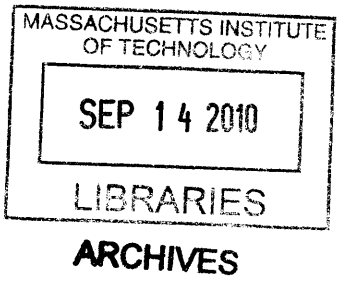
Surround Vision

A handheld screen for accessing peripheral content around the TV

By

Santiago Alfaro



Submitted to the
Program in Media Arts and Sciences,
School of Architecture and Planning,
in partial fulfillment of the requirements of the degree of
Master of Science in Media Technology
at the Massachusetts Institute of Technology

September 2010

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Abstract

If one thinks of a television set as a window into another world, then whatever one sees through it could be assumed to continue past the edges of the TV. If the TV shows a forest scene, then to the sides of the TV one should be able to find the continuation of this forest, meaning more trees and perhaps a stream, a path and even some birds and squirrels.

This thesis describes a novel system that situates the viewer at the center of a surround space. The system proposes that the main program be augmented with content that is specifically created for spatial continuity or other perceptual effect, and that the viewer use a hand-held navigational device with a viewing screen to access this secondary source of information, even while keeping an eye on the main screen. This navigational paradigm begs for new storytelling conventions and presents new storytelling challenges.

The thesis describes a working prototype, three types of footage used to test the system in various scenarios and a user study that provides initial understandings of the effects of this system on the audience. This thesis explores how a system that enables exploratory interaction with the contents on the TV will affect both the industry and experience.

Thesis Supervisor: V. Michael Bove, Jr.
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To My family who from a distance still serves as a great inspiration to all my adventures where ever they keep taking me;

Lastly to all my friends, local and abroad, who are always ready with open arms, big heart, quick wit and watchful eye.

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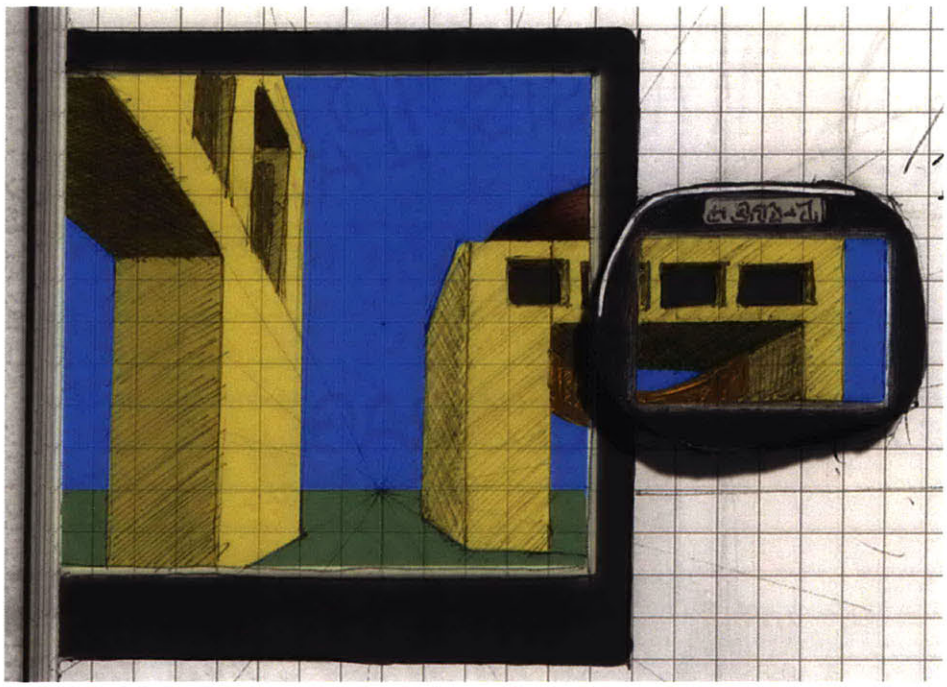


Concept Sketch of how the image can extend the TV frame using a hand held device.

1. Introduction

The traditional television programming is designed by directors who have a clear idea of how a narrative will unfold, editors who sequence shots, and live production units who decide where multiple cameras will be placed and how these cameras will be switched. For different types of content, like live events, where many cameras are following the action or for film and TV, where a director has a very clear picture of how the story will be told and what specific angles will be shown to the viewer, decisions about narrative flow are based on the need to fit the narrative into a single temporal stream that can be displayed a rectangular screen. This "single screen" convention limits how the audience can experience and interact around the content of a TV program.

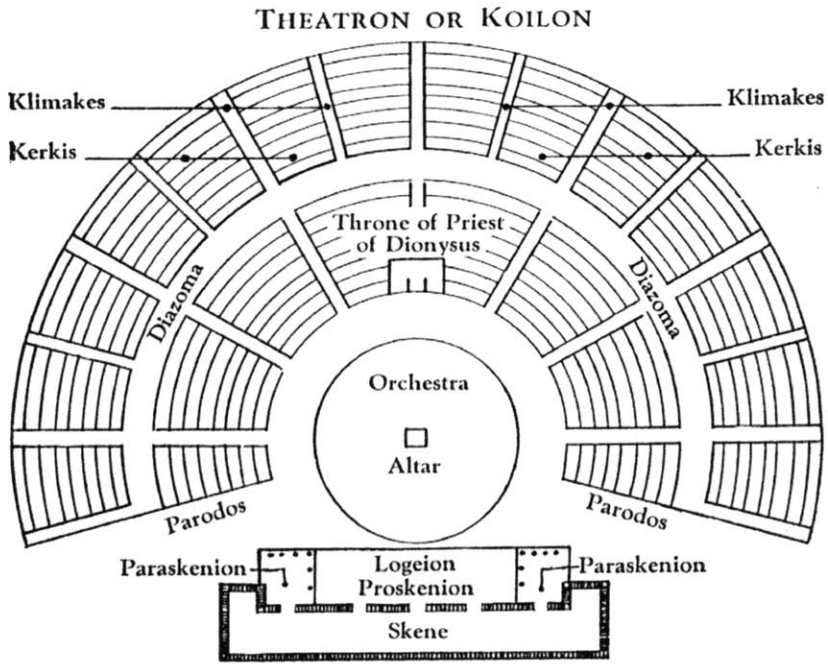
This thesis proposes Surround Vision, a system that transforms the TV-watching experience into an immersive activity and allows the viewer to explore and construct a more complete picture of what is

happening "off screen" or on the “other side” of the screen. The main interface to this system is a handheld device that gives the viewer a way to access this extra content so that he/she may choose the point of view with relation to the content on the main screen and the viewer's position relative to the screen. The system presumes that content makers will use the secondary channel for related views or expanded narrative threads, and that the viewer will become an explorer rather than a spectator, and take a more active role in the unfolding of the story.

The use of more than one screen has been discussed in the past. What I propose is to use a second screen as a personal device. Multiple screens around the room can provide a surround context but such an experience will lack the level of intimacy and control that Surround Vision can offer. When the TV experience is split into two spheres of usability (shared and personal), the field of TV entertainment suddenly derives new potential for interactivity and social, shared construction of story.

Will viewers who have only ever experienced a mono-directional television set enjoy this public/personal mode of television viewing? Can this new paradigm bring richer interactions to the household? Will the industry embrace an innovation that requires a new way of thinking about writing, editing, capturing and broadcasting media? Through interviews and user studies, this and other questions are addressed.

The long-term vision for the proposed system is that it will not only change the viewer experience, but will also increase the story creation opportunity and encourage directors (or storytellers) to invent new methods and conventions, possibly constructing their story using parallel synchronous action with the intention of engaging the viewer in an active exploration to discover the whole story.



Image[1]

Plan of "Theatron." *"the stage started to win some ground over the spectator area in such a way that first it was no longer a full ring"*

2. Background

Ancient Greek theater is believed to have evolved from a rural festival called Dionysia[2] where, after processions and festivities, the public would gather around performers who would dance and act for their audience. It is not hard to imagine how people would gather around the performers surrounding them, creating a central performing space, distinguishable from a surrounding viewing area. As time and technology advanced and the quality and complexity of performances evolved, theaters begun appearing. In these constructions, the stage started to win some ground over the spectator area, which transformed from a full ring to a semi-circle halfway around the stage and finally to a horse-shoe in front of the stage. With the arrival of the silver screen, modern theaters

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[1] "Theatron or Koilon." Blueprint. *Scenery* 29 July 2010 <http://www.cornellcollege.edu/classical_studies/lit/CLA364-1-2006/01groupone/Scenery.htm>

[2] From Wikipedia. http://en.wikipedia.org/wiki/Dionysia

became straight rows of seating arranged parallel to a flat screen. Nowadays we find movie theaters that provide each viewer with a fully encompassing experience using screens that resemble spheres. Thus the entertainment experience has transformed from the action being surrounded by the audience, to the audience being surrounded by the action. The idea for this project took root as I thought about this sort of transformation and anticipating what might be next.

Modern Experience

Modern movie theaters combine a big theatrical experience-- grand theaters, big screens and the thrill of the social experience-- with an ambiance of intimacy that resembles the experience at home. In the movie theater, every movie goer has the sensation of being in a front row seat. However, for most people, the home experience has been reduced to a small screen. At home, the social experience has been scaled back from that of the theater, and is fraught with assorted interruptions. Also the unique feeling of a larger-than-life screen is being reduced by the smaller size of the TV set. The current trends from the industry and consumers that tend to go bigger, louder and more defined are an indication that we are trying to take the home experience towards something more complex than what is offered.

The next step

The evolution of the spectator-action relationship indicates two directions for innovation. As an innovator, I can either go back to the early concept of audience engulfing the action, which might lead to ideas like holograms and displays with a 360 degree viewing angle, or I can look at the current state-of-the-art in which

the action surrounds the audience. We see this latter approach in several technologies including Virtual Reality or Immersive Media. These trends in home entertainment and media deployment suggest that there is an opportunity for well placed innovation that will extend the art of media content and offer viewers a more engaging media experience. This thesis is my attempt to do just that.

During my time at the Media Lab I have come in contact with several interesting technologies. Through the combination of these technologies, my background in industrial design, discussions with co-workers and research, the Surround Vision project has taken shape.

Related Technologies

Computer Vision

Projects in Computer Vision have fascinated me, even as they provided me with an understanding of the immense possibilities and uses of machines that "see". As part of my exploration, I developed a project that used face recognition techniques and started learning about other applications for these technologies.

Through various experiments I began to discover the potential for computers that are aware of the physical surroundings, not necessarily by recognizing objects but rather using simple movement using tags, edge detection or optical flow.

Virtual Reality
Creates the feeling of being completely inside a virtual world.

Virtual and Augmented Reality[3]

Virtual Reality has tried to give people access to non-

[3] Image: NASA "Head-mounted display and wired gloves" Photo. *How Stuff Works* 2 08 2010 <http://electronics.howstuffworks.com/gadgets/other-gadgets/VR-gear.htm/printable.htm>

Augmented Reality Superimposes virtual images over the real world.

physical worlds and, through metaphors like avatars and digitally created societies, give users control over their actions in these worlds.

Augmented Reality[4] superimposes digital information on the physical world by means of a camera and a processing unit. Concepts like the "Magic Lens" give users the opportunity to access this extra layer of information by using a mobile device that is moved around by the user. The experience created by these technologies suggests directions for the development of Surround Vision.

The two technologies differ in a very important detail: the level of immersion of the user. This often drives preference for one technology over the other, as many users will feel sick since their brains are "seeing" something that the rest of their senses are not picking up.

The ideas of simultaneously being in two worlds or simply generating the presence of a different world through the perceived window of a hand-held screen informed my intention with Surround Vision. In thinking about these concepts and about the issues raised by users feeling uneasy with these technologies, I had good starting points for the details of my system.

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[4] Image: Caleb project at Graz University "Handheld Game Devices (PSP, Gizmondo, Nintendo DS)" Photo. *Games Alfresco* 16 04 2008. 2 08 2010 <http://gamesalfresco.com/2008/04/16/10-best-augmented-reality-devices-that-will-reinvent-mobile-video-games/>

Obscura Digital. Surrounds the users with media, creating an overlaying virtual world inside a specific room

Immersive Media[5]

Immersive media is the creation of an involving experience that attempts to give the viewer a feeling of being inside a completely different world by projecting on to screens that cover the complete field of view of the spectator, an example is the Omni Theater at the Museum of Science in Boston. Companies, like Obscura Digital[6], create a similar effect by locating screens on every surface surrounding the user, thereby creating an overlaying virtual world inside a specific room.

I was interested in the way Immersive Media presents the virtual world to the user. Stepping away from the AR and VR approaches, Immersive Media does not use goggles or any type of head-mounted displays. I think this allows the user to feel more comfortable throughout the experience and ultimately feel permanently in control.

Industrial design and the user experience

The Surround Vision project requires an accurate look at the TV experience in order to understand when and where the new interactions may be appropriate. My background as an industrial designer gives me the tools I need to interpret the current user experience.

More than simply looking for ways to make products look nicer and sell better, Industrial Design encompasses the study of humans, their surroundings and the way they both interact, with the added

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[5] Image: Obscura Digital, Inc "Trump Tower Dubai" Photo. *Obscura Digital* 2010. 10 08 2010. <http://obscuradigital.com/>

[6] http://obscuradigital.com/

ability to create the elements of that surrounding and that interaction.

Next I will discuss how Surround Vision is informed by Industrial Design in terms of both the user roles and interactions and the physical device itself.

User roles and interactions

The starting concept of Surround Vision is that one story will be streamed to the main TV screen as are most programs made today; but that a second layer of content such as parallel synchronous scenes that relate to the story flow will be developed such that they can be accessed around the edge of the screen by each individual viewer via a hand held device. The interactions between the user and the handheld device, the graphic interface and the main TV can all be analyzed through Industrial Design. Currently the role of the viewer is that of a passive spectator. Technology allows some level of control over the overall pace of the narrative by giving the viewer the ability to play, pause, forward and rewind. But there is no way to actually change the narrative of the story or allow the curious viewer to explore and discover details that might enhance that narrative. The user's choice and level of control rely on a system to manage information related to the content being watched or with other offerings that might be of interest. Other technologies try to integrate the user's life with the TV experience by allowing control of calendars, schedules and other internet features like Facebook or Twitter. The Surround Vision system could be adapted to work with these elements; however, they fall outside of the main objective of this project, which is focused on the story experience as television content is extended and situated for access in the viewer's surround.

The potential for social interactions created by having more than one person using this system is another important consideration of the project. Assuming the director concerns him or herself with story discovery, Surround Vision can provide the opportunity for more than one person to explore and share their discoveries about the story world. If Surround Vision is used as a gaming platform, then multiple players might choose to work together and combine their efforts by dividing the virtual space, i.e. "you look on that side of the room while I look on this side," to accomplish whatever the objective of the game might be.

The hand-held device

There is a choice between designing a specific device for Surround Vision or utilizing existing handheld devices such as a cell phone or tablet that, if equipped with the necessary sensors and processing power, might prove suitable for the development and distribution of the system. This raises a larger question about whether we as designers should keep pushing the capabilities of the existing devices to their maximum potential or whether it makes more sense to design devices that have fewer capabilities but are exceptionally good at doing the few things they do.

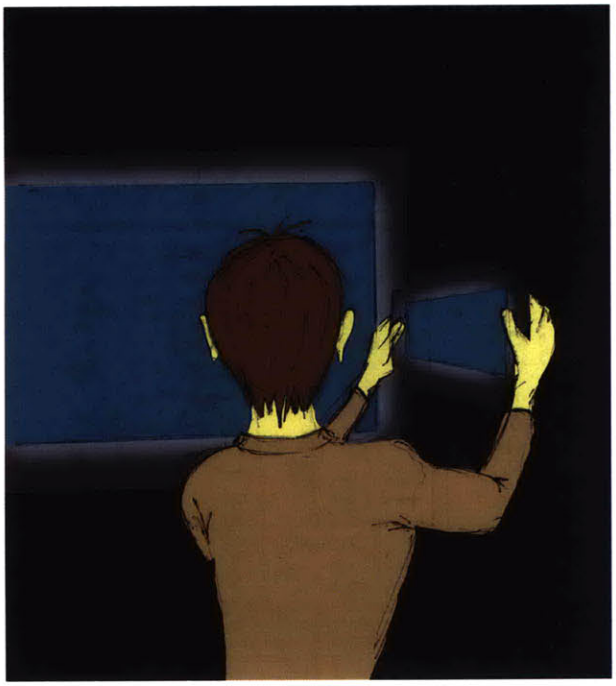
In the case of Surround Vision, the main advantages that would come from creating a new device specifically for the system is the control of the form factor to allow for direct targeting of specific audiences. A smaller, lighter screen, that is not as expensive as an iPad would be suited for a preschool audience that can use Surround Vision while playing an exploration game with a character in the TV screen. This device could have grips, colors and textures more suitable for the wear and tear expected from a preschooler. An older generation that is not very familiar with high-end cell phone devices might feel more comfortable with a design that

requires less controls and configurations and might even resemble an old-style magnifying glass or a pair of opera glasses.

The TV Experience

Currently, TV watching is a shared experience. When more than one person is in the room, there is no way to have an individual experience unless multiple screens and tuners are in place. A main contribution of Surround Vision is that it provides two channels for the story experience. The main program content appears on the traditional "shared" TV screen; in the case of this content, very little needs to be changed, at least from a production perspective. The secondary, surround content, can be accessed by directing a secondary personal hand held device. This mode allows each user to control what and how they watch the program. Dividing the activity in this way, users can access elements of the program that are not part of the main program stream without affecting the viewing of the other viewers who may also be watching the main program in the same space. This provides a comfortable and personal experience. As viewers have different but complimentary experiences, Surround Vision also provides a unique opportunity for users to share, compare and compliment each of their experiences with that of their fellow watchers.

The main contribution of this work is that Surround Vision suggests and provides a system to explore a new paradigm for telling stories through the media of TV, one in which the full story is revealed through the exploration of the surrounding space. The system encourages the viewer to adopt a more active role when watching TV. During development, partners in the industry have seen in the system a valuable way of conveying extra information that compliments the experience by making it closer to a live event or simply by giving a feeling of control to the viewer.



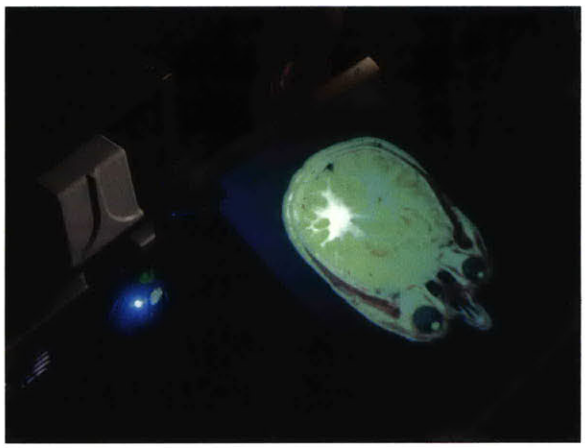
Concept Sketch of what the interaction would be like.

3. Related Work

Multiple Device Experience

Interacting with Digital Media at Home via a Second Screen

Dr Emmanuel Tsekleves et al. [1] have made studies on interactive TV and more specifically in the use of a second screen to access these services. They arrived at this study after having tested iTV with only one main screen and hearing the disconcerted opinions of the users. The addition of a second screen proved to be well accepted. People preferred to not waste the "real estate" of the main screen with interactive features but were more than willing to interact with the secondary device. This proves the benefits of having a split experience where the shared experience is unchanged while each viewer has a personal experience through a second device



Flexible Display Users can move the screen back and forth and to the sides revealing slices of a 3D rendering (taken from the paper [2])

A handheld flexible display system

Jonathan Konieczny et al. [2] have developed a flexible back projected screen that displays images from a spherical lens. What intrigued me was the way that the user can move the screen back and forth and to the sides revealing slices of a 3D rendering; this movement gives the user control of his/her exploration of an object. The idea of exploration became also a central theme for them. Konieczny's work gave me ideas on the importance of the handheld screen and the possibilities it could have.

Usages of the Secondary Screen in an Interactive Television Environment: Control, Enrich, Share, and Transfer Television Content

Pablo Cesar et al. [3] published a study in which they collected and analyzed the current (2008) examples of second screen technology when watching TV. They further divided the experience into four main categories: control, enrich, share, and transfer television content. It is clear from their analysis that there is a good opportunity for secondary screen technologies in the household that will enrich the television experience.

New Broadcasting Techniques

Mixed Reality Techniques for TV and their Application for On-Set and Pre-Visualization in Film Production

In this paper, Graham Thomas [4] gives a review of the technologies present in 2006 for mixed reality television and film, with a specific emphasis on real-time generation of virtual images

Children create their own creatures in a 3D building program online. Augmented Reality is used to simulate live races of virtual creatures.

as on Live-TV. A great example of this is the BBC show "Bamzooki"[7] where children create creatures in a 3D building environment online and then see them compete against one another through augmented reality. These techniques are applied in-studio and have no effect on the user experience at home but with little imagination the same techniques could be used to create virtual surrounding images that could work with Surround Vision.

Augmented TV

MATRIS Project

This Project has developed a system that generates augmented reality applications with minimal hardware. The system measures in real-time the movement of a camera, using image analysis to track the features in the scene that is being captured, and couples this with data from an inertial sensor. No additional sensors, special markers, or camera mounts are required [5]. The Surround Vision system will use similar technologies so that the device can orient itself with relation to the main screen in any context as well as detect the camera movement in order to locate the virtual images as stationary with relation to the user's surroundings. This way no additional equipment has to be installed and the handheld device will do all of the processing and computation.

As the project advanced, we veered away from this type of technology because not all handheld devices would have the

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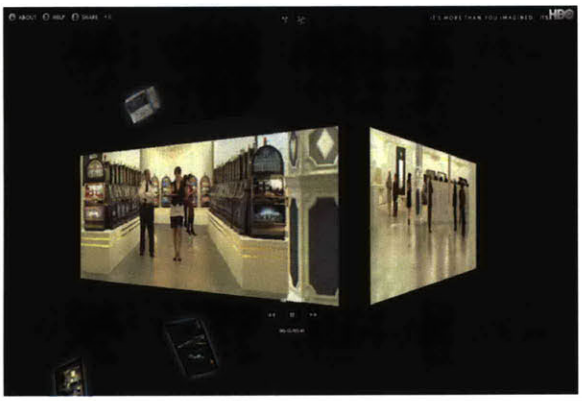
[7] Image: "Jake and the red team cheer on the Zooks" Photo. *BBC* 01 02 2004. 15 06 2010 <http://www.bbc.co.uk/norfolk/kids/jake_humphrey/bamzooki.shtml>

cameras necessary and, as we are talking about TV watching in the living room, the poor lighting condition would make this very difficult.

"...use their devices' touch screens to control 360-degree views

Enhanced Blu-ray Bonus Features for iPhone(TM) and iPod Touch(R)[8]

In July 2010, Universal Studios came out with what they say will be the "very first iPhone/iPod touch-enhanced Blu-ray bonus feature." Special features on DVDs have been a big selling point for the movie industry, and these features vary in complexity and technology. This new feature will allow users to control specific features on the Blu-ray DVD player with the handheld device, as long as the Blu-ray player is connected to the internet or is Wi-Fi enabled. In this first example, the user will be able to control a 360° view of an object and change some characteristics. *"With iPhone or iPod touch in-hand, Blu-ray viewers can use their devices' touch screens to control 360-degree views of the movie's supercharged street-racers and instantly punch up exclusive technical specs for the film's high-tech cars."*[9]



Screenshot of the movie environment at HBO Imagine

New Storytelling Paradigms

HBO Imagine[10]

HBO put together a web based project through which the user can see a story that

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[8] Image: "Use of a mobile phone to interact with the TV" Photo. *Commingsoon.net* 20 07 2009. 21 07 2010 < http://www.comingsoon.net/news/movienews.php?id=57310>

[9] Control *Fast & Furious* Blu-ray Features on iPod & iPod Touch (2010). Retrieved 21 07 2010 <http://www.comingsoon.net/news/movienews.php?id=57310>

[10] Image: "HBO Imagine Universe" Screen Capture. HBO Imagine. 05 09 2009 <http://www.hboimagine.com/>

has been filmed through many camera angles. The user can spin a cube in order to go from angle to angle and, in doing so, discover different hidden parts of the action that compliment the story.

Interactive Narrativity

In the paper "Interactive TV Narratives: Opportunities, Progress, and Challenges, Marian F. Ursu et al. [6] explore the effects and opportunities of getting away from the linear narrative and discuss different ways in which the TV experience can be affected by the user.

1. The user can have a choice of different linear narratives that are accessed through a "multistream synchronous delivery and time-shifted viewing" [6].
2. Services can be offered in parallel to the TV broadcast. These can be accessed either through the main broadcast (enhanced TV) or through secondary devices and channels such as web pages or SMS messages.
3. Cross-platform delivery allows the viewers to send suggestions and opinions about a specific broadcast that can actually change the course of the narrative being experienced.

Late Fragment, an Interactive Film[11]

Late Fragment is a film project by director Anita Doron in which she explores how the viewer can radically control their experience of the film.[12]

"Late Fragment is an interactive film that lets audiences piece together, both literally and figuratively, the

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[11] Image: "Late Fragment." Photo. *latefragment.com* 2007. 01 08 2010 <http://latefragment.com/>

[12] Zjawinski, Sonia. " Viewer's Cut: Interactive Film Gives Editing Tools to You" Wired Magazine issue 17.01. 22 December 2008 <http://www.wired.com/entertainment/hollywood/magazine/17-01/pl_screen>

cinematic narrative in front of them. The physical experience is not unlike channel surfing in front of the television, except imagine that each channel presents different scenes from the same story. Sitting on the couch, remote control in hand, audiences can click "enter" on their remote control, and impact the way the story unfolds, sequencing the events of the story depending on when and how often they click "enter." Late Fragment is like many of the non-linear movies we have come to love including Crash, Short Cuts, and Amores Perros. But with Late Fragment audiences now impact what scene they may get next."[13]

Tamara (a play)

Tamara, play14 by John, provides another story model that can inspire content for Surround Vision. The play is usually set in a large house with many rooms. The actors play out their scenes with entrances and exits from the various rooms.

> *"Thus the members of the audience make a series of choices, and depending upon these choices, each spectator creates their own individual viewing of the play from point of view they develop.*
>
> *There are five key choices in the play:*
>
> *1. As characters leave and separate from a room, which will you follow?*
>
> *2. Or will you wait and see who shows up in one or several rooms?*

---

[13] From the project website. http://latefragment.com/

[14] Tamara (play). (2009, December 24). In *Wikipedia, The Free Encyclopedia.* Retrieved 05:22, August 11, 2010, from http://en.wikipedia.org/w/index.php?title=Tamara_(play)&oldid=333683647

3. Will you follow the same character all the time, or switch characters as the play progresses?

4. Will you stay with a friend, or each adopt different strategies?

5. How will you respond when an actor gives you instructions (i.e. to follow them, or wait in the room, etc.)?"

Still from street footage used to prove the concept

4. System Development

During the process of building and prototyping Surround Vision, we concentrated on Hardware, Software and Content. Our efforts would iterate between the three fronts while keeping an overall view of the project in such a way that the advancement in one would inform the others.

Hardware

The hardware development went from an off the shelf device that was adapted to our needs. Once the initial prototype was working, we moved the application to an iPad tablet that gave us the opportunity to fine tune the physical and usability aspect of Surround Vision.

Version 1 – Samsung Tablet [15]

The first version of the system was built in a Samsung tablet in order to be able to go back and forth between my Windows machine and the Windows tablet for debugging purposes. This created a hardware problem since the tablet had none of the sensors required for a system like this. I used a Compass Module with Tilt Compensation[16] that communicated through i2c, as well as an Arduino[17] board with USB interface to both power the sensor and communicate its data to the computer through Serial Port. Code and data worked nicely except for a lack of precision from the compass. I later realized that the tablet gave off some interference so a "bracket" had to be created out of bent acrylic in order to keep the sensor at a sufficient distance from the tablet so as not to be affected by it. This first version worked reasonably well and was the basis for the first demonstrations and user testing.

Version 2 - iPad[18]

For a widespread deployment we chose an Apple iPad. Not only does the device come with all the sensors we needed, but the size, weight and screen size were very well-suited to our purpose. Also, the operating capacity of the iPad is more than enough to handle the video processing at the same time with the sensor data and the wireless data transfers. However, this device did not have a back-facing camera so we had to resort to a graphical interface to enable the user to orient and fix the e-compass data to correspond to the particular arrangement of the living room.

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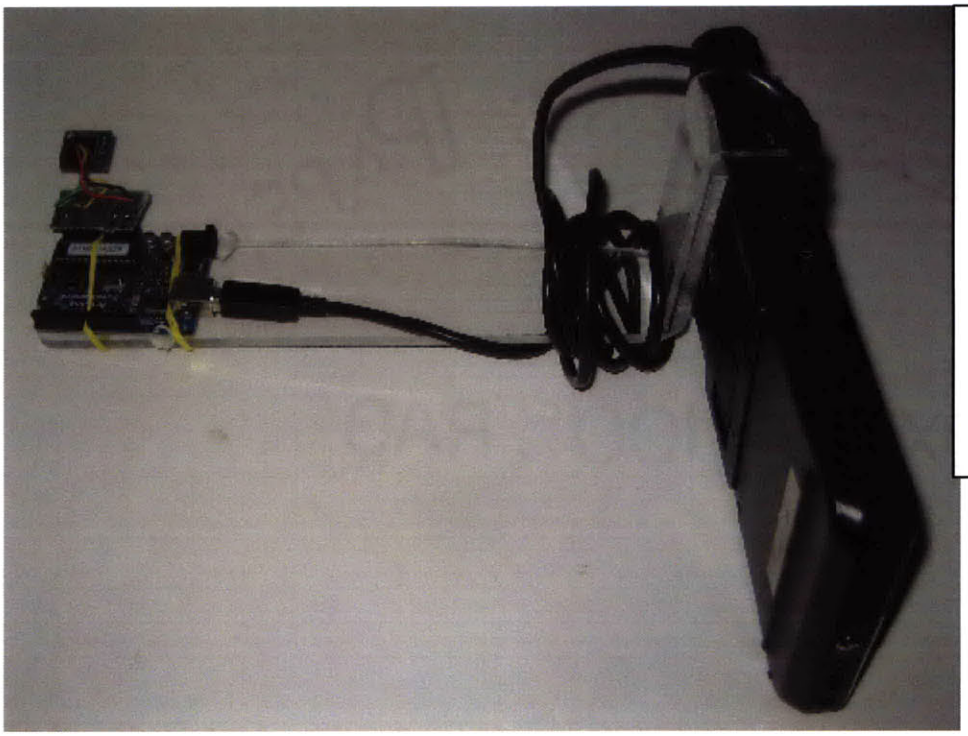
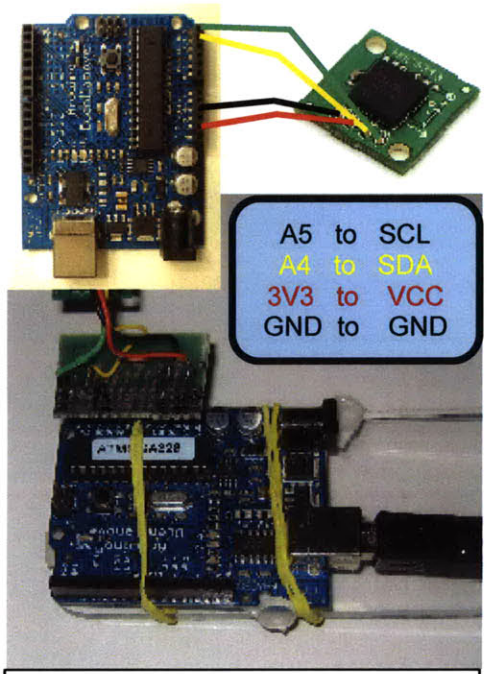
[15] Samsung Q1U-XP. See Annex C
[16] HMC 6343 from Honeywell. See Annex D
[17] Arduino Duemilanove. See Annex E
[18] iPad Wi-Fi 16Gb. See Annex F

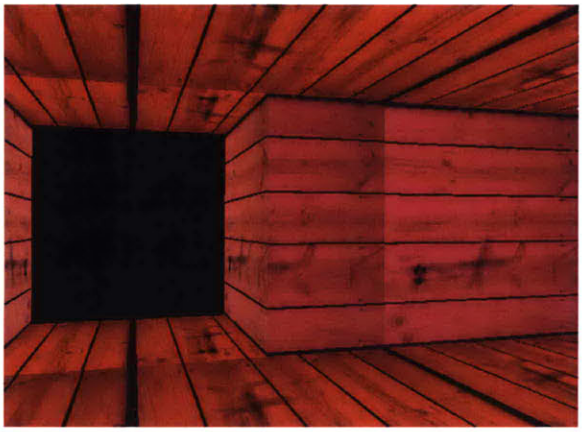


First prototype consisted of a Samsung tablet, a sensor chip and an Arduino board.
The sensors had to be placed at a distance from the device to avoid magnetic interference.



The sensor chip sends a constant stream of tilt, rotation and heading Serial values that is interpreted by the Arduino board and sent as ASCII values to the tablet.

The tablet receives the ASCII values through the virtual parallel port of the USB connection and uses them as orientation for the camera.



A very simple 3D space composed of surfaces or walls of different colors

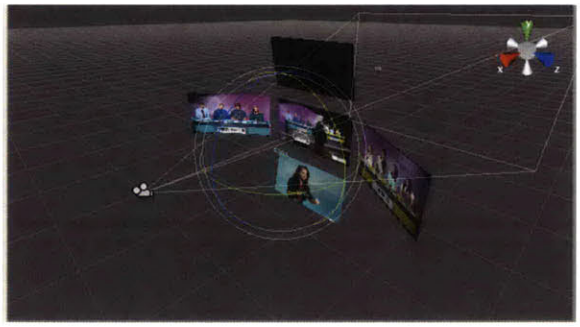
Software

The software development went through three versions during this process. First a low level control of graphics and sensor data. Second we used commercial software that allowed great control over cameras, 3D environments and user interface. The final version was written to exploit the interfacing and networking capabilities of the iPad.

Version 1 – OpenGL & ARToolKit

The first beta versions were made using OpenGL to create a 3D space inside which a camera would be able to look around. The first version consisted of a virtual camera that would rotate on its vertical (Z) axis responding to keyboard input. This way the user could look around a very simple 3D space composed of surfaces or walls of different colors, revealing in which direction the camera was pointing and how accurate the movement was. The thinking was to then have the keyboard input replaced by accelerometers and the flat walls of the 3D space each containing a separate video. Once the accelerometers were working properly and the video was ready, the 3D world was reduced to three planes in front of the camera. In this way I developed the first attempt with center, left and right views.

The system still needed a way to recognize its position with respect to the TV. For this I used the back-facing camera on the Samsung tablet and, with ARToolKit [7] libraries, managed to have the virtual camera always point to the center plane when the device's camera detected a tag. First, I printed a big tag and taped to the TV with the intention of then replacing the printed tag with a tag in the screen, which could have either been an SV designed by me, or the system



Design environment in Unity 3D

could be programmed to recognize the "bug" (logo) of the channel that was currently on. This would not only let the device know where the TV was, but also what channel it was on.

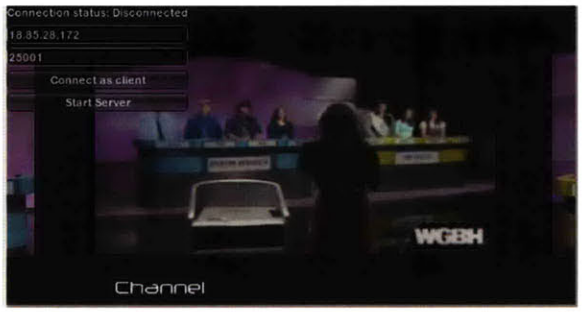
The content was hardcoded in a laptop that would simulate the main TV and also on the device so there was no real streaming of content from a server to the device, but I was leaving this detail to tackle on later versions. Because of the independence between the videos in both devices, there was a little lag between the handheld and the TV. The device had a slower playback, so I had to code a mechanism for starting both systems at the same time so that the videos would sync up, and this sync up had to be done after one minute of continuous playback.

This version had to work directly from the Visual Studio program, as it was in constant debugging.

Version 2 – Unity 3D

For the second version, Unity 3D was chosen as the developing platform. This software is specifically designed for the creation of computer games with the added bonus of making the final game easy to compile for different OS, including mobile devices. We felt it was a good idea since Surround Vision has the same requirements as typical computer game: user input, video, 3D spaces and network connections. This new version in Unity also allowed me to create an interface and a stand-alone application, making it much easier to simply double click an icon on the desktop, choose whether I was opening the file in the main screen or the device and simply lean back and relax.

A downside to using Unity was the lack of ARToolKit. I could not use the toolkit libraries from inside Unity, but Unity did allow me to



Screen capture from the device while running the app.

set up a client-server network and program it so that when the main screen changed channel, the device would also change channel. This meant that even if the device did not know where the TV was physically, at least it would know which channel it was showing.

I found that the difference between the playback rates of the device and the laptop was much bigger than on Version 1. While the laptop only had to show one video at a time, the device has to have at least two videos playing simultaneously, respond to sensor data and listen to the server. In this version, I replaced the synching process of Version 1 with the simple idea that every time the channel changed, the incoming video would start from the beginning, this way the videos would sync up automatically when the channel changed.

Screen capture of the iPad home screen with the SV (Surround Vision) icon.

Version 3 - iPad[19]

The iPad was a good hardware choice, but not the best choice when it came to software. Two main issues were that in the iPad you cannot generate 3D transforms, nor can you display more than one video at a time, both basic necessities of our system. The big break came thanks to the release this year of HTML5, which adds a <video> tag creating browser supported video without having to resort to other programs such as Adobe Flash. HTML5 also allows for 3D transform of images, creating the perspective views needed for Surround Vision. So we could create a framework in HTML5 with an array of video tags that behave as in 3D except that HTML5 does not support accelerator data. To get around this, we had to write an application inside another application. The inside application, written in HTML5 and Java Script, would handle all the graphics and videos. The outside application was written in Objective C and would handle and transmit the sensor data.

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[19] Important to mention and thank Vincent Lee again for writing the code that enabled Surround Vision to work on the iPad.

Having overcome two big hurdles, the problem of no simultaneous video in the iPad was still an obstacle.[20] The second big break came with another long awaited release, this time of HTTP Live Streaming, a comm. Protocol by Apple and aimed for the iPhone software, that would allow streaming by creating small downloadable segments of data and making a playlist to organize them.

At this stage, we brought all these pieces together and used VLC to take a video file, create a UDP stream and host it in a server. This file was taken by HTTP Live, made into smaller chunks and hosted so that the iPad could download and display the video. This worked smoothly except that the videos could not play at the same time; therefore, even if one could pan around and see the frame of another window, a physical click (or touch) had to be done that would stop the currently playing video and start the new video.

When almost resigned to this interface of touching the video and stopping all others, we ran into the "foodcam,"[21] which streams a live video feed from a webcam. It turns out that this live stream is nothing but a very fast changing set of images (MJPGs) and this allows it to play natively in any browser and any device. This resulted in the current iteration, which uses VLC to read a video file from a server and export MJPGs to the browser in the iPad. Since the MJPGs are just images that rapidly change, the iPad allows simultaneous playback and with HTML5, 3D transforms are possible. The result is multiple streams of videos shown simultaneously in one screen with accurate control through the sensors in the hardware.

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[20] Apple understandably did not allow simultaneous video playback so as to not drain the system with so much data to process.

[21] The Foodcam is an intrinsical part of the Media Lab daily life.

Content

The question of what kind of media should be offered through Surround Vision is crucial not only because the system has to be able to prove its adequacy for existing forms of content, but also because the importance and success of Surround Vision might generate new ways in which content is created as well as new ways of telling stories. For content we used initially a custom video that served to prove the concept of the project. We then acquired professionally made footage from different sources.

Screen capture from the device while running the app. with the Ames St. footage.

Custom Video

I used three video cameras to create the original content. Setting up next to a busy street, I placed the cameras in such a way that the field of view of one camera ended roughly where the field of view of the one next to it started, in order to create a continual image once the videos were place together in the system. I chose a street where the camera on the right would be able to see a car approaching in the distance; the car would then be captured passing from right to left by the center camera, and finally be seen heading off in the distance through the left camera. I recorded footage for about three minutes, during which time various cars passed from one side to the other, as well as bicycles and pedestrians.

Once in the system, the main screen would show the footage from the center camera only. By using the device, the user was able to switch from camera to camera, side to side, and see what was going to happen before it occurred on the main screen, effectively giving a sense of having more information about the scene that they would have without the system.

Screen capture of the iPad with the DVD footage.

DVD Features

The feature of choosing different camera angles was somewhat popular some years ago. I tracked down some of those DVDs and used the special feature in order to be able to show different angles at the same time. This made for more interesting action than just passing cars on a quiet street, but it presented the problem that the footage was nowhere near properly suited for Surround Vision. Some angles were difficult to differentiate, as the only difference was that one camera was at a tighter shot than another. Also, the pictures shown by the cameras were not continuous, since this was not a concern of the director at the time. So even if we are presented with action scenes with many things happening at once, the arrangement of the angles around the main screen was somewhat fortuitous, as one camera could be a close up of the action while the other one an aerial view. Given this situation, it was a great exercise to understand the functionality of this system in order to find the best way to distribute all the camera angles around the user. Another setback from this kind of footage is that the multiple angle feature was used to show a behind-the-scenes type of filming, with cuts and repeats and shouts of "Action!" Therefore, it was impossible to try to sync this footage with the final film that you might see in a theater, since that final product is highly edited and pieced together from all the different camera angles. This footage was part of the user study so I'll discuss later the conclusions drawn from it.

TV Broadcasts

WGBH Quiz Show

Once sponsor companies were showing interest, we were able to acquire footage from more specialized sources as well as in settings that were closer to the current workflow when recording a program. The first one of these was WGBH's Quiz Show[22], a game show taped in front of a live audience in which two teams compete against each other in answering general knowledge questions. When visiting the set, I realized that they used four cameras, three that were each dedicated to the host and the teams and a fourth that would pan over the set giving aerial views as well as flythrough views of the audience. Since this is a live show, the final product and the raw footage from the cameras were the same. The raw footage had long breaks while they adjusted the set at different parts of the show, which were of course cut out of the final footage that airs on TV. Aside from that, all the cameras had the same synched footage. So in the end I was able to show the final show as it airs on the main TV, and on the device I placed the cameras showing the teams (one on each side of the TV) and the general panning camera in the center. With this the users could follow the show as they would at home while complementing it with the new camera angles that we offered.

Screen capture of the iPad with the Quiz Show footage.

[22] http://www.wgbh.org/quizshow/

Screen capture of the iPad with the NASCAR footage.

Fox Sports NASCAR

The other professional footage that we were able to use was a NASCAR race given to us by FOX Sports. I was not able to go to the actual race and see the set up but we received an assortment of camera footage from various angles. In the first, the camera followed the race going from the first car to the last and showing the action; we used this footage on the main TV. The other focused more on specific cars, like the two leaders and the cars in third and fourth place, etc. This gives the idea that in the future you could choose whichever car you want to follow, or even just pan through the views of all cars and see details that would have been impossible to catch before. We also got a slow motion camera but at this point we have not yet decided on the best way to use this.

Living room setup where the studies took place.

5. User Studies

The user studies conducted for this project were set up in a space at the Media Lab, arranged to look and feel similar to a living room in which the subjects would be able to feel comfortable while trying out the system. After a short survey aimed at establishing the existing TV-watching preferences of each subject, the subjects would get a briefing about how the system works and operates. Then they were left to themselves to enjoy the programming and use the system. Four different types of programs where shown: a sports event, two action movies and a show taped in front of a live audience (Quiz Show). The users were allowed to change back and forth through any of the shows as they preferred in order to explore the possibilities of Surround Vision in any and all programs. After the session, they were given a questionnaire participated in an interview in order to get more information from the users in a conversation-style setting.

General Questions

We aimed at answering at these general questions, either by direct interviewing or by observation of the user's behavior.

1. Does the interaction force the user to do something different than they would have before? (This can be answered by both observation and questioning)
2. Does it change the user's attitude and engagement?
3. Did using this device affect what the user learned?
4. Does the user get more out of the content with this device than without it? Is it just different, how so?
5. Is there an increased understanding of the material? How so? Of what? (Ex. This could even be as simple as, "Aha—I now know the steps that are taken when the race car driver crashes.")
6. Transfer, i.e. can they apply this new knowledge to somewhere else?
7. Since we are currently in a paradigm shift, how does this system change expectations for future viewing experiences? What do users take away after having no previous experience with this?
8. What did they expect from this experience?
9. How did it meet or fall short of those expectations?
10. What applications could this device be used for?
11. How do they see it being used in the future?

Intro Questionnaire[23]

The Introduction questionnaire was designed to establish general behaviors and trends in the subject's TV-watching habits.

1. Do you enjoy watching TV? For what purpose(s) do you

[23] Appendix A has a sample of this questionnaire completed by a user.

usually watch TV?

2. How often do you watch TV?
3. Where do you watch TV?
4. With whom do you watch TV?
5. What types of shows do you watch?
6. For how long do you watch TV?
7. What else do you do, if anything, while watching TV?
8. Do you own a Smart Phone?
9. If YES, do you use it to? (Check all that apply)
    a. Navigate the Web
    b. Watch videos (as in YouTube)
    c. Watch shows or movies (as in Hulu)

Observation

While the user is engaged with the system, these are some of the things that we were on the lookout for:

1. Are they focusing mostly on one or the other screen or switching from one to the other.
2. Are they distracted?
3. How do the users grab / hold the handheld?
4. Do they look comfortable, tired, confused?
5. When not directly looking at the device, how do they hold it? (stretched arms, rest in lap) What angle?

Exit Questionnaire[24]

The exit questionnaire was designed to be used both as a direct questioning tool as well as a guide for the interviewer to touch upon

[24] Appendix B has a sample of this questionnaire completed by a user.

each detail of interest when conducting the informal Q&A session at the end.

General experience with the system

1. What did you think about the experience?
2. How did you interact with the device? How is this different than watching normally?
3. How were you using the handheld?
4. How did you physically watch differently? Sit differently?
5. Were any of the programs compelling without SV? With SV? Because of SV? More than others? How? Why?

About each of the sample footage

Sports[25]

1. Was the system rightly suited for this type of footage?
2. Was the footage rightly suited for this type of system?
3. Did you find the peripheral content relevant?
4. Do you think your experience changed because of the system? (If so, for better or for worse?)
5. Did you see something that you would have missed without SV?

Concluding comments

1. How would you use this system differently?
2. How could I make this better?
3. What additional things could be included with this device to make it something you would use frequently, or would use to enhance the experience, etc. (For example, lenses or filters to alter the footage...)

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[25] These same questions were asked for all other footage so they will not be transcribed in this document.

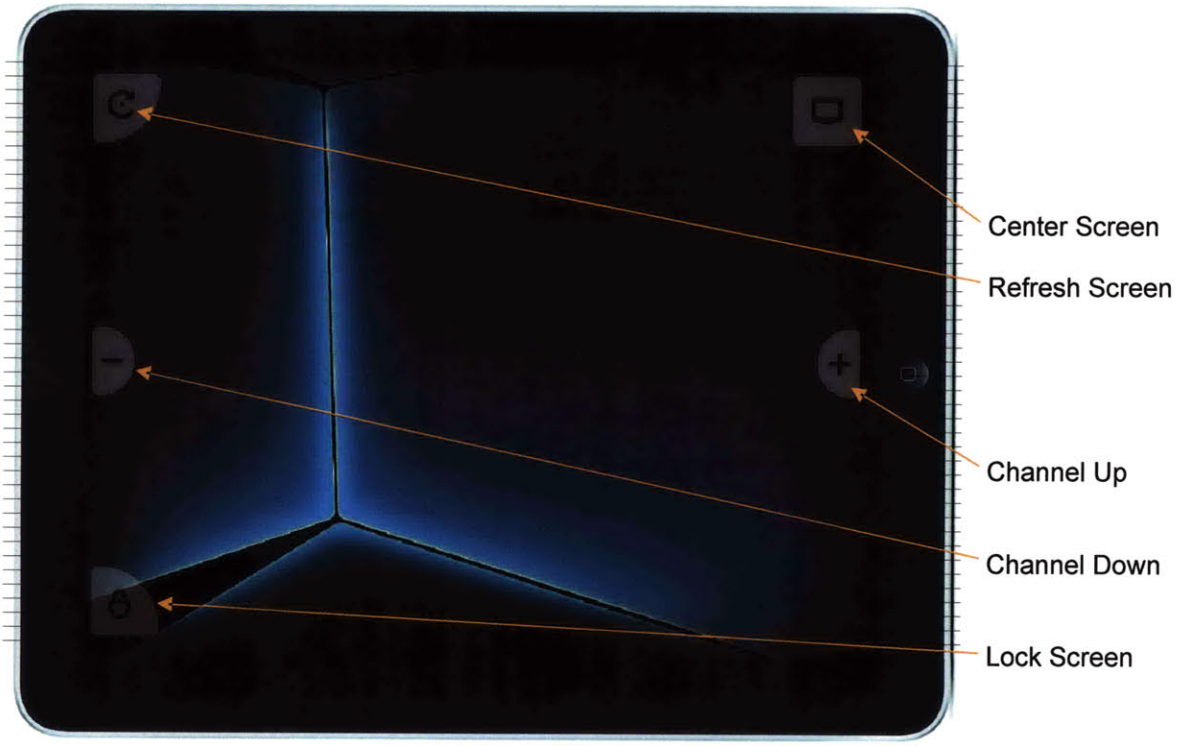
4. What would you watch if you had the ability to do this at home?
5. What else can you do with Surround Vision?
6. How often would you use this?
7. Where would you use this?
8. Where could you see this being used?
9. For what content do you think this would be good?
10. What would you do if you were at home and saw that the program you were watching was SV enabled?
11. What device would you prefer SV to be built on?

User Testing Conclusions

User testing revealed interesting insights in different aspects of Surround Vision like usability, interface, content and overall intention of the system. Here I will present the general comments common amongst most users, their specific suggestions and my own observations.

From the entry questionnaire, it was clear that, for this age range (18 to 29), people do watch TV during their weekly lives but it is rarely the main activity; users would be eating, working, studying or even ironing clothes and sleeping while watching TV. Many of the comments made were about having to move so much to access the content, some would rather have a scrolling interface so the device could be kept still as a second screen.

After they answered the intro questionnaire, the subjects were given a brief explanation of how the system works and left to use it at their convenience. The first surprise was how differently the footage was received by the users depending on the order in which it was presented, and how this affected the overall experience.



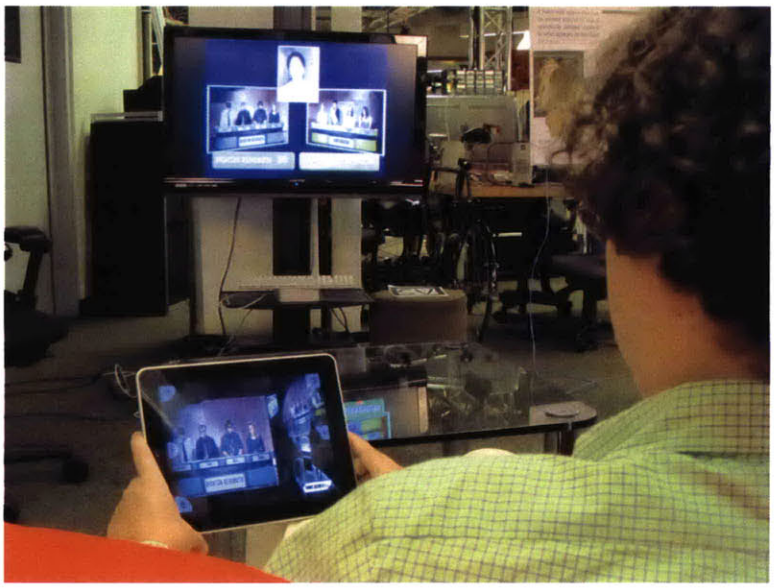
This screen was used to explain the controls and general usability to the users.

Testers Comments

General

The first video that the users' saw with Surround Vision was the action movie. Since this video is a behind the scenes compilation of a scene, it has many fast cuts and cameras that are not in a correct spatial relation to the user, therefore the testers expressed difficulty in understanding what they were looking at, or from what angle they were seeing it. Once the channel was changed to the live show, it was easier for all testers to understand their position in relation to the set and the experience became much more enjoyable.

For a second cohort of testers I allowed them look at the TV footage first so as to understand what they were about to see and then watch it again with the iPad in their hands. It turns out that this familiarity helped in the understanding of the camera angles and the new information to be found in the peripheral content. For this group of users the action movie was more interesting than for the first group and for some even more enjoyable than the live show. Because they had previously seen part of the footage, comparing their experiences with and without Surround Vision was easier, as the revealed footage became more relevant to them.



Both groups expressed difficulty when shifting their eyes back and forth between the screens; some were simply worried that they missed something, while others experienced dizziness when having to change the focal plane rapidly between the screens. Finally, many praised the concept but recognized that their TV watching is more for relaxing that for being active, so a way to keep the idea but change the interface was coming up repeatedly. Nonetheless, it was expressed that, with the right content, like something more

compelling or of personal interest, the ability to move and stand and explore might greatly enhance their experience.

Usability

Once past the initial phase of getting used to the system and the different videos, it was easier to inquire about the actual operation and general usability of the system. Users offered the following suggestions that refer more specifically to aspects of the system and suggestions to the interface:

Zoom. Almost all users mentioned how they would want to have zooming capabilities, either by pinching the screen or moving the device away or towards the body. Zoom in this case was a common term for two different interactions. Most common was how users wanted to get closer to the action in any one of the peripheral screens. This way the main screen would show some video and the secondary screen would be like a magnifying glass or a pair of binoculars getting closer to the action. This is "Video Zoom". The other type of zoom is "System Zoom," a navigation feature in which the virtual camera would drop back revealing all the peripheral windows at the same time. This way, a quick glance would let you choose the most interesting of the cameras at that moment quickly zoom back in centering on that camera. This would improve the usability and reduce the need to actively explore all the cameras.

Control. Some users wanted some control over the playback, like the ability to fast-forward, rewind, pause, etc. This might be because some users felt that going back and forth made them miss some of the action. I have to argue that if the user has the ability to

disrupt the playback flow, the synchronicity between the hand held and the main screen would be lost. Without the synchronized content, the Surround Vision project loses one of the main features, which is the feeling of an existing world that extends past the frames of the television.

Choice. Many of the users insisted on wanting the ability to manually scroll through the different angles without moving their body. I have always understood this to be a big issue with Surround Vision and I believe that it is a matter of who the user is and what their intention in front of the TV might be. If the program being watched has a simple story line and the viewer has all the information come from main screen, then all they might want to do is set Surround Vision to a specific angle and use it as an auxiliary screen. If the program comes with some hidden information, then a more exploratory attitude could be adopted. These are the scenarios that we will test in the future by including games and activities in the programming. I even saw the users standing up and turning to all sides because they find the system more interesting than the video, and wanted to explore how far and wide went.

Navigation. The idea of a small icon that would show what camera was being seen with reference to the main action was put forth. This would help the spatial understanding of the scene. For instance, if one was watching a boxing event all cameras would be around the ring and the user could understand where the camera he or she was seeing was with relation to the action.

Menus. To give the choice of which camera to watch through, Cam1, Cam2, Cam3, and so on was suggested. This is interesting because it could be a menu that would place the chosen camera in the center without the need to move around. When a camera was chosen we could give cues with arrows or some graphical device to show where the user should turn to see the desired camera. The

menus could also give the choice of what in particular to focus on. This was one of the most compelling ideas I heard. Someone could be interested in how the cameras are rigged or the lighting in the set was placed, so the system would suggest and orient the user towards views that would show a specific feature of the content.

Sound. Some users wanted the sound of all the screens. We have thought of this, sound can be a great way to attract the user's attention to what may be happening in other screens. With sound, the curious user will be interested in exploring his or her surroundings. We recognize the value this but we have not come up with a satisfying plan on how to do this, since the result is a big mix of sounds from various screens.

My observations

I kept an eye on testers' reactions and general behavior as they were using the device, in order to catch certain reactions that were done unconsciously and therefore not mentioned in the questionnaires.

The learning curve is steeper than I had imagined. When using a handheld device, users are accustomed to tilting and turning the device but not their whole body. Moving the action from their wrists to their shoulders and upper body proved confusing. Even when the idea was understood, the device would be turned to the point of almost being perpendicular to the user before they would adjust their body and turn a few degrees from the waist.

Because of this confusion, the user seemed uncomfortable and confused, twisting their necks trying to adapt to the hand held screen instead of moving the screen around their body.

A second point was how the attention is kept mostly on the new device. Users are not used to changing their focus of attention when watching TV and the handheld, being the most novel

experience, was getting most of the attention. This might change once the novel aspect of the system wears off and the content becomes more appropriate.

Also noticeable was the level of engagement the subjects had while using Surround Vision and how it became comfortable after using it for a little while. Quickly after getting used to it, the users would find something to focus on and explore.

General Conclusions

It was encouraging to watch the level of engagement of the users. In the live show footage the users would play a guessing game when a question was asked, to either try to catch the answering team to see them up close or to go to the non-answering team just to see their reactions.

A good way to note the excitement of the users was their enthusiastic suggestions of other occasions where they would want to use Surround Vision.

Any Sports, Golf, Baseball, Hockey they were all mentioned, there was a clearly identifiable benefit to watching these live action events with the aid of an extra screen that could be placed around them while still concentrating on the main action.

Discovery channel type programming was suggested, where you could look around the space being showed, inside a building or an old battleship. This conversation led to virtual tours of buildings and how this could be a show in itself where the filming crew takes video of beautiful buildings around the world with 360 degree cameras so the viewer can use Surround Vision to explore all around.

Many testers where intrigued by the live show video and suggested any show including debates or interviews to be able to watch the "unseen" expressions of the participants.

Many users were excited to suggest scenarios that would completely forget the TV connection or even the living room experience, some ideas were walking down a street and seeing through Surround Vision the state of that same street 100 years ago, or actually being at a live sports event but still being able to control zoom and viewing angles with a handheld device.

6. Future Work

The future for this type of innovation that involves mass distribution and not a small amount of economical backing is always tied either to the consumer or the corporate side. Sometimes an innovation is so compelling that it slowly gets adopted by a massive amount of users until big companies notice. Other times, companies invest from the get go in technology and distribution that such a massive push will make the innovation know by the general public an accepted. For Surround vision, I feel I can try to create some interest in both areas. In order to deploy a new TV-watching experience, we need to reach as many people as possible. This means that we need to extend Surround Vision's capabilities into different devices, operating systems, hardware configurations and user interface designs in order to reach a larger audience. At the same time, working with sponsors on more specific project will make it more attractive to other companies who might take an interest in this system.

Hardware

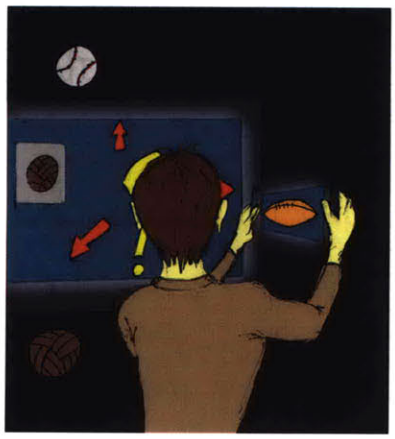
We plan to extend Surround Vision into many other devices. As long as the sensors are in place, Surround Vision should work. It might be interesting to look at the different configurations and study a way for Surround Vision to work with what the device has to offer. If one particular device doesn't come with a gyro but does have a back-facing camera, then I could use computer vision techniques to sense the lateral movement that the gyro would have sensed.

I am very interested in exploring the possibility of creating a device that is made with Surround Vision as its main purpose, this way a toy for children could be created and would go hand in hand with special programming for them to explore around their rooms and be active while watching TV. Also this would give me absolute freedom to play with the form factor. For example, the device could resemble some binoculars, a magnifying glass, a rifle for first person shooter games; it could go in your wrist, on your shoulder or be some cool goggles. Getting away from the cell phone might make things more difficult but certainly more exciting.

Viewer watching the main plot unfold while also keeping an eye on a different character.

Content

Understanding why a user would want to actually avert his or her attention from the main screen to the secondary handheld screen is one of the most important issues for the project. Current TV viewing is premised on the artful stream of images and sequences created by the editor/director. In order for directors/editors to work with Surround Vision, we need to demonstrate principles and conventions for content development that lead to compelling interactions on the part of ordinary viewers.



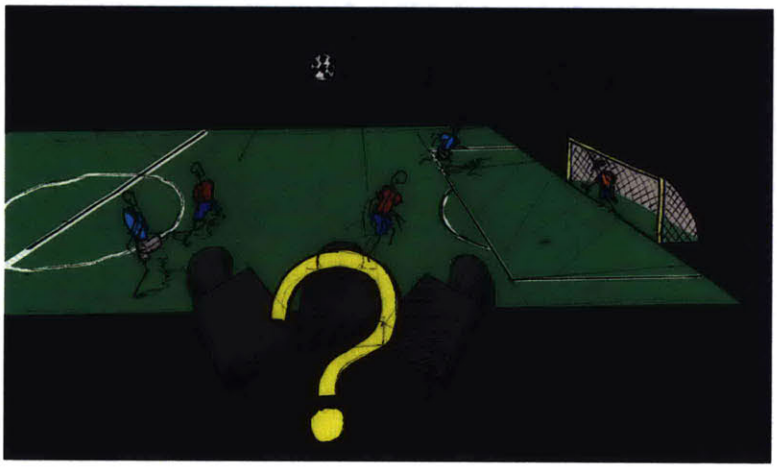
Viewer trying to find a clue that matches the one on screen, amongst several hidden around the TV set.

Some scenarios that have been discussed that will compel the user to search the peripheral content are:

Story: A new style of storytelling might suggests that different groups of viewers keep watch on different characters or story lines that pass in and out of the main frame, this way a story that might seem fragmented can be put together through later conversation by the viewers.

Activities: Information can be hidden outside the frames for the viewer to find and complete tasks towards a goal. Educational programs for children can hide clues and different objects that the children may have to identify among similar objects. These activities also include the exploration that has been discussed in several parts of this document. With the aid of a graphical interface, the system could behave as zoom glasses, or special filter scopes to reveal fingerprints or stains that will help resolve a murder.

Sports: The example given for the user studies was a very basic way of experiencing sports with Surround Vision. We want to go much further and have other kinds of sports. In group sports, like American football, the action takes place simultaneously in different places within the playing field. With this system, the user could follow all the action by having the main camera angle in the main screen and secondary events on the handheld device.



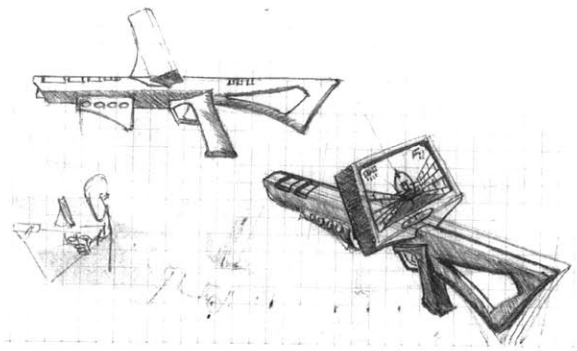
Many cameras to choose from when watching a live sporting event from home.

Behind-the-Scenes: By moving the device around the room the viewer could witness the context in which the content was created.

The set, lighting, sound technicians and director could come into view as they work on the content being displayed at that moment.

Social Interaction: Two users who each have this system could interact by using it to look to the sides and see each other while they are each in their own houses. This will create a telepresence that, even though is not tied to the content on the main screen, may prove to be an interesting area to think about.

Audio: Given that users are familiar with the Surround Sound effect and understand the spatial cues that audio provides, Surround Vision will take advantage of this by showing the images that correspond to the sounds that are at one point outside the screen's boundaries. To enhance this effect, I intend to have a sound channel on the device that should also change with the position of the device in order to give the local sound corresponding to the view on the second screen.



Concept Sketch of a control for First Person Shooter type of games

Gaming: First person shooter games would be well-suited for Surround Vision. The main screen can show a shared view, for example the map of the space being explored with the markers of where each player is. In turn, the handheld device will show the forward view of each player so the player will have to turn his or her body in order to be aware of the immediate surroundings, bringing a level of realism to the game.

Logistics

This project deals with the TV-watching experience so it naturally has to involve TV producing and broadcasting companies, as well as those who create content, like directors, editors and writers. One of the main objectives from the start was to create a system that would enter the environment with as few ripples as possible. Some

of the ways in which we want to accomplish this is by using devices that are capable of handling most of the computation, including receiving all the additional content, through a network connection. This way we avoid changing anything on the main TV system. In addition, since we do not change the broadcast that goes to the TV, the broadcasting company will not have to alter the established mode of transmitting the content. What we propose is a secondary channel of lower definition that will carry all the additional content and send it to a server to which the devices will connect, synchronize and download.

A harder question comes when thinking about capturing the content. Personally, I would like to see how directors change the way of setting up and telling a story, when they take advantage of the possibilities that Surround Vision allows. Many stories have secondary and even tertiary plots; in Surround Vision these could be more extensively developed.

7. Conclusions

The aim of this project was to create a new experience for watching television, an experience that would give the option of having a more active attitude towards watching, would provide opportunities to expand the story form, and encourage a merging of shared and personal experiences. During the development process a watchful eye was kept on the various players and technologies that are important in television today in order to propose an idea that did not increase cost or logistic complexity. In the process we managed to create prototypes with off-the-shelf parts and homemade videos that successfully proved the concept and conveyed the major ideas. This was the initial spark that got companies such as WGBH and Fox Sports interested enough to want to participate in some way. A final prototype was made that responds accurately to sensor data, allows an initial level of user interfacing, and receives a constant video stream that is synchronized with the stream that is received by the main television set. The latest version was possible

by developing an application style system that deployed in an iPad, with professionally-shot footage of real TV programs. This allowed us to set up a user study that has given us insights and clear direction for the future of the project. Finally, in order for these thesis ideas to move forward (and someday find their way into everyone's living room) we need to insure the creation of more specific content that takes advantage of Surround Vision.

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9. Appendices

Appendix A - Entry Questionnaire

Date: 3 Aug '10 Session: 2 Subject: 1

Surround Vision Introductory Questionnaire and interview guide for all participants.

1. Do you enjoy watching TV? For what purpose(s) do you usually watch TV?
   - I don't watch tv very often
   - Entertainment, information
2. How often do you watch TV?
   - Twice or week
3. Where do you watch TV?
   - Home
4. With whom do you watch TV?
   - By myself
5. What types of shows do you watch?
   - Documentaries
   - Comedy
   - Movies
   - News
6. For how long do you watch TV?
   - One hour
7. What else do you do, if anything, while watching TV?
   - Eat, iron clothes, check email
8. Do you own a Smart Phone?
   - No, I've a B Berry
9. If YES, do you use it to? (Check all that apply)
   a. Navigate the Web
   b. Watch videos (as in YouTube)
   c. Watch shows or movies (as in Hulu)

Appendix B - Exit Questionnaire

Date: 4 Aug '10 Session: 1 Subject: 1

General experience with the system

What did you think about the experience?

A lot of fun.
would have been better to have full screen on the side screens

How did you interact with the device? How is this different than watching normally?

To be honest I prefer the large screen with editorial camera choice but I think if the screen quality on ipad is improved it will be a great experience

How were you using the handheld?

scrolling to different views

How did you physically watch differently? Sit differently?

I was more engaged - tried to figure out which camera angle was which - sat upright

Were any of the programs compelling without SV? With SV? Because of SV? More than others? How? Why?

Not sure. With quiz show it was cumbersome to scroll between when you didn't know where the action was happening

About each of the sample footage.

Sports (Nascar)

Was the system rightly suited for this type of footage?

yes - but would be helpful to have more info on what the camera angles are.

Was the footage rightly suited for this type of system?

Did you find the peripheral content relevant?

yes- but I didn't like the distortion effect

Do you think your experience changed because of the system? (For better, worse)

yes. but again, if I'd known which camera angle was which I could have more actively (rather than randomly scrolled between them)

Did you see something that you would have missed without SV?

Live Show (Quiz Show)

Was the system rightly suited for this type of footage?

Sort of - would be nice to default to where the action is

Was the footage rightly suited for this type of system?

Did you find the peripheral content relevant?

less so - only care about team answering the question.

Do you think your experience changed because of the system? (For better, worse)

camera angles made sense here.

Did you see something that you would have missed without SV?

No.

Action Movie (Bond)

Was the system rightly suited for this type of footage?

Not really – Movies are good because the director chooses the most compelling cuts.

Was the footage rightly suited for this type of system?

Did you find the peripheral content relevant?

No - camera angles were not capturing very different content

Do you think your experience changed because of the system? (For better, worse)

For the worse - distracting

Did you see something that you would have missed without SV?

no

About the Social Expereince

Did you know the other person? Yes No

Did you interact with the other person? About what?

Was the other person's experience different from your own?

Do you feel you witnessed something through your system that the other person might have missed?

For what content do you think this would be good?

sports, documentaries, news

What would you do if you were at home and saw that the program you were watching was SV enabled?

What device would you prefer SV to be built on?

I liked the ipad. good size.

Appendix C – Samsung Tablet Specs

Samsung Tablet Q1U-XP[26]		
Operation System	Operating System	Genuine Microsoft® Windows® XP Tablet Edition
Main Chipset	Main Chipset	Intel® GMA950
Memory	System Memory	1GB DDR2 400MHz
Display	LCD	7" WSVGA Touch Screen LCD, 1024 x 600 resolution, LED Backlit - 300 nits Brightness
Graphic	Graphic Memory	128MB Shared Memory
Multimedia	Sound	HD Audio
	Speaker	Two Stereo Speakers (1.5W)
	Integrated Camera	Front Facing Video Chat (300P), Rear Facing Video/Still (1.3MP)
Storage	HDD	60 GB, 1.8", 4200 RPM
Dimensions	Dimension (W x D x H)	8.96" x 4.88" x 0.93"
	Weight	1.52 lbs.

[26] From Samsung website. <http://www.samsung.com/us/consumer/office/mobile-computing/ultra-mobile-pcs/NP-Q1U/000/SEA/index.idx?pagetype=prd_detail&tab=spec>

Appendix D – e-Compass Specs[27]

Characteristics	Conditions*	Min	Typ	Max	Units
Power Supply					
Supply Voltage	VDD Referenced to GND	2.7	3.3	3.6	Volts
Current	All VDD pins connected together				
	Run Mode (10Hz Output)	3.5	4.5	5.5	mA
	Standby Mode			1.0	mA
	Sleep mode		10		µA
	Power-up peak (VDD = 3.3V)		8		mA
Power-on Rate	Minimum rise time for POR	0.05	-	-	V/msec
Compass Function					
Field Range	total applied magnetic field (de-gauss if exposed to >5gauss)		±1	±2	gauss
Heading Accuracy	At Level, +3.3V	1.0	2.0	3.0	deg RMS
	±15° tilt		3.0		
	±60° tilt		4.0		
Heading Resolution	Output Data		0.1		degrees
Heading Repeatability	Output Data (1σ)		±0.3		degrees
Heading Hysteresis	Output Data (1σ)		±0.3		degrees
Update Rate	Run Mode (1, 5, 10Hz)	1	5	10	Hz
Tilt Range	From Horizontal		±80		degrees
Tilt Accuracy	0° to ±15°, +3.3V		±1		degrees
	±15° to ±60°		±2		
Tilt Resolution	Output Data		0.1		degrees
Tilt Repeatability	Output Data (1σ)		±0.2		degrees

[27] From Honeywell website. <http://www51.honeywell.com/honeywell/>

Appendix E – Arduino board Specs

Arduino Duemilanove[28]	
Microcontroller	ATmega168
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limits)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
Analog Input Pins	6
DC Current per I/O Pin	40 mA DC
Current for 3.3V Pin	50 mA
Flash Memory	16 KB (ATmega168) or 32 KB (ATmega328) of which 2 KB used by bootloader
SRAM	1 KB (ATmega168) or 2 KB (ATmega328)
EEPROM	512 bytes (ATmega168) or 1 KB (ATmega328)
Clock Speed	16 MHz

[28] From the Arduino Website.
<http://arduino.cc/en/Main/ArduinoBoardDuemilanove>