

INTERACTIVE STEREOSCOPIIC INSTALLATION:
A PHOTOGRAPHIC COLLAGE

A Thesis

by

SHYAM KANNAPURAKKARAN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2010

Major Subject: Visualization Sciences

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Approved by:

Chair of Committee,	Karen Hillier
Committee Members,	Carol LaFayette
	Jeff Morris
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ABSTRACT

Interactive Stereoscopic Installation:

A Photographic Collage. (August 2010)

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Chair of Advisory Committee: Prof. Karen Hillier

The research involves the creation of an interactive installation showcasing the dynamic nature of human visual observation of a still photograph. Using an eye tracker as an input device, the data collected is used to create a photographic collage in stereoscopic 3D. The installation is artistically inspired by selected photographic works of artists David Hockney, Maurizio Galimberti, Joyce Neimanas and Cubist painters especially Picasso. One of the key factors in their work that is adapted in this research, is the representation of the way eyes search points of interest demonstrated in what they painted/photographed. The installation will demonstrate an *expressive representation* of the viewers' experience of looking at a photograph. This will be achieved by applying certain manipulations of the photograph based on the input obtained from the viewer using an eye tracker. The eye tracker collects information about the location and number of instances of where the viewer is when observing a photograph. This is fed into software that processes the data and determines the location and the size of the area of the photograph and amount of the manipulation to be applied to that area. These two constitute the artistic rules that are used to create the end product the photo collage. The individual pieces of the collage will be arranged in a virtual 3D model by the artist and will be projected in stereoscopic 3D. The development of this installation progressed through multiple case studies and optimization based on ease of use, cost and availability of resources. This process is intended to be a framework for artists working in interactive visual media.

DEDICATION

To The One

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NOMENCLATURE

3D	Three-Dimensional
ABS	Acrylonitrile Butadiene Styrene
ALS	Amyotrophic Lateral Scierosis
CMOS	Complementary Metal Oxide Semiconductor
CPU	Central Processing Unit
DIY	Do It Yourself
FAT	Free Art and Technology
GB	Giga Bytes
GPU	Graphics Processing Unit
HDR	High Dynamic Range
IEEE	Institute of Electrical and Electronics Engineers
IR	Infrared
LAN	Local Area Network
LED	Light-Emitting Diode
MSP	Max Signal Processing/ Miller S. Puckette
OpenCV	Open Computer Vision
OpenGL	Open Graphics Library
PCB	Printed Circuit Board
RAM	Random Access Memory
SIGGRAPH	Special Interest Group on GRAPHics and Interactive Techniques
TAMU	Texas A&M University
USB	Universal Serial Bus
USD	United States Dollar
VRAM	Video Random Access Memory

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CHAPTER I

INTRODUCTION

The mechanism of human visual perception has played a key role in the field of visual communication. It is heavily used in the field of art, entertainment, marketing and other visual media. To some degree, they all base their creative output on the very basis of how and where the attention of the viewer travels. According to Rudolf Arnheim in his book, *Art and Visual Perception - A psychology of the creative eye*, every act of seeing is a visual judgment. Visual judgments are immediate and indispensable ingredients of the act of seeing [1]. Human vision is selective, it scans, skips, and pauses. According to Alan Woods in the section ‘*Photo Collage*’ in the book *David Hockney*, human vision can neither be totally identified with nor separated totally from the consciousness it serves [2]. Human visual perception is not just about identifying patterns but a dynamic search for the best interpretation of the available data [3]. The observations of the eye are not only geographical. In his book *Design and Composition* Nathan Goldstein talks about visual balance.

“Any visual work like painting, drawing or a photograph done on a flat and bounded surface has a visual balance. Each element of the work including masses of color and shapes, possesses a visual weight, with a degree of eye appeal, based on the element’s relationship with the surrounding ones. The visual weight causes our eyes to move in a direction of a differing or otherwise attracting feature in a work” [4].

The journal model is *IEEE Visualization and Computer Graphics*.

A. Artistic Intent

To demonstrate the dynamic nature of human visual observation of a still photograph, I propose to create an interactive, immersive, and customizable virtual 3D photographic collage-based installation. The act of observation is captured with an unobtrusive user interface. The data collected is used to create a personalized statement of the viewer's visual experience. The instances resulting from the interactivity will be captured in real time and played back as a projected stereoscopic sequence or presented to the viewer as source images.

B. Goals

The primary goal of this thesis is to create an interactive installation representing the dynamic nature of human visual observation, processed and re-presented in stereoscopic 3D. Only a visual stimulus is used as opposed to a real life situation where one could interact with the surrounding environment and people. The viewer will look at a still photograph randomly selected from an image bank. The eye tracker unit then acquires the gaze and fixation information. This is used as the basis for creating artistic rules for the generation and arrangement of the individual pieces of the photo collage. The artistic rules include the selection of the area to be manipulated, type of manipulation to be applied, and the arrangement of the manipulated images on planes arranged in a virtual 3D space. Unlike the photographic collage works of David Hockney and other contemporary artists using photographic collage medium, the final result is not completely based on pure artistic intuition but also on the feedback of the viewer by his/her act of observing the still photograph. The newly formed photographic collage will be projected in stereoscopic 3D. These results can be used to create more collages by taking the eye tracking data from the same

viewer or multiple viewers by recording each instance of the processed photograph.

C. Personal Motivation

My interest in creating an interactive installation stems from the experience at Viz-a-gogo (annual showcase of Texas A&M VizLab student work) and my fascination for immersive visual media. Helping to organize and set-up an installation for the annual event, I realized how I could use my interest in photography and technical knowledge to create a photographically based installation. I also realized the potential of how an installation could be used as a tool for creating art by studying the works of artists like David Hockney, Joyce Neimanas, and Maurizio Galimberti. After discussing with Prof. Karen Hillier regarding the various routes, I selected the artistic approach of David Hockney as a means to begin examining the photographic collage. Also attendance at SIGGRAPH '08 gave me a hands on experience of eye tracking and its potential to harness the dynamic nature of human visual perception. I decided to use it as a tool to help generate a photographic collage based on the viewers' interactions with still photographs. Additionally stereoscopy adds the immersive component to the final result.

CHAPTER II

STATE OF THE ART

Innovations in understanding the mechanism of human observation and visual perception are found within various disciplines including but not limited to visual communication, scientific research, way finding, public safety, and art. Relevant previous work for this research exists in case studies that can be classified into two main categories: artistic and technical. The study involves exploring selected works of visual artists Picasso, David Hockney, Maurizio Galimberti, and Joyce Neimanas as well as selected work of musicians who use interactive technologies. These photographers/artists used either single or mixed media to exhibit the dynamic nature of human visual observation, by the use of exploding the image and artistically manipulating various areas of interest, level of detail, and composition of the image.

A. Cubism

Cubism is considered by many art critics to be the most revolutionary of the modern art movements. Cubism had its origins in the early nineteenth century and was pioneered by Pablo Picasso and Georges Braque. It constituted the greatest upheaval in art since the Renaissance [5]. The key characteristic of Cubism was that the artist was no longer obligated to depict objects in a realistic manner but was also influenced by his mental conception of them. Traditional perspective was abandoned and objects were splayed out to show them from several viewpoints in the same canvas with only a few defining details. Because of this Cubist paintings imply the passage of time. Greater freedom was allowed than before in manipulating the subject matter to unify the composition; the elements in a picture might be chosen and placed purely according to the aesthetic considerations rather than being firmly based in reality [5].

The Cubist paintings were representations of the artists' act of observation of the subject during the time he/she spent with the subject (Figure 1) [6].



Fig. 1. Road at L'Estaque. 1908. Oil on Canvas, Georges Braque

The introduction in 1912, of new materials to the canvas by the painters such as newspaper, wall paper, wood, and metal confirmed the autonomy of the work of art by emphasizing its quality as an object. It also added to the Cubist exploration of the possible means of representation: pieces of paper or other objects could serve the same signifying function as paint (Figure 2) [7]. This resulted in disparate often abstract elements being brought together in a collage to create objects [5]. Cubism influenced a vast array of modern visual culture including film, architecture, sculpture, photography, and graphic and industrial design. It also influenced Futurism, which began in Italy. The significant characteristics of Cubism that I gained towards my

research are the explosion of the image and the element of time.



Fig. 2. Guitar. 1912-13. Sheet Metal and Wire. Pablo Picasso

B. David Hockney

The artistic inspiration for the project comes mainly from selected works of painter/photographer David Hockney. David Hockney started making photo collages in early 1982. The initial works were on Polaroid SX-70 film arranged edge to edge with borders uncut. Later he started using border less machine-made prints from 35 mm film (Figure 3) [8]. In his article *'Mapping and Representing'* in the book *David Hockney*, Andrew Causey mentions Hockney's motivation behind the photo collages. According to Hockney the motivation behind his collages was the incompleteness that he found in traditional photography. He believed that a still photograph does not show



Fig. 3. Une Promenade, Place Furstenberg, Paris. August 1985, Photographic Collage, David Hockney

the element of time. Unlike a painting, which takes time to make, and the marks are an accumulation of decisions over time, a photograph is an image that captures one moment of time; made all at once. His second criticism was photography is influenced by the camera's eye; we always feel that we are looking through a window. This, according to Hockney resulted in a disassociation between what is seen and the viewer. His goal was not just to get closer but be a part of what is being photographed. In his photo collages he took pictures by moving the camera until he had marked out and recorded an area of real space. In this exercise he may or may not have moved himself or changed the position of the subject. In either case the passing of time was registered, and there was a relationship between the time and the rectangular area that the images marked out [9].

The influence of the cubist system of analysis was evident in Hockney's photo collages, in the sense that they were all representative of his observation of the subject

and the surroundings during the time he spent with the subject, rather than the actual form of the subject (Figure 4) [10] [11].

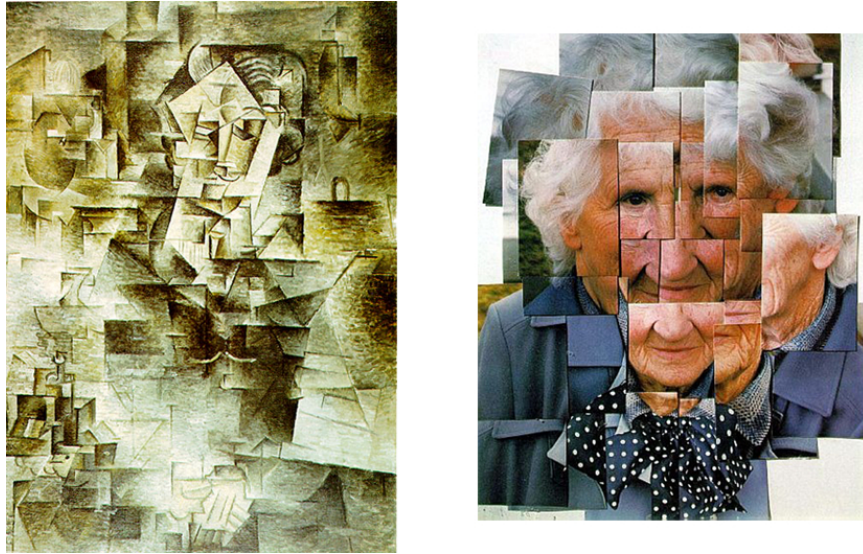


Fig. 4. Left: Portrait of Daniel-Henry Kahnweiler, Paris, Autumn 1910 Oil on Canvas, Picasso, Right: Portrait of the Artist's Mother, 1985 Photographic Collage, David Hockney

Hockney's initial work in Cubism starts with the '*Cubistic Studies, Paris*' drawn after Picasso sculptures in 1973. In the issue of *Art and Design* on David Hockney, the editor describes David Hockney, as the first major contemporary artist to reassess the significance of Picasso's aesthetic innovations. Hockney rejected the historical view that Cubism led to abstraction and used the liberating influence of Cubism as a major inspiration for his work in the 1970s [12]. Hockney's reinterpretation of Cubism combined with the 1980 Picasso retrospective resulted in the composite photo collages on which he began to work in 1982. It was an attempt to depict the passage of time in a moving subject, or his movement around a static subject [13].

Hockney used the Cubist system of analysis in his photo collages to show different

viewpoints of his subjects, which included people, objects and places, and also various ways to indicate movement of the subject in space. In his Polaroid photo collages Hockney used the white border as a grid to layout his composition. In order to achieve this he positions himself at a particular distance from the subject and painstakingly moves the camera horizontally and vertically at small distances so that each image has a segment of the whole. These photographs, sometimes numbering up to 150 were sometimes correctly positioned so that the composition lines flowed to give a realistic depiction of the subject or shifted enough to exaggerate or duplicate a particular part of the subject (Figure 5) [14]. In other compositions he moved around the subject giving it shape and fluidity while maintaining the grid for his composition [15].



Fig. 5. Henry Moore Much Hadham 23rd July 1982, Photographic Collage, David Hockney

With the use of a 35 mm camera and borderless machine made prints Hockney dispensed the use of a geometric grid. This gave him more freedom in the composition. Most of his collages had his feet as a starting point. This was like an announcement of the subjective nature of the image as seen by the photographer and allowed him not just to get closer to what is being photographed but also be a part of it, one of the aspects that he believed traditional photography lacked. With the removal of the geometric grid he could arrange the pictures edge to edge or overlapping each other and with varying number of pictures as required to show desired detail. He had more



Fig. 6. Left: Telephone Pole. 1982, Photographic Collage, David Hockney, Right: Chair, Photographic Collage

freedom in exaggeration or duplicating his subject, which resulted in a varying range of look and feel to the final composition. He played with perspective, sometimes like the Cubist painters totally disregarding traditional perspective or in Hockney's case reversing it. He uses the camera's ability to move from a distant shot to a close-up

to create a perspective in which the farther objects appear nearer to the viewer and the nearer ones appear farther [15](Figure 6) [16] [17].

Another important aspect depicted in his collages was the passage of time. He wanted his collages to represent an experience rather than a moment frozen in time like in traditional photography. In a way he was trying to portray the way he saw the subject in front of him through his photo collages. The level of detail size and position and orientation of a particular detail was dependent of whether or not he was attracted to it (Figure 7) [18]. Hockney's collages started taking more organic shapes as his work progressed. The shape was the result of the visual experience rather than any aesthetic rules of composition. The research uses Hockney's style of representing the visual experience of the subject and the element of time.



Fig. 7. Photographing Annie Leibovitz While She is Photographing Me, 1982, Photographic Collage, David Hockney

C. Joyce Neimanas

Sarah J. Moore in her exhibition catalog of Joyce Neimanas's work at the Center for Creative Photography at the University of Arizona describes her work as follows. Joyce Neimanas is well known for her work in mixed media. She is an artist who works on several ideas at a time freely drawing her imagery from various sources. Her approach towards the surface of the photograph is radical, rejecting the notion of media purity, her work has taken many forms like using negatives she did not make herself, manipulating the surface extensively, and making elaborate collages of SX-70 prints. Instead of treating the photograph as a precious object, she uses it as a tool to explore the larger questions of representation, reality, and personal expression through media [19].

In 1980 Neimanas began working extensively with the Polaroid SX-70 format. Her artistic style of combining mixed media was extended to the modern picture-making technology. With its reputation to capture reality "*in a second*" Neimanas made the most direct statements on how unreal photographs can be. Her initial examinations with the new process was to question the scale and relationship of the white border to the object depicted within. Later she altered the SX-70 prints by various means and used it in combination with other mediums. She started experimenting with arranging the SX-70 prints as a way to constructing an alternate perspective space [19].

This gave her the opportunity to layer the Polaroids to form a dense surface with multiple layers of information achieved exclusively through traditional photographic means, while at the same time dismantling many expectations of a traditional photograph. Time is a fundamental element in the SX-70 collages, particularly in her earlier works. The method she adopted in creating these required from several hours

to several days, rejected the eminence of the one definitive image that captures the "decisive moment". She used the time as a means of showing the change in the physical state of the subject that she was photographing, by extending the shooting sessions over several hours or some times several days, thereby creating a visual record of the same. By using multi-point perspective and the resulting mobile focus, she was able to make the viewer *read* the image to find the plot. This was an important idea in most of her work. A Neimanas SX-70 collage can be confounding precisely because it was difficult to read. Even with the fracturing of time and space through multiple images, there was a strong urge to see these collages as one coherent narrative or to see them as a representation, although intellectually one knows they are pure abstraction [19].



Fig. 8. untitled # 3, 1980; SX-70 Collage, Joyce Neimanas

Her earlier collages had a fairly recognizable single subject and a standard rect-

angular format. In *untitled # 3* (Figure 8), 1980, other than the middle section the entire composition is clear and maintains a strict grid. The visual relationship of each print relates to the whole as if a single image has been cut into sections [19].

As she developed her work, the overall shape of the collages loosened and became more organic and gestural, exaggerating the tactile and decorative quality of the surface. Sometimes the imagery becomes highly dreamlike. In *untitled # 11* (Figure 9), 1982, a child is on the floor holding up the book *Alice in Wonderland*. The particular page showing is "a stack of cards," which might refer to tricks, to foreseeing the future by reading cards, or to the many SX-70 prints comprising the collage. The relationship of the individual prints to the whole grew more complex through the intricate weaving of disparate and incompatible images and information [19].



Fig. 9. *untitled # 11*, 1982; SX-70 Collage, Joyce Neimanas

For my thesis the most significant characteristics of Neimanass work is the extended use of time and the use of Polaroid SX-10 format.

D. Maurizio Galimberti

Maurizio Galimberti is best known as an "instant artist" photographer and the creator of the Polaroid movement itself. His photography has been developing through time



Fig. 10. Johnny Depp Portrait, Polaroid Mosaic, Maurizio Galimberti

and in a dimension of research and discovery of rhythm and movement. From his initial experience as an amateur photographer, Galimberti turned professional and since the beginning of the 1990s has linked his name to the use of film for instant

Polaroid photography. With his creation of photo-mosaics, they became increasingly complex and articulated, clearly inspired by Futurism and Cubism(Figure 10) [20]. Creativity and planning became the main feature of this best developed and known technique: Polaroid Mosaics, through which he found his way to expressing dynamism re-inventing an already exploited, but up to that moment less striking, technique [21] [22].

In his "*New York Polaroid*"(Figure 11) [23]project he commits to capture the soul of the city, with patient reflection, and give back an image full of depth and perspective that tells of glorious amazement at the fantastic and trivial. Aware of the psychedelic nature of the visual elements in the city, Galimberti analyses and separates then chooses an expressive bridge to give meaning to every encounter. In the Polaroid mosaics he constructs an unlikely drawing of the skyscrapers as we actually see them - softened the lines that follow clean Cartesian coordinates, or the syncopated rhythms of ragtime, or the city's frenetic effervescence. Single shots capture moments and rapid movements. He captures all the reference points that grabs his attention like restaurant and shop signs, silhouettes and passersby, taxis and busses, notice boards and inscriptions and buildings. He then artistically manipulates the surface using handy objects like a stick or even a toothbrush, and transforms it into something that does not have the essence of what is real. This engraving brings unexpected colors and the frames close the scene with stark lines that emphasize some element of the real. For my thesis the most significant characteristics of Galimbertis work is the use of a strict cartesian grid and the use of repetitive images to create a visual texture.



Fig. 11. Yellow Dance, Polaroid Mosaic, Maurizio Galimberti

E. Other Relevant Projects

Ardhanarishwar(Dancer: *Kaustavi Sarkar*)(Figure 12), a photo collage based on the classical Indian dance Odissi. Odissi, is the classical dance style of Orissa - the land



Fig. 12. *Ardhanarishwar*, 2007, Photographic Collage, Shyam Kannapurakkaran

of temples, the land of sculptures. The flowing movements and graceful poses of the dance bring to mind the breathtaking beauty of Orissa's temple sculptures. The dance is sculpture in movement and sculpture is frozen dance. Both are intended

to be an infinite source of joy and wonderment. The project was done as part of the *Observation is Kinetic* assignment for the Color Photography class (Instructor: Prof. Karen Hillier) at the Department of Visualization, TAMU. The initial idea was to capture the motion in the dance form by means of long exposure photography and then breaking it using steady still poses. While observing the dancer perform during the shooting session, the outstanding sculptural quality of each pose drew more attention. This resulted in a collage depicting the sculptural nature of the dance form. The aspect of drawing attention to a particular section in what one sees is one of the aspects that I am emphasizing in my thesis.

F. Stereoscopic Image

A small distance separates human eyes; hence each eye receives a slightly different image of the visual field. This difference, known as *disparity*, gives the perception of depth through stereoscopic vision. A similar disparity can be achieved in photography by using two cameras separated by a small distance, usually mimicking the separation of the eyes. Once the two images are obtained they can be viewed using a stereoscope or projected using 3D projectors and viewed using special glasses to perceive the illusion of depth. Since these pictures are stereo pairs (Figure 13), they give the disparity that the brain uses to give stereo depth vision [3]. The illusion of depth is directly related to the focal length of the lenses and the distance between the cameras used to take the pictures. The research uses this relationship as a tool to present the results in a virtual 3D format.



Fig. 13. Cathedral, Houston. October 2008, HDR Stereo Pair, Shyam Kannapurakkaran

G. Eye Tracking

The study of how our eye moves has long been a topic of interest to vision researchers. The heart of the investigations is based on the notion that there is a systematic relationship between the way the eye moves and the way a person sees the world [24]. The rapid eye movements between fixation points are essential for our vision. These movements result in the stabilization and refreshing of the image that is formed on the retina when one is looking at something. Researchers record eye movements in several ways. The earlier methods included recording on film using a cine camera, detecting the small voltage changes around the eyes, or most accurately by attaching a mirror to a contact lens placed on the cornea where a beam of light may be reflected off the mirror and photographed on continuously moving film [3]. Modern eye trackers use a combination of precision video cameras, infrared lighting and appropriate software to accurately identify and track the pupil. Infrared lighting is used to avoid discomfort caused by strong visible light sources while recording the eye movement. Eye tracking data obtained by such techniques gives us an idea of *gaze* (where we are looking) and *fixation* (duration of gaze). This technique is used in this research

to collect the required information as a basis for formulating and applying the rules for manipulating the photograph that the viewer observes. The following paragraphs give a brief description of the eye tracking systems and projects that were referenced for this installation.

1. faceLAB Eye Tracking System

faceLAB, a product of seeing machines monitors gaze detection, eye closure, facial gestures and head position. The system uses two IR cameras that record the eye movements, head position and rotation, eyelid aperture, lip and eyebrow movement and pupil size(Figure 14). The data can either be sent live to be processed or saved as a report and used later.



Fig. 14. faceLAB Eye Tracking System

Pros: *faceLAB* system is highly accurate and requires very little setup time. Since the cameras use IR illumination there is no need for any additional light on the face of the subject. The use of two cameras give the actual position in the 3D space and not just the 2D tracking information. The system is stand alone and can be networked using standard LAN system.

Cons: Cost(more than 30,000USD), *faceLAB* system is very expensive. This installation required a system that would run in a Macintosh platform. The system

available at the Visualization Laboratory was Windows based.

The installation did not require the amount and precision of data that was given by the eye tracker.

2. EyeWriter Initiative

“Art is a tool of empowerment and social change, and I consider myself blessed to be able to create and use my work to promote health reform, bring awareness about ALS and help others” –Tony Quan, aka TEMPTONE

The eye writer project is an ongoing collaborative research effort to empower people who are suffering from ALS (*Amyotrophic lateral sclerosis*) with creative technologies. It is a low cost eye-tracking apparatus and custom software that allows graffiti writers and artists with paralysis resulting from ALS to draw using only their eyes. Members of Free Art and Technology (FAT), Open Frameworks, the Graffiti Research Lab and The Ebeling Group communities teamed-up with a legendary LA graffiti writer, publisher and activist, named Tony Quan, aka TEMPTONE to develop a low-cost, open source eye-tracking system that will allow ALS patients to draw using just their eyes (Figure 15). Tony was diagnosed with ALS in 2003 and was subsequently completely paralyzed. The long term goal of the EyeWriter Initiative is to create a professional/social network of software developers, hardware hackers, urban projection artists and ALS patients from around the world who are using local materials and open source research to creatively connect and make eye art. The core development team consists of members of FAT, OpenFrameworks and the Graffiti Research Lab, with founding support from The Ebeling Group and the Not Impossible Foundation and additional support from Parsons Communication Design & Technology [25].

The EyeWriter software uses an affordable do it yourself (DIY) eye-tracking head-

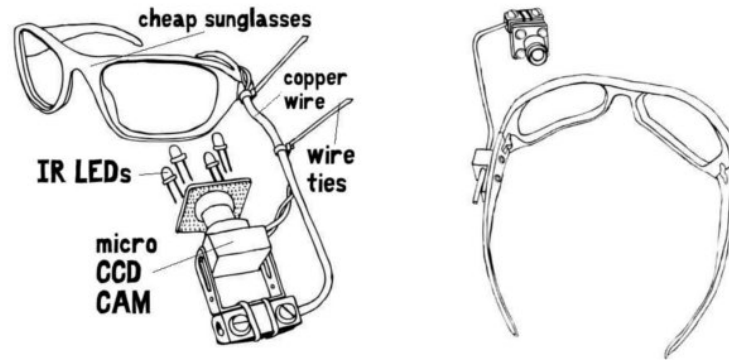


Fig. 15. DIY EyeWriter Head Set for Eye-tracking

set made out of off-the-shelf components(Figure 16) [25]. I have adopted this approach to build the eye-tracking unit for my installation. A detailed description and parts list for the same can be found in the Methodology section of this report.



Fig. 16. Graffiti Art Using EyeWriter, TEMPTONE

Pros: Inexpensive(50USD), easy to assemble and operate. Does not require any additional hardware/software support if used with Max/MSP/Jitter.

Cons: The camera in the front of the eye could be a distraction.

3. EyeMusic

EyeMusic is an interactive art project at the University of Oregon Cognitive Modeling and Eye Tracking Lab in which an eye tracker is connected to a multimedia performance environment to create computer music and interactive art based on eye movements. EyeMusic explores how eye movements can be sonified to show where a person is looking using sound, and how this sonification can be used in realtime to create music. The system consists of an eye-tracker unit(LC Technologies Eye Gaze Communication System) that reports the tracking information to a realtime computer program(written in Max/MSP/Jitter)(Figure 17). The computer program generates and modifies sounds and images based on these data(Figure 18). Project Personnel:

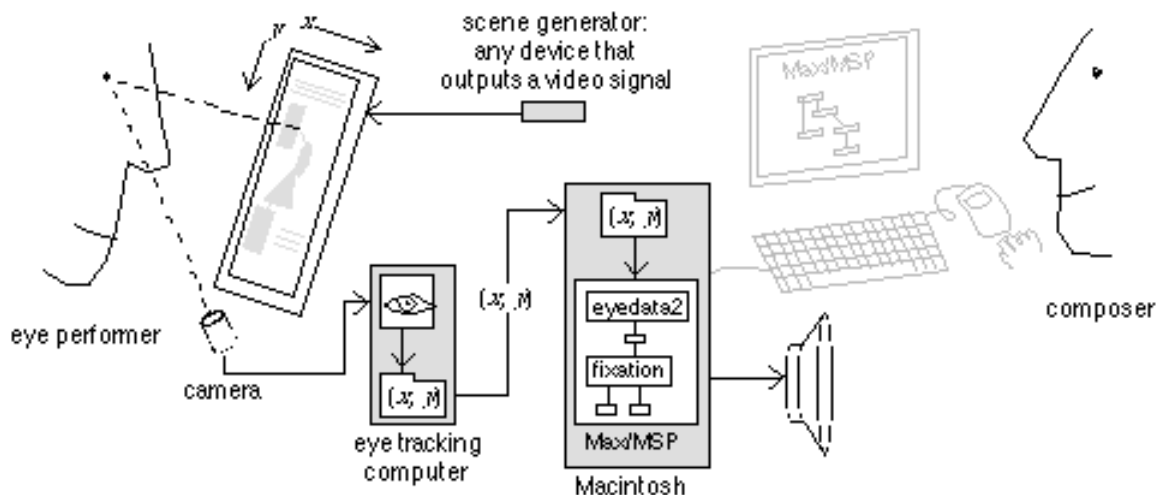


Fig. 17. EyeMusic System Components Overview. Arrows Indicate the Flow of Data

Anthony Hornof, Troy Rogers, Tim Halverson, Jeffrey Stolet, and Linda Sato. Dr. Stolet and Troy Rogers are affiliated with Future Music Oregon. EyeMusic pushes the human eyes beyond an organ for perception, it allows it to be a manipulator thus

creating unusual feedback loops. It motivated the performer to look at a physical location either to process it visually or to create sound. Through it all, EyeMusic explores how the eyes can be used to directly perform a musical composition [26] [27].



Fig. 18. Anthony Hornof Practicing EyeMusic V1.0

Pros: The schematic layout of the installation is very similar to the one I am using for mine with the exception that they are using eye tracking to make music and resulting visuals, and I am using eye tracking for creating visual representation of a viewers act of seeing a photograph.

Cons: The eye tracking unit is independent of the Max/MSP environment and also expensive(30,000USD).

4. Other Eye Tracking Solutions

Several open source eye tracking solutions were studied and tested for this thesis. Some of them were discarded because of the complex programming involved to customize it for my needs and the others required a second computer to run and were mainly MS Windows based. A few of them were openEyes, OpenGazer, TrackEye, ITU Gaze Tracker and OpenCV FaceTrack.

CHAPTER III

METHODOLOGY

The goal of this thesis is to create an interactive installation that demonstrates the dynamic nature of human visual observation of a still photograph. The interactivity comes from collecting the eye tracking data from the viewer looking at the still photograph. The final result will be presented in as a photographic collage in virtual 3D. The collage will be a result of the manipulations of the original photograph that include transformations like scale and translation and visual components like color, level of detail, contrast and saturation. The amount and type of manipulations applied will be based on the viewer's feedback in the form of the eye tracking data.

The study of established artwork and available technology in the previous sections include the the following principal characteristics that are considered important to the aesthetics of this installation:

- the element of time,
- representation of the visual experience of an object or an event,
- use of a geometric grid to layout individual images,
- cost and availability of hardware.

The technical aspect of this art based installation to demonstrate human *visual experience* is the notion of *fixation and gaze*. This lays the foundation to the concept of determining and emphasizing the areas of interest based on tracking the eye movements. I am specifically interested in collecting the data related to where the eye is looking(gaze) and how long is it looking at that point(fixation). This will allow me to identify the areas and the amount of artistic manipulations to be applied to create

the photo collage. In order to achieve my artistic goals and to keep everything within the technical limitations and cost range proper planning guidelines were made.

A. Planning Guidelines

1. General Installation Constraints

There were a few factors that I wanted to be incorporated in the installation. The installation space was to have easy accessibility simple to enter and exit. The available stereoscopic projection system required controlled lighting, so that was one of the factors that had to be included. Although the installation could be viewed by multiple people at one time, it is primarily designed for one individual. The hardware components of the system had to be either obscure or if visible be designed to functional and aesthetic.

2. Technical Considerations

The input device(eye tracker), programming, and computing requirements were finalized after several case studies and tests. Since the installation is in stereoscopic 3D the computer used had to deliver two identical video outputs for each projector. The efficiency, affordability and availability of these components was essential for the successful construction of this installation. These were the guidelines I followed for the technical requirements of my installation:

- cost, the cost of the hardware used had to be minimal,
- availability, the hardware/software used for the installation had to be readily available,
- platform/operating system, the installation is based on a Macintosh platform,

so all the input devices and programming tools had to be compatible with Macintosh,

- ease of customizing the program to accommodate changes at the location, and,
- ease of transporting and storing.

3. Programming Environment

The most important aspects of this installation are interactivity and stereoscopic display. For this reason the programming environment for this installation had to support simultaneous realtime video and data processing. The programming for the installation was planned to be in a modular fashion which means that each function in the pipeline was done by individual modules that performed the assigned task. Also the data transfer between these modules needed to be fast and less processor intensive. So the software used for the programming of this installation had to be flexible, customizable, manage 2D and 3D graphics data efficiently and handle live video input and data processing.

With all these considerations in mind Max/MSP/Jitter was chosen as the programming environment for this installation. Max is a visual programming language for music and multimedia developed and maintained by a San Francisco based company '*Cycling '74*'. Max was originally written by Miller Puckette as the Patcher editor for the Macintosh at IRCAM in the mid-1980s to give composers access to an authoring system for interactive computer music. A major package for Max/MSP called Jitter was released in 2003, providing real-time video, 3-D, and matrix processing capability and support for MS Windows. A major update to Max/MSP/Jitter, Max 5, was released in 2008. I am using this version as the programming environment for my installation. Max/MSP/Jitter is available on the Macintosh and MS Windows

platforms. But Max was originally developed for the Macintosh environment and runs optimally in this environment. The Max/MSP/Jitter programming environment is highly modular. The user creates programs or *patches*(Figure 19) that are made by connecting a series of graphical modules that perform specific tasks. This enables Max/MSP/Jitter to give realtime feedback of every new addition to the patch [28].

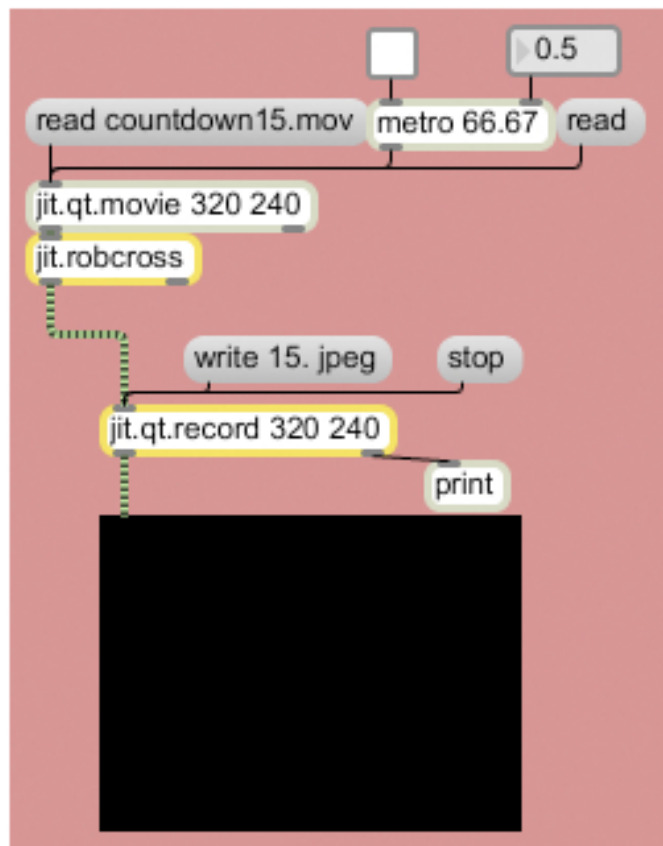


Fig. 19. A Simple Recording Patch in Jitter

B. Physical Requirements for the Installation

1. Computing Requirements

With the considerations mentioned in the previous sections the installation is developed on a Mac Pro Desktop Macintosh computer, running Mac OSX 10.6.3 version of the operating system. The key hardware features of the computer relevant to this installation include but are not limited to 2.93 GHz Quad-Core Intel Xeon processor, NVIDIA GeForce GT 120 Graphics card with 512MB VRAM and two video out ports, and 8 GB RAM. The computer had the latest versions of Quicktime, OpenGL and Max 5.

2. Eye Tracker

The interactivity of this installation comes from translating the act of human visual observation using the input from an eye tracker. As mentioned in the previous chapter(Chapter II, Section F), I looked at several options for the hardware and software for the eye tracker. The key characteristics that I was looking for is summarized earlier in section 2 of this chapter. With these in mind I decided to go with the DIY head set for the EyeWriter(Chapter II, Section F.2). The component list for the eye tracker and their respective price is listed below.

- Logitech C120 Web Camera (19USD),
- Infra Red LED's (0.95USD x 4),
- polarizing filters from used 3D movie glasses(0USD),
- miscellaneous electronics(5USD),
- paint and other hardware(8 USD).

Although the basic design for the headset was based heavily on the EyeWriter headset, there are few changes that I made to it for aesthetic reasons, the main being the housing for the camera and the glasses. The housing for the headset used for the installation is built around the PCB(Printed Circuit Board) of the camera. This resulted in the octagonal shape. Both the housing and the glasses were modeled in Maya and printed on a 3D printer in ABS(Acrylonitrile Butadiene Styrene) plastic material(Figure 20).

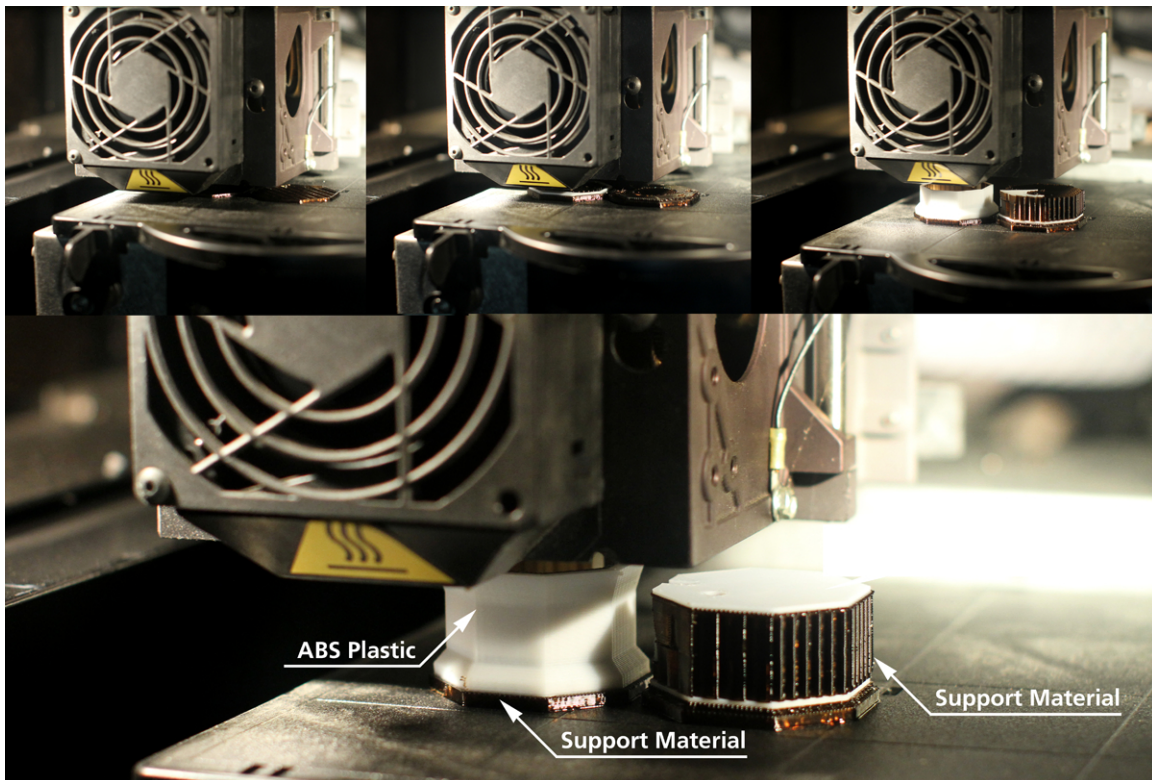


Fig. 20. The Camera Housing Being Printed in the 3D Printer

Once the printing was done and the support material removed the individual components were spray painted to get the desired finish. The IR LED's were then attached to the front panel. Resistors(Figure 21) were attached to make sure that

the voltage received by the LED was reduced to 3Volts from the 5Volts supplied by the USB.

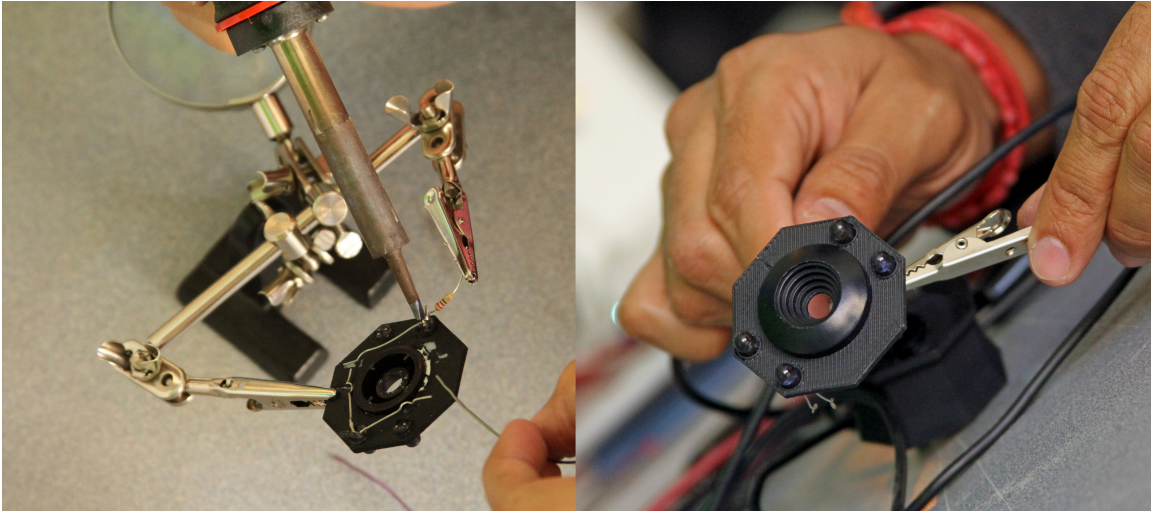


Fig. 21. IR LED's Attached to the Front Panel.

The IR filter behind the camera lens was removed in order to make sure that the CMOS sensor could receive IR light. The use of IR illumination allows the camera to wash out every other detail except the dark pupil. This way the eye tracker is not affected by the color of the eye. It was important to keep the pupil the only moving object in the camera's field of view that is sent to the Jitter patch. In order to achieve that polarizing filters arranged in opposite directions are used to cut off visible light entering the sensor(Figure 22).

The camera was connected to the computer using USB 2.0 interface and the IR LED's were also powered using a USB power source. The headset could be worn over prescription eye wear also(Figure 23)(Figure 24).

The camera is mounted in such a way as to cause minimum obstruction to normal viewing of an image projected in front of the viewer on a screen(Figure 25).

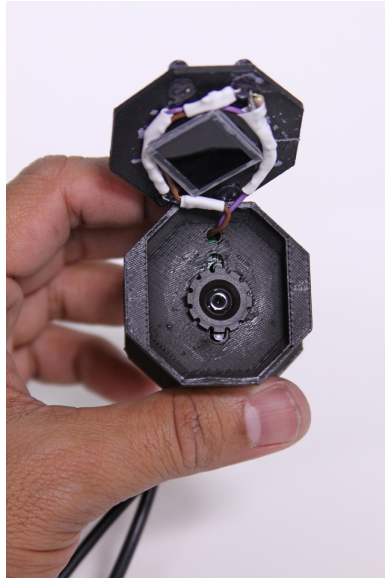


Fig. 22. Polarizing Filters to Cut off the Visible Light



Fig. 23. Eye Tracking Headset

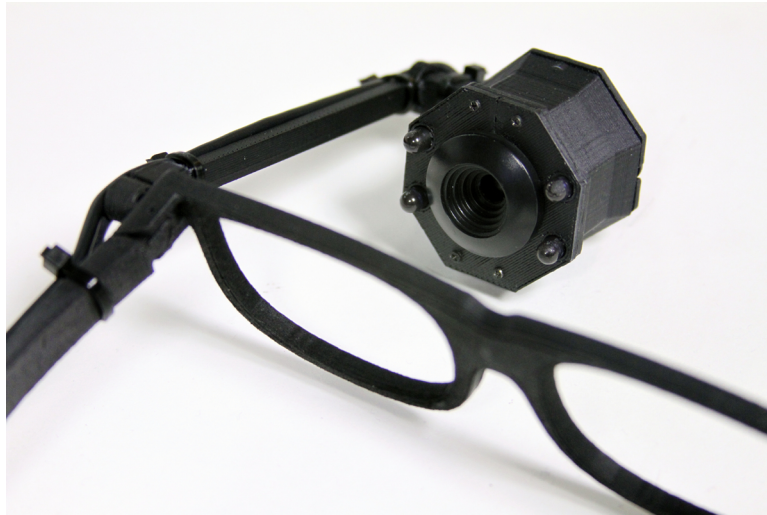


Fig. 24. Eye Tracking Headset Showing Infrared LED's and Camera

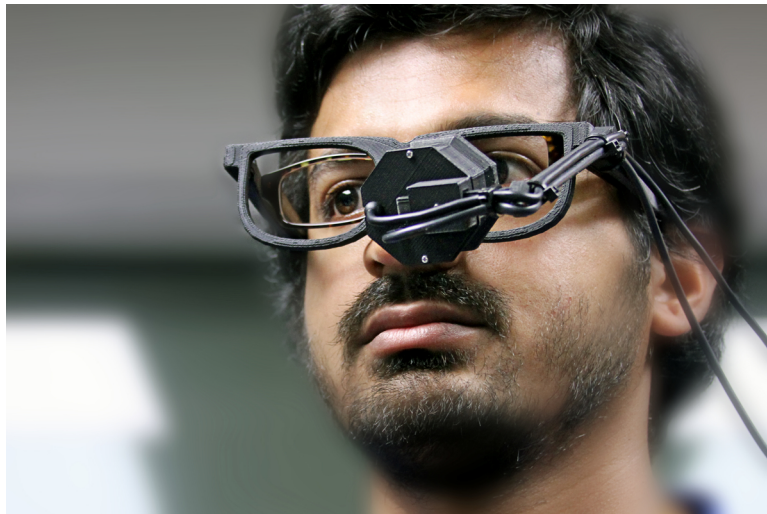


Fig. 25. Viewer Wearing the Headset

3. Projector System

The output of the installation is projected in stereoscopic 3D. Two types of projection systems were considered for this thesis, the active projection systems using LCD shutter glasses and the passive system using linearly polarized glasses. The cost of the hardware required for an active system was out of the scope of this thesis(6000USD). As a result the passive system is used. This required that the left and right camera views be projected separately and registered accurately on the projection surface. For this I used a dual projector mount which could be adjusted in order to get correct registration of the projected images. Linearly polarized filters are attached to the front of each projector with opposite directions of polarity, so that when viewed through a polarized pair of glasses the left eye of the viewer sees only the left image and right eye sees only the right image(Figure 26).

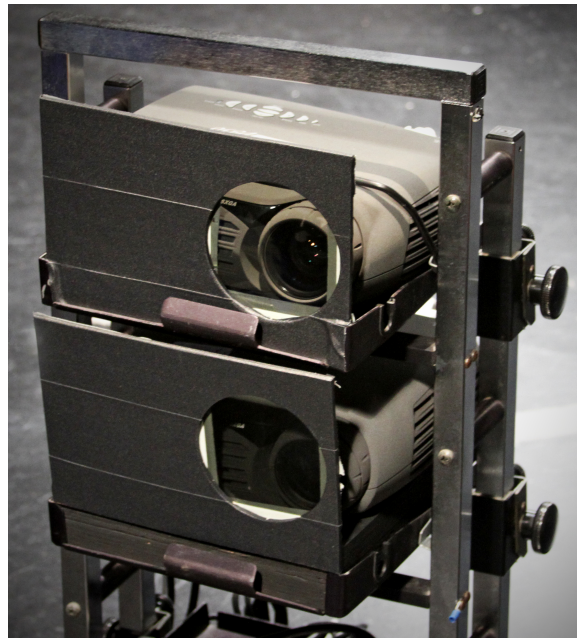


Fig. 26. Dual Projector System for Stereoscopic Projection

4. Projection Screen

This installation uses a passive stereo viewing system with using a pair of linearly polarized filters with opposite directions of polarity. This installation uses a silver lenticular screen(silver screen)(cost 25USD)(Figure 27). The primary reason behind using this screen is its ability to retain the polarity of the projected light. The term silver screen comes from the actual silver content embedded in the material that made up the screen's highly reflective surface. The percentage of light reflected from a nonmetallic(dielectric) surface varies strongly with the direction of polarization and the angle of incidence: this is not the case for an electric conductor such as metal. As the stereoscopic projection depends on maintaining the polarization of the images to be presented to each eye, the reflecting surface needs to be metallic. Also the highly reflective surface of the silver screen reflects more light thus compensating for the brightness loss due to passing through the polarizing filter [29].



Fig. 27. Silver Lenticular Projection Screen

CHAPTER IV

IMPLEMENTATION

Once all the physical components of the installation like the eye tracker, projector, screen, and the installation space were in place , I could put together individual patches in Max/MSP/Jitter to do specific tasks finally leading to the creation of the photo collage. The development of these patches went through several iterations and optimizations based on input and assistance from individuals working in related fields.

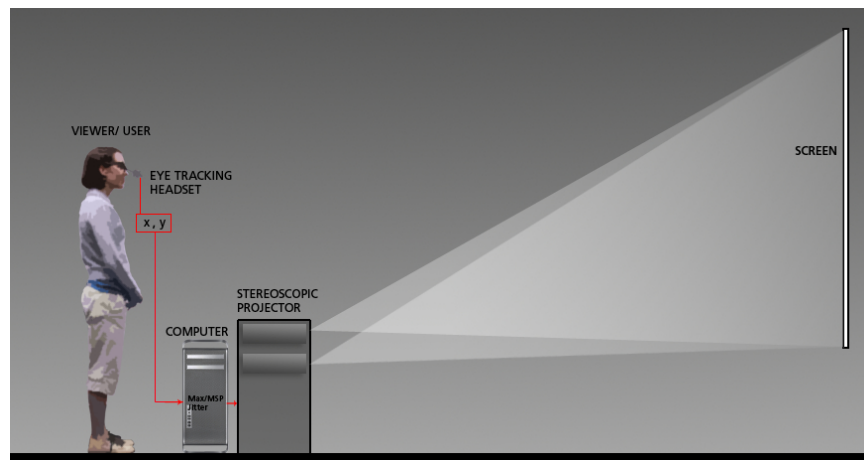


Fig. 28. Schematic Layout for the Installation

A. Installation Layout

The size of the space required for the installation is determined by the size of the projection screen and the required projector throw distance. The projection screen is 65in wide and 70in tall, the optimum distance for the projector is calculated to be 10feet from the screen. Adequate circulation space is also given around the instal-

lation. With this information, and the available hardware the following schematic sketch was drawn(Figure 28).

B. Generating the Photo Collage - Software Patch

The core of the installation is the Max/MSP/Jitter patch running on the Mac Pro. As mentioned in the earlier chapter, the patch is designed in a modular fashion. Each module performs a specific task and send the information back to the main patch where the collage is generated. The flowchart shows the schematic layout and functions of each module and the general data flow(Figure 29).

1. CollagePatch

The CollagePatch(Figure 30) is the main patch in this installation. The CollagePatch is where the image is loaded, manipulated and then saved. The main components of the CollagePatch and their functions are,

- image file load – randomly chosen from an image bank. This is done using a *read* message to a *jit.qt.movie* object,
- image file save – after the collage has been made the resulting image is saved to the hard disk using the *jit.qt.grab* object. The file is saved in JPEG format,
- set the camera attributes for the right and left images in the *jit.gl.render* object,
- display each image in the respective projectors and toggle between full screen and window mode,
- send the number of rows and columns the image has to be divided into,
- initialize the other patches that are part of the installation to perform their respective tasks.

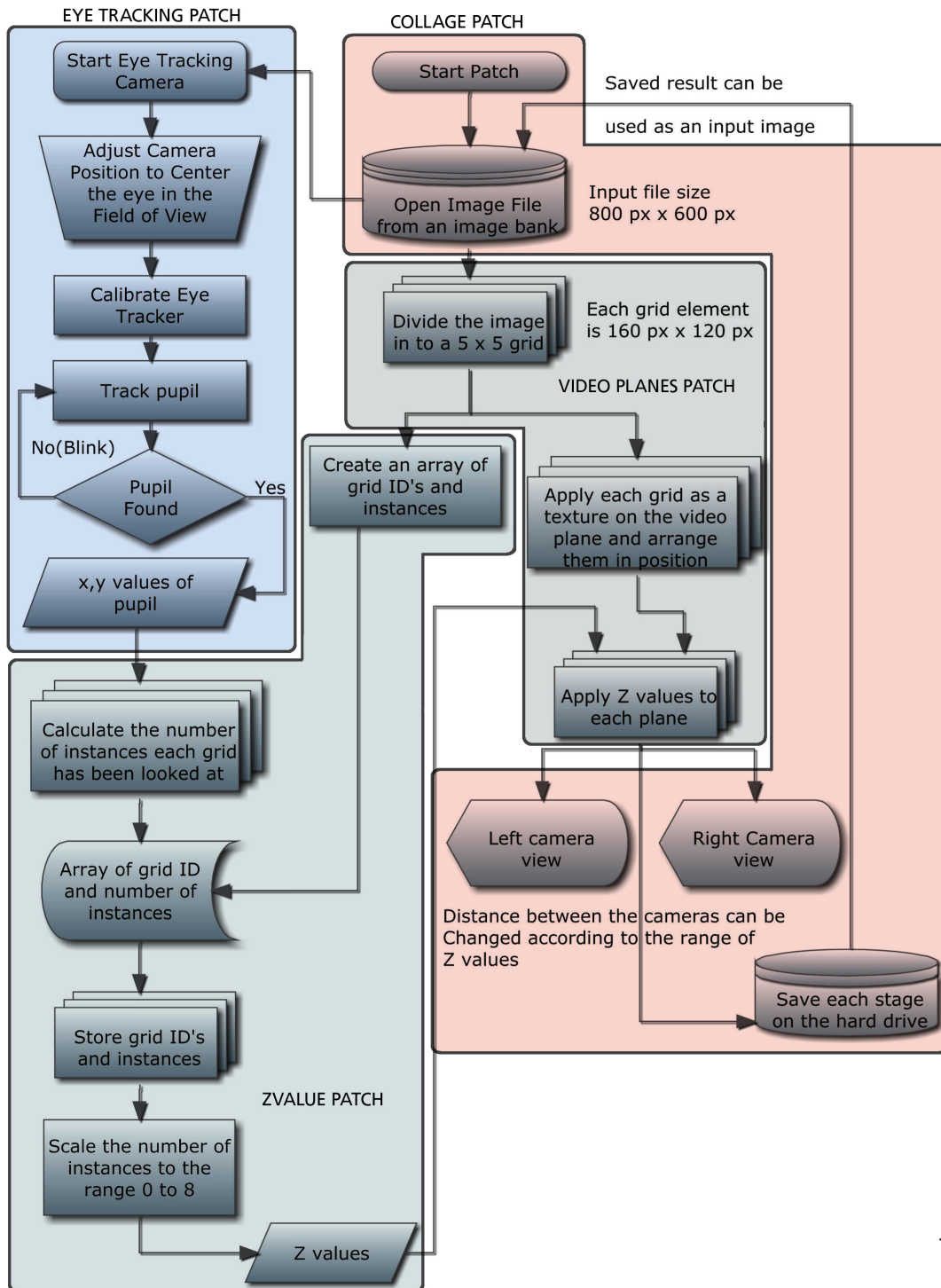


Fig. 29. Flowchart Showing the Schematic Layout and Functions of Each Module

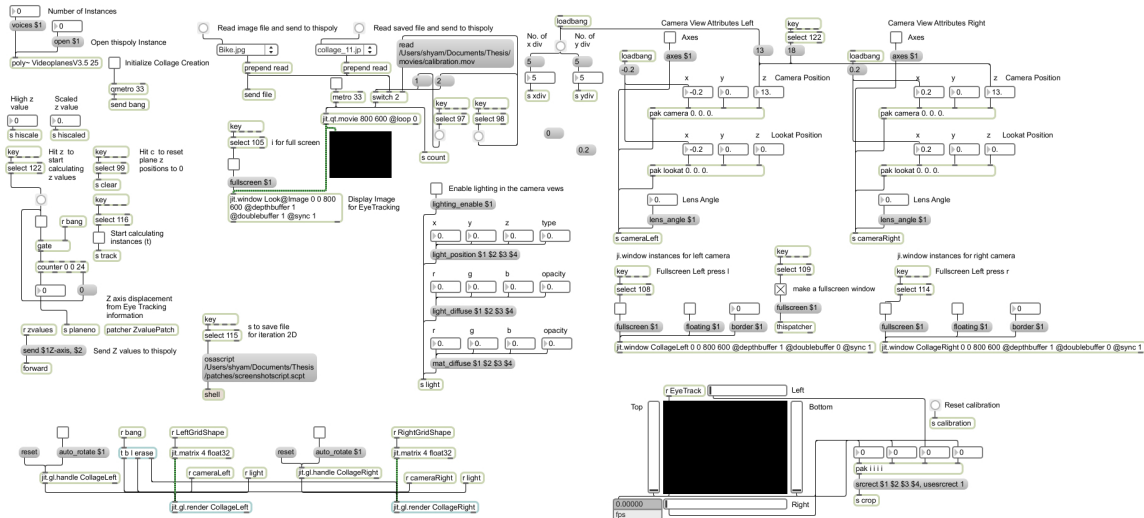


Fig. 30. CollagePatch Screen Shot

The resolution of the input image is 800 pixels wide by 600 pixels tall. The number of rows and columns is a critical component of the performance of the computer. Increasing the number of rows and columns will increase the processing load on the computer and slow down the process. After evaluating the aesthetic aspect and considering the computing constraints the number of rows and columns are fixed to be five. This will result in twenty five 160 pixels wide by 120 pixels tall grid elements.

2. VideoPlanes

The VideoPlanes(Figure 31) is responsible for dividing the image into individual grid elements. The CollagePatch communicates with the VideoPlanes through the *poly~* object. The VideoPlanes patch receives the file from the CollagePatch, finds the area to be cropped and then applies it as a texture on a *jit.gl.videoplane* object. Each instance of the *poly~* object received by the VideoPlanes patch has a unique ID, which makes it possible to have individual controls over each plane using the respective ID.

The default aspect ratio of the *jit.gl.videoplane* object is square. Since I am dividing the image in a 4:3 aspect ratio, each video plane has to be scaled by 1.33 in the x direction.

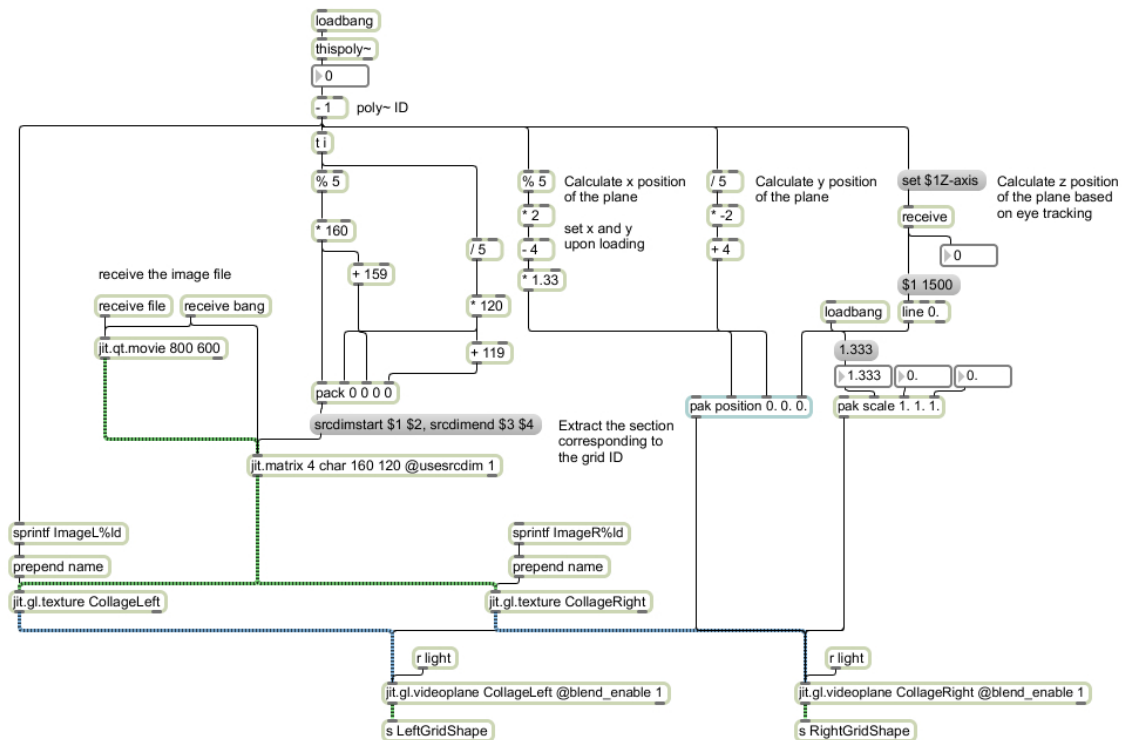


Fig. 31. VideoPatch Screen Shot

3. EyeTracker

The EyeTracker (Figure 32) patch takes the video input from the headset using the *jit.qt.grab* object. The video is cropped using the *srcdimstart*, *srcdimend*, *usesrcdim* messages to make sure that everything except the pupil is not visible for the tracking. The video is then converted to greyscale using the *jit.rgb2luma* object and the thresholds adjusted so that the pupil is visible distinctly to track. The position of

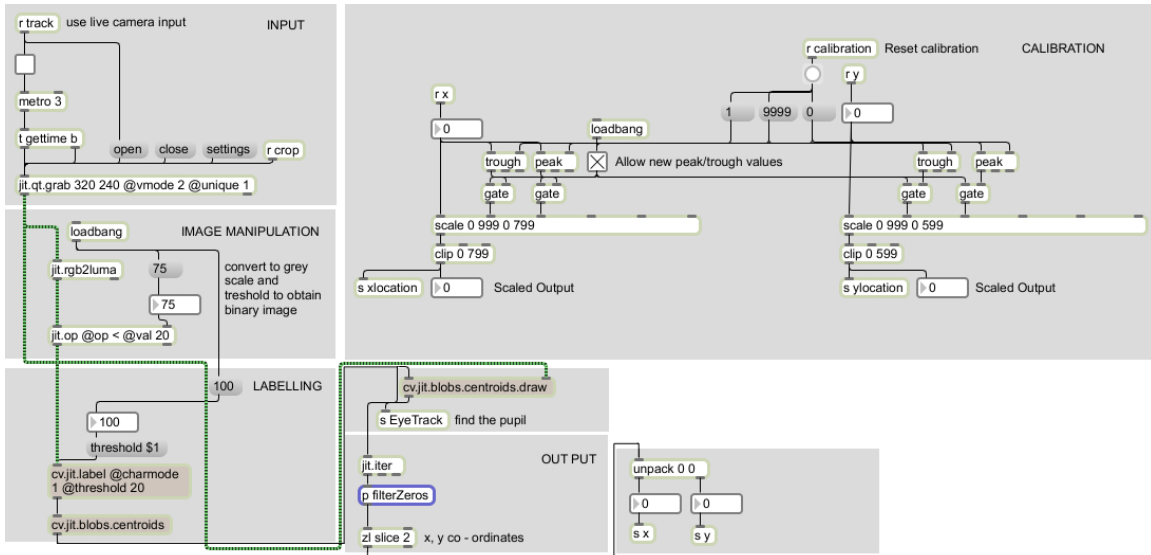


Fig. 32. EyeTracker Patch Screen Shot

the pupil is tracked using the `cv.jit.blobs.centroids` object. This object gives the ID of the object tracked and its x and y co-ordinates. When no blob(pupil) is detected, the `cv.jit.blobs.centroids` will output a zero ID value. The FilterZeros sub-patch will stop such values from being sent to the CollagePatch for further calculations. This way whenever there is a blink there are no values coming out of the EyeTracker patch. The values are clipped to make sure that they stay within the bounds of the image projected.

4. ZValuePatch

The ZValuePatch(Figure33) takes the input from the EyeTracker and calculates the number of instances a particular grid has been looked at and stores this value in an `coll` object. The number of instances a grid has been looked at is an indication of the *fixation* value for that particular grid. These values are then scaled to a range of

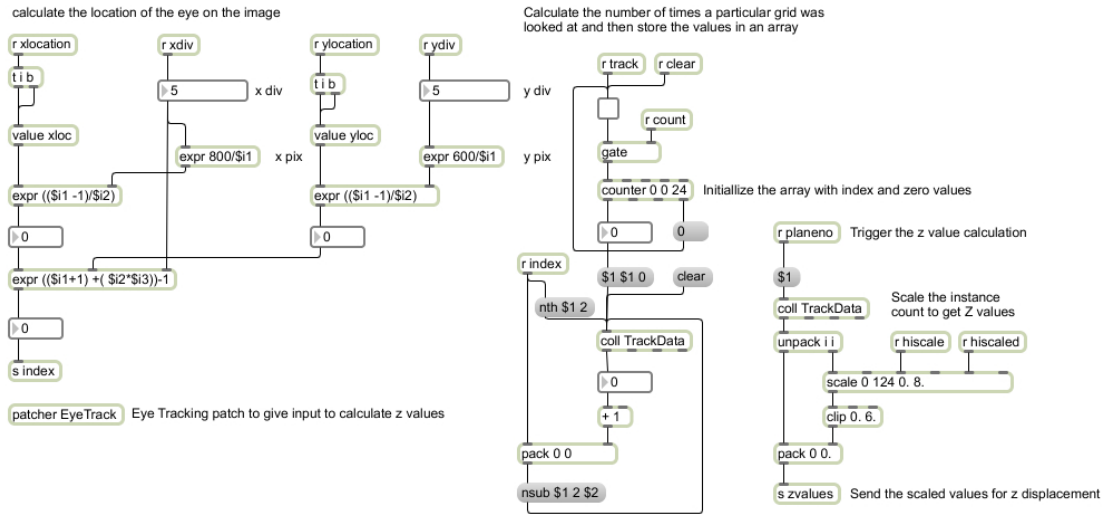


Fig. 33. ZValue Patch Screen Shot

choice to determine how much each of the grids are translated in the Z axis in the final collage. The maximum scale value determines the separation between the two cameras used to generate the stereoscopic display. This is because of the thumb-rule that the distance between the camera's should be at least 1/30th of the distance between the camera and the closest object to the camera. The Z values along with the grid ID are then sent to the CollagePatch where they are applied to the individual video planes.

The final output is sent to the respective projectors and projected onto the silver screen. At this stage if the user wants to get a still of the result, the image could be saved to the hard drive and could possibly be used as the input image for another iteration of the same process. The number of iterations is unlimited and each stage could be saved as a separate file. The viewer/user can also make a print out of each stage if required.

CHAPTER V

RESULTS AND EVALUATION

A. Expected Outcome for the Final Thesis Work

This thesis is intended to represent the *visual experience* of the act of human observation of a still image in the form of a stereoscopic photo collage. The artistic inspiration is based on characteristics identified in selected works of artists like Picasso, David Hockney, Joyce Neimanas, and Maurizio Galimberti. The results should be iterative with each stage saved as a separate file. The computing and hardware needs for the research are to be readily available, easily customizable and inexpensive. The programming environment should be easily understandable and should allow modular programming.

B. Results

Following are the results that were obtained during the presentation of this installation at the Visualization Sciences Laboratory at Texas A&M University. The Original image and the different stages of development are shown in sequential order(Figure 34, 35 36, 37).

C. Evaluation

The artistic success of the installation hinges upon the final outcome of representation of *human visual experience*. A proper evaluation of the installation can be done under the following main considerations.



Original Image

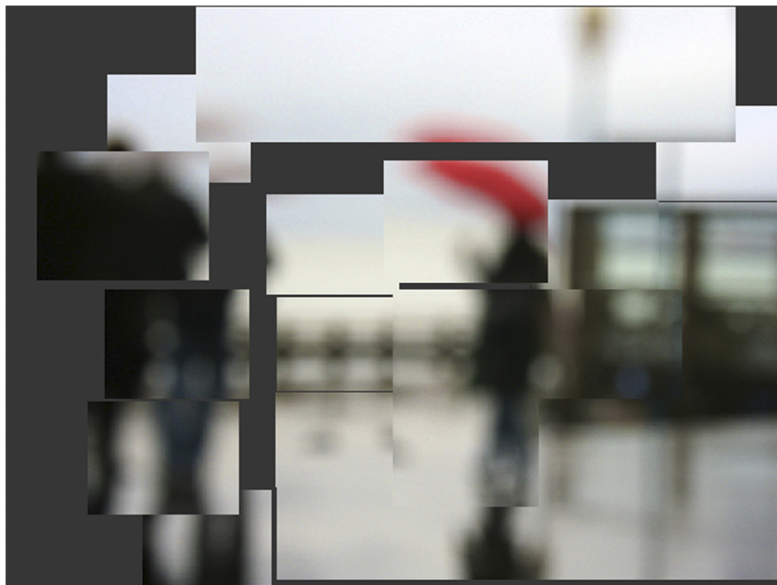


Collage

Fig. 34. Result 1 – Original Image and Collage

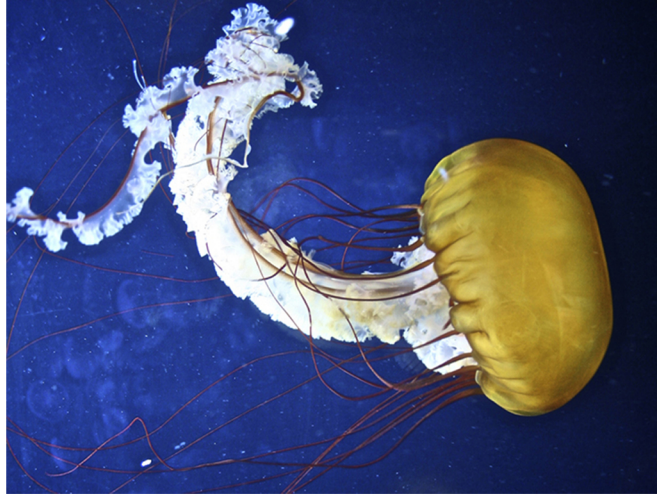


Original Image

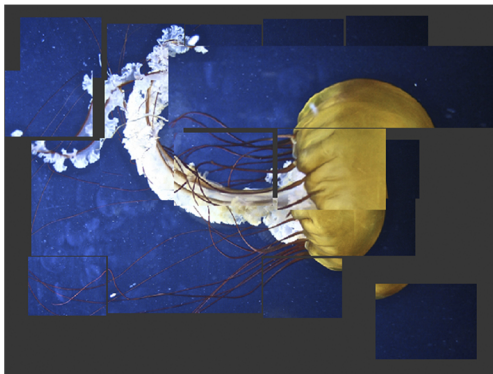


Collage

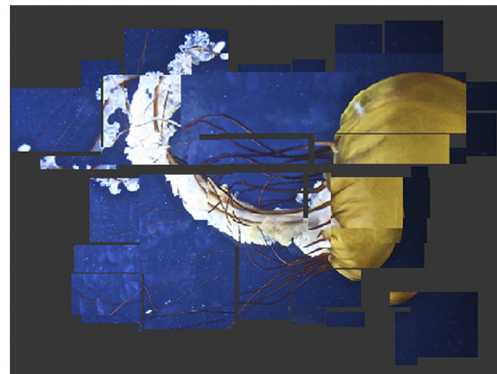
Fig. 35. Result 2 – Original Image and Collage



Original Image



Collage Stage 1



Collage Stage 2

Fig. 36. Result 3 – Original Image and Collage in Two Iterations



Original Image



Collage Stage 1



Collage Stage 2

Fig. 37. Result 4 – Original Image and Collage in Two Iterations

1. Artistic

The installation draws its inspiration from identified characteristics of selected work of artists like Picasso, David Hockney, Joyce Neimanas, and Maurizio Galimberti. Each artist had a different approach towards the photographic collage medium. The element of time was a common across the works of all the artists. The installation is successful in representing the element of time in different scales. Through various iterations the installation demonstrates how the element of time affects the generation of the final photo collage. From the research done for this thesis it was found that David Hockney's initial collage works were based on a grid that was forced on him because of the use of the Polaroid SX-70 format. The works of Joyce Neimanas and Maurizio Galimberti also use the Polaroid SX-70 format and follows a grid pattern even though the former let go of it as her work progressed. The installation uses a pre-determined grid to split the original image, thus following a grid pattern in the final arrangement. Visually the white border that is characteristic to the Polaroid film is missing in the final output of the installation. Research for this thesis also showed that the later works of David Hockney and Joyce Neimanas did not follow any grid for arranging the individual photographs. David Hockney started using borderless machine-made prints made from 35 mm film which gave his collages a more organic shape that represented the experience that he had while shooting. The installation however is restricted to the use of a strict grid mainly due the the way it is programmed. In its present state there is very little scope to show any sense of direction in the arrangement of the individual pieces. The form tends to become more organic and less rigid at the end of every iteration resulting in interesting transformation from the original image. The repetition of a particular section like the one found in Galimberti's photo mosaics could not be achieved in this version of the installation.

2. Technical

The key technical goals for this installation can be summarized as follows:

- cost, the cost of the hardware used had to be minimal,
- availability, the hardware/software used for the installation had to be readily available,
- platform/operating system, the installation is based on a Macintosh platform, so all the input devices and programming tools had to be compatible with Macintosh,
- ease of customizing the program to accommodate changes at the location, and,
- ease of transporting and storing.

The installation uses a single Mac Pro desktop computer for all its computing requirements. All the software for the installation runs under one platform and is tweaked to use the system resources optimally. The eye tracker used for the installation was built completely in-house with readily available off-the-shelf hardware. The eye tracker in the case of this installation is the tool with which the viewer creates the art - the photo collage. All the hardware can be conveniently packed transported and stored if necessary. The assembly/ setting up of the installation involves, unpacking the hardware, making the electrical connections, and registering the two projectors on the screen. This is a fairly simple process. The filters and glasses used for the stereoscopic viewing experience are also inexpensive. Overall the technical goals set for this installation have been met to satisfaction.

CHAPTER VI

CONCLUSION AND FUTURE WORK

A. Conclusion

The creation of this interactive installation to showcase the dynamic nature of human visual observation required careful planning and several iterations of hardware and programming solutions. The workflow and technique documented in this thesis has proved efficient towards the success of this installation. The artistic and technical goals set for this installation has been met to the satisfaction of the artist. This work is expected to be a guideline to the artists and researchers who are working in the field of interactive visual media.

B. Future Work

This installation is completed under the guidelines discussed in the previous chapters of this thesis. Future extension to this installation can be done in both artistic and technical direction. The present body of work uses a single surface of projection and stereoscopy to present the result. The results could be projected on multiple surfaces located at different distances from the viewer. The shape of the final collage should also be influenced by the eye tracking data that is collected. The order in which the sections of images appear in the collage is the same as the original image. This order could be changed based on the number of instances each grid appears in the eye tracking data. Omission, repetition, and exaggeration can be added to make interesting results. The present solution does not allow the camera to move in the virtual space. This could be a feature that will make the results more immersive. Video can be used as a source for input to create a video mosaic in a very similar

fashion to the structure of the still work, in contrast it will be a time based piece as input and output.

On the technical side, optimization could be made in the hardware that can reduce the cost. Use of Mac mini instead of Mac Pro will be a factor to reduce the cost. Use of other input parameters like position of the user can add to the interactivity of the installation. New technologies like the iPhone 4 which has a front facing camera and a gyroscope along with the accelerometer can give realtime eye tracking and position information and the scope of the installation can be widened from a still photograph to an actual real object.

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