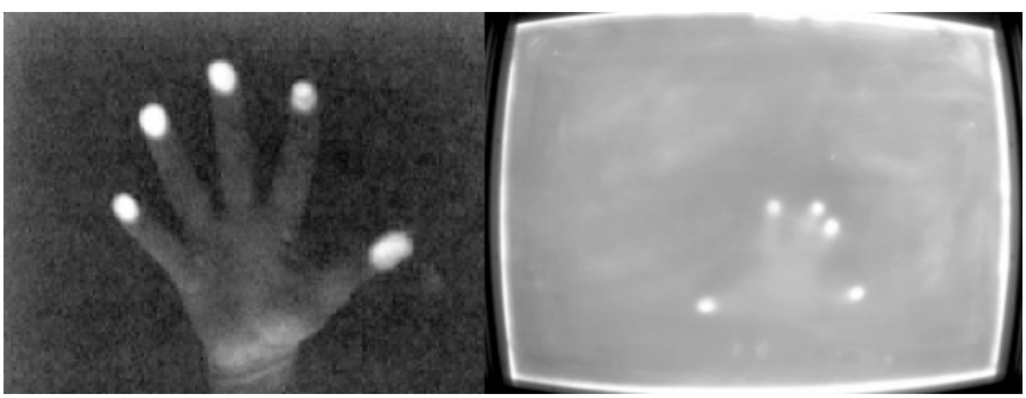


Figure 46: The image on the left shows touch events using FTIR. The image on the right was captured using DSI. Both images courtesy of the Natural Users Interface Group wiki.nuigroup.com

PROJECT TIMELINE

Fall 2007

- Multi-touch Table construction
- Interface research and conceptualization, script writing.
- Navigational structure, game concept development.
- Project Trailer, initial web-site development.

Winter 2008

- Multi-touch table- construction complete- begin testing.
- Interface design, art and asset creation: home screen, game 1, transition screens.

Spring 2000

- Multi-touch table- Cosmetic table design, platform construction.
- Complete Interface design, art and asset creation: game 2, game 3, all particle screens.
- Interface programming: home screen, particle screens, games 1 and 2.
- Revisions to project trailer, web-site

Summer 2008

- Multi-touch table- New camera received.
- Interface design: sound design, adjustments to interface structure.
- Complete Interface Programming: navigational structure, game 3,
- Interface debugging.

Spring 2008- Fall 2010

- Change thesis Advisor, revisit project perimeters
- Thanks to Rafael Hernandez, table now functioning!
- Recode entire interface using tbeta
- Debug interface
- Thesis Revision and completion

BUDGET

Multi-touch Table		
•	PC Computer	supplied
•	Web Cam (2)	$150
•	Projector	supplied
•	Power Supply	$35
•	LED Array	$75
•	Acrylic Top	$150
•	Mirror	$50
•	Framing	$300
•	Architect Vellum	$50
Final Installation		
•	Building Supplies	$300
•	Speakers	supplied
Software		
▪	Flash CS3	supplied
▪	vvvv toolkit	open source
▪	Touchlib Library	open source
▪	Desuade Partigen	donated
▪	Flash Plug-ins	$50
▪	Poser 7	$150
▪	3D Swift	$150
Services		
▪	Intern	$200
University Research Grant		-$500
Total Expenses:		$1160

CONCLUSION

In the course of developing Searching for the Alchemist, we encountered a number of challenges to the development of an effective user interface and made some conclusions about the effectiveness of using multi-touch to create a collaborative user environment. One challenge stems from using Flash as our development environment. Flash is a powerful tool for creating animations and AS3 (actionscript) is developing into a fully functional object oriented scripting tool. However, responding to mouse events is deeply engrained within the Flash design. Touchlib works effectively by capturing touch events and mapping them to mouse events that are then sent on to Flash. This works well for the most part. Some mouse events, however, do not map well to touch interactions. For example, using a mouse there is a clear distinction between a rollover event and a click event. Touch interactions do not allow separate rollover and click events. The effect of these limitations was further compounded by an early decision we made to make SFTA functional using either a mouse or a touch interface.

The inevitable consequence of these two issues, dual support and a mouse bias resulted in the SFTA project becoming more "mousey" than we would have preferred in order to adequately answer our thesis question. Neither do we believe that simply making the project entirely a touch application and abandoning all mouse support would have significantly altered the program's limitations. The most direct solution to this problem is to develop using a language that allows more direct access to the touch actions such as C.

Alternatively, Touchlib may well develop over time using future improvements to AS3 to include a number of custom actions that more fully encompass all the types of interactions in a touch interface. A final improvement might lay within the nature of a touch interface itself. As currently implemented, multi-touch tables do not include any dynamic response to a users touch. This is much like a harpsichord that makes no distinction between a soft touch and a sharp touch to a key. If a multi-touch interface could distinguish between light touches and hard touches, the response could made much more nuanced allowing the interaction to be more complex.

Going into our project, our desire as a team was to push the limits of our individual experience and explore many aspects of user interaction and new media installation. Project set-backs during the summer quarter and the many technical challenges encountered during winter/fall quarters necessitated that the goals of our project be continually revisited and re-evaluated. In the end, building hardware from the ground up, creating all original content, and developing a novel interface were all intense learning experiences for both of us and we are pleased with what we accomplished. Thanks to the invaluable support from Rafael Hernandez, our multi-touch table is now functioning and being used for on-going research within the Multimedia department; something we had originally hoped would be one of the outcomes of our project. When we began our project, multi-touch was a brand new technology and there were very few applications already adopted for commercial use. As we concluded our project, the adoption of multi-touch interfaces in general was quickly becoming a distinct reality. However, the use of multi-touch interfaces for collaborative, multi-user interaction is still an area that is ripe for exploration.

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List of Figures

APPENDIX A – GAME SCRIPT

Introductory Cinematic Script

"Welcome apprentices. I, Chronos, am curator to the Academy of Alchemy and Magic. You have arrived in troubled times, my friend. This academy, is the portal to the great elemental realms of Earth, Fire, Water, and Air. All can be reached from here. Now these kingdoms are under a terrible spell! Nicholas Flammel, our great scholar, has vanished! And his disappearance has caused quite a stir. If he isn't found soon, I fear for you and all who come after. Something must be done quickly, our whole world will be destroyed. "

Home Screen Objects (text descriptions displayed in scroll upon touch)

Figure 47: chart identifying alchemical tools / narrative

A) *Albemic: this rounded vessel with long snout works well for separating elements of air and water. Vapors trapped inside are pure liquids thus preserving their vital properties.*

B) *Beware the sands of time. A spell to slowly invoked can lead to destruction of the conjurer and any witnesses.*

C) *This glass vile contains the orange powder known Cupric, a fire element that quickens reactions. Mind its potent effect.*

D) *The vessel known as a crucible combines elements of fire and earth and can withstand great heat. In the hands of a powerful alchemist, it may transmute metals into gold.*

E) *It is said that this book of spells and potions belonged to the great Nicholas Flammel himself and contains all his wisdom. Inside are directions for all the great spells. Beware it's use, lest ye meet with a fate similar to his.*

F) *This bottle holds the Elixir of Life, purest of all water elements. Heals all mortal substances but must not to be combined with anything divine.*

G) *The pear-shaped vessel called an aludel captures and combines vital liquids. When used by a master alchemist, it will produce the purest liquid of all, the elixir of life.*

H) *A small green bottle is rumored to hold the tears of the earth spirit. Contained within are many vital properties of earth and water. It must be first, bound to earth, or will quickly be dispelled.*

I) *This strange apparatus left behind by Nicolas Flamel is rumored to be a portal to hidden realms. The secret of its use has been lost, but believed to be hidden within his book of spells.*

J) *Mortar and Pestle: a cup-shaped vessel of hard-baked clay, suitable for grinding substances with a blunt pestle. It is also useful for mixing elements of earth and water.*

K) *This vessel contains the blue powder Umber, A most vital and potent earth element. It's properties have been known to slow time and reverse some transformations*

L) *The matrass is a pure glass vessel with long neck, suitable for collecting all substances, both mortal and divine.*

Home Screen Instructions (spellbook opened)

Page 1: *Four symbols represent the great elemental realms that define the principles that rule the world. The Realm of Air. Realm of Fire. Realm of Earth. Realm of Water.*

Page 2: *At last I finally have it - a means to travel to each of the four realms! I will call it the alchemist compass. And the operation is so simple. First align the pointer with the realm to travel to. This activates the magic symbol. Press the symbol and magic handles will appear. Grip these and pull firmly to reveal a gateway to another world!*

Pages 3: *It seems the magical forces that drive the mechanism are extremely potent. Each day it must be polished for it quickly becomes corrupted and so quite useless. It took many days to find the right combination of chemicals to clean it.*

Page 4: *First a solid binder must be laid down then a suitable elixir can be mixed in. Beware for if the wrong combination is combined the results can be explosive!*

Air Game Instructions (spellbook)

Page 1: *The sixth operation in alchemical transformation is the process known as distillation. This will increase the purity of any gas or liquid.*

Page 2: *To cure the air realm of any impurities, I first built this distillation apparatus* *of unique and magical properties. The burner must be lit before the pot is placed over it. Once lit and the assembled, corrupt liquid is spooned in from the side to release the pure spirit of air.*

Page 3: *I have entered plans for such an apparatus below. Note that the pots must be stacked in the correct order.*

Page 4: *What strange forces are at work?! Each time I open the book of spells, I find the plans have mysteriously disappeared!*

Air Game Win

"Wizard, you are powerful indeed. I am Ventus, spirit of air. To show you my appreciation for restoring my realm, I offer you this piece of the philosopher's stone. May it bring you good fortune on your quest."

Water Game Instructions (spellbook)

Page 1: *The spirit of water can exist in many forms at once, as air, liquid, or solid ice depending only on temperature. What I have found is that the temperature is only a measure of how fast the particles are moving*.

Page 2: *To convert the water realm from one of ice to liquid, the crystals of ice must be set in motion. The more they move the higher the temperature will climb. At a critical melting point, all the ice will vanish leaving the spirit of water as a free flowing liquid.*

Water Game Win

"Greetings apprentice! I am Hydroxia, spirit of water. You have successfully vanquished the evil spell from my realm and returned it back to it's original state. As a reward, may I present you with a piece of the philosopher's stone."

Fire Game Instructions (spellbook opened)

Page 1: *Can it be true? The great energy of the fire realm has been restrained behind a powerful barrier! Without fire, all living things may soon perish!*

Page 2: *I believe the Turrets in the corners hold the key. I have created this glass vessel that emits magical fireballs. Perhaps If those blocks can be arranged to target the fireballs into the turrets, the barrier can be shattered and order restored.*

Fire Game Win

"Wizard, you are powerful indeed! I am Entropa, queen of this fiery place. You have shown a spirit more vital than the forces seeking to extinguish our world. As a reward, take this magical stone. May it bring you fortune on your perilous journey."

Compass Icon Pressed (global)

Dark forces are approaching. Are you sure you want to abandon this challenge?

Press compass to return to the alchemist's lab. Press here to continue the challenge.

Loose Game (Global)

"You have failed! The universe has now fallen under the forces of evil. Await the impending darkness."

Particle Screen Haiku

Water Realm

Spirit of water,
She lays frozen within
Awaiting a touch.

Air Realm

Element of air,
now trapped and corrupted,
dreams of purity.

Fire Realm

A cleansing with fire
burns away impurities,
restoring hope.

Earth Realm

Element of earth,
Lord of all form and substance,
Lies now in chaos