(Not) Drawing The Line: Technology Re-Examined

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Thesis submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Master of Fine Arts In
Creative Technologies

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May 04, 2017
Blacksburg, VA

Keywords: Holographic Hive, Electromagnetogram, Primitive Touchscreen, Ephemeral, Video Projection Mapping, Pepper’s Ghost, VDMX, Julia Fractal, lo-fi, hi-fi, Touchless ZX axis sensor, Consistency Of Vision, Icosahedron, Hexagonal Lattice, Post-Internet.
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ABSTRACT

(Not) Drawing The Line: Technology Re-examined is the culmination of interdisciplinary research exploring the nature of materiality and process in the fields of art, science, and technology. Exploration and experimentation in these diverse disciplines have helped to illuminate many of the ideas and concepts that have guided the overall research process. These explorations have also honed the ability to critically examine how technology is perceived and represented, post-internet.

This document illustrates the processes involved in the conception and creation of a body of work manifested through visual and technological problem solving, investigative research of materials and technologies, and the fundamental concerns of art, technology, form and pattern. These empirical areas of research are punctuated by literary texts on the philosophy of art and technology that have informed many of the visual comparisons represented. This body of evidence is an exploration of the idea that the evolution of technological developments can often be attributed to the creation of art through the heuristic experimentation and visual explorations of the artist.
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GENERAL AUDIENCE ABSTRACT

(Not) Drawing The Line: Technology Re-examined is the result of exploration and research in the areas of studio art, science, and technology. Many of the ideas and concepts presented in this documentation are a result of curiosity-driven research which uses materials and processes to help form connections across disciplines. In most examples, the materials used are common or familiar items such as the #2 pencil, reflective surfaces such as a mirror, or clay used for ceramics.

The intention behind the work documented in this thesis is to help the viewer look at these everyday materials in a different way than their common use suggests through visual comparisons and wordplay. Its goal is to suggest that a new use or discovery may be presented in common materials and that solutions to complicated problems could be found right under our noses, so to speak. at its core, it is a commentary on technology, its uses, and perceptions during our current, post-internet place in history.
I would like to thank Simone Paterson, Carol Burch-Brown, Samuel Blanchard, Martha Sullivan, Thomas Tucker, and Dane Webster for their guidance and support during my time as a graduate student, and to the other faculty members and administrators at the School of Visual Arts, especially Ray Callahan, Deb Sim and Kevin Concannon. I would like to express my appreciation to the following departments, staff, faculty and programs within Virginia Tech in no particular order; to the Institute for Creativity, Arts, and Technology for the use of its facilities, and for awarding me a SEAD Grant during my final term, and to all the staff members there especially Lisa Jansen. To the production staff at Moss Arts Center especially Ryan Hassler. The College of Architecture and the Industrial Design program, for honoring me with the Robert Graffe Book Award. To Robin Boucher at the Perspective Gallery. A special thanks to Dean Karen DePauw for all of her efforts to make Virginia Tech a more inclusive and supportive environment, and especially for choosing me as a participant in the Global Perspectives Program. The Science Museum of Western Virginia. I would like to express my deepest gratitude and appreciation to Virginia Tech Emeritus Professors Jerrie Pike and Raymond Kass for generously allowing me to live in their beautiful guesthouse for this past year, and making me feel like family. Lastly, I would like to dedicate my thesis to my Grand Aunt Doris Liguori who encouraged my return to school and cheered me on until her final day in the June of 2016.
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Chapter 1: Introduction

As a graduate student in Creative Technologies, I found it difficult to articulate what that embodied. I attributed this dilemma to two areas of concern, which in my opinion seem to coincide with both the advantages and the disadvantages of being an M.F.A. candidate in such a relatively new field.

An interdisciplinary approach for the foundation and knowledge I needed for my research was a huge advantage. This was made possible by an understanding and open-minded faculty. In retrospective, it was my inability to articulate what Creative Technologies embodied that allowed for a true advantage—or the disadvantage of not having many examples to work from within the program—as it provided a crucial question to work from. What are Creative Technologies? Are antiquated technologies still considered a technology, if not can their status be elevated through the creation of art? How has technology’s complex relationship to art and the general influences each has played on one another over the course of history affect how we perceive technologies—new and old—and how we perceive art? The intersection of art and technology has become the basis of the artistic interpretations presented in this body of work.

Chapter 2.1: Chasing The Ephemeral: Creative Technologies

Historically art has had a tremendous influence on the development of technology, and equally technology has had a tremendous influence on how art is created, distributed and viewed. This overlap between art and technology has become ubiquitous in our day-to-day lives. Together, this pairing have made for a more inclusive human experience, fluid exchange of ideas, and enabled the development and evolution of our species. Art and technology are extensions of our thoughts, consciousness, and of our will as humans, both collectively and as individuals manifesting the physical.

In some many ways, the artist and technologist have parallel roles to society, which is increasingly difficult to differentiate in contemporary creative discourse. Art has informed technology, and technological advancements have transformed the art world. Cyril Stanley Smith’s states in his book, Art, Technology and Science: Notes on their Historical Interaction, that “It is misleading to divide human actions into “art”, “science,” or “technology,” for the artist has something of the scientist in him, and the engineer of both, and the very meaning of these varies with time so that analysis can easily degenerate into semantics.” (Smith, 1970, p. 493)

Smith’s argument that technological developments are often the consequence of the artistic drive, or as he directly states: “My point is only that the invention of a technique has, until recently, been more likely to occur in an aesthetically sensitive environment than in a practical one.” (Smith, 1970, p. 501) So that, for example, “All optical devices have their roots in the polishing of ancient mirrors and the cutting of accurate facets on gems for a more decorative glitter.” (Smith, 1970, p. 508) Smith’s extensive histor-
ical research makes a compelling argument that nods towards art being the generative force behind our technological advancements.

Chapter 2.2: Holographic Hive

The *Holographic Hive* is an installation consisting of 187 convex mirrors, video content of moving geometric shapes and computer software that allows you to spatially “map” the output from a projector to create a holographic illusion. Haze is used with this installation to accentuate these illuminations. The *Hologram Hive* is a deconstruction of the methods used to create a traditional hologram, and the illusion created by scientist John Henry Pepper in 1862. The *Holographic Hive* is an installation that examines and explores the possibilities of the ephemeral qualities of light as a holographic apparition.

![Holographic Hive](image)

Figure 1. Holographic Hive 2015, Experience Studio, Moss Art Center. First Installation.

RESEARCH

The *Holographic Hive* was originally a final assignment for a class on Lighting and Projection Mapping, with Professor Thomas Tucker. Typically video projection mapping—a technique that uses software to “map” the 2-dimensional output of any standard projector onto a 3-dimensional surface—is used on opaque or translucent surfaces. Having completed several projects for the class mapping onto opaque cubes, I wanted to challenge myself to push past the standard.

During my research I came across a use of video projection mapping at the musical festival called Coachella where a holographic likeness of the dead rapper Tupac was resurrected for a performance.
Utilizing the video projection mapping software, a computer-generated likeness of the performer was projected from a 90-degree angle onto a reflective surface which was then bounced off an angled piece of mylar, a shiny thin piece of plastic that has semi-transparent qualities. The final effect allows another performer to stand behind the mylar and co-mingle with the holographic apparition. Inspired by the possibilities this presented, I researched everything I could find on the subject.

I found that the technique used for Tupac’s resurrection performance at Coachella was actually based on an old theatrical illusion technique called the Pepper’s Ghost Effect, named for the scientist John Henry Pepper who first demonstrated the effect in 1862. (“Pepper’s Ghost,” n.d.) Aside from the inclusion of modern technology the differences between the Pepper’s Ghost illusion and the Tupac resurrection are minimal. Here is an Instructables link that further describes the process that I used for reference to better understand the process. I kept coming across links on Youtube and a variety of articles written on the performance that referred to the performance as “The Tupac Hologram”.

During my years before graduate school, I had spent a fair amount of time researching how to create a hologram on film, a scientific technique known as holography. I spent countless hours reading everything I could on the Holocenter Website. I purchased Gavin D.J. Harper’s book on Holography and the Holography Handbook with the intention to learn enough about the process to potentially create my own version. The whole procedure was involved and while I found the process intriguing I could not visualize a way to work it into my practice until the creation of the Holographic Hive.
PROCESS

After my initial research on the “Tupac Hologram” and Pepper’s Ghost, I kept thinking about holograms and my experience working with lasers. Merriam-Webster’s dictionary defines a hologram as “a three-dimensional image reproduced from a pattern of interference produced by a split coherent beam of radiation (such as a laser); also: the pattern of interference itself.” (Merriam-Webster’s, n.d.). I was very familiar with creating interference patterns with lasers, and have experimented with various optics including convex and concave lenses as well as diffraction and refraction techniques. I knew I wanted to try projection mapping off a more interesting surface and was inspired by the various uses of reflective materials as an effect. I stumbled upon Nitin Vasanth’s “pyramid hologram hack” that triggered an ah-ha moment for me. The pyramid hologram hack reflects also borrows from the Pepper’s Ghost illusion but instead uses a pyramid structure. Vasanth describes how it works as “Four symmetrically opposite variations of the same image are projected onto the four faces of the pyramid. By principle, each side projects the image falling on it, to the center of the pyramid. These projections work in unison to form a whole figure which creates a 3D illusion”. (Vasanth, n.d. para. 4) I then thought that the light bending off clustered convex mirror in close proximity could have a similar effect.

IMPLEMENTATION

To prove my theory I decided to build a prototype. I learned quickly that convex mirrors were cost-
ly, and after many days of dealing with vendors in China in an attempt to procure a lot of large mirrors, I decided to use one-inch convex mirrors to build my prototype. At first, I tried laying the mirrors out in rows, there was too much of a gap between each mirror. In order to get the mirrors as close together as possible, I ended up using a hexagonal or triangular lattice pattern. In this formation, the mirrors would be in close proximity and also triangular the reflection centrally above each closer of three.

My initial prototype was a success enough and I moved forward and invested in 37, eight-inch convex truck mirrors, which had to be removed from their housing. I documented the creation of the *Holographic Hive* and its first installation, which I collaborated with David Mills. The full documentary can be found here [Smoke and Mirrors, The Making Of The Holographic Hive](#).

**FINAL OUTCOME**

The Holographic Hive was installed and performed three times, each time in slight variation with different projectors, projection angles, and orientations. I learned from each experience that the output of the projector in lumens and projection angle is crucial to the success of the effect as well as the use of haze. The optimal position of the Holographic Hive itself should be at a 45-degree angle from the ground and the projector an opposing 45-degree angle from the ceiling. The projector should be hung no higher than 12 feet at 8,000 lumens.

Links for additional installations:

- [Holographic Hive: President Sands of Virginia Tech’s visit to the Experience Studio](#)
- [Holographic Hive: Planetarium at the Western Virginia Science Museum](#)
- [Holographic Hive: Thesis Exhibition At The Armory Gallery](#)

![Figure 7. Holographic Hive 2017, (Not) Drawing The Line: Technology Re-examined Exhibition, The Armory Gallery.](#)
Chapter 2.3: Before Graduate School

Light as a medium is an elemental focus that has guided and informed the creative process as an artist who embraces technology. Its tenuous and ephemeral nature is used as a gateway to explore concepts, technologies, and processes of much diverse media. One could argue that the ephemeral nature of our human existence has been perpetuated throughout history by our art making and our advancements in technology. Throughout time, art and technology can be looked at as representations of our self-consciousness brought into existence through making. Our will to leave behind relics of our own thoughts and processes to endure past our ephemeral existence and to extend our current experience beyond what nature can provide. Our inventiveness in both of these areas inspires and moves us forward.

In order for me to move forward to continue my evolution as an artist and as a human, it felt necessary to further conduct further research on an academic level. Thus, in discussing the research, processes pertinent to my trajectory as a student, it feels essential to provide a few highlights to better understand my thesis work.

Prior to my enrollment, I worked as a professional photographer and lighting designer for nearly 13 years. My passion for photography was initially fueled by my desire to capture light and its ephemeral qualities. Figure 8. is an example of a commercial portrait and the subtle sculpting of an image that is possible when controlling light. Figure 9. is an example of capturing light in a natural. Figures 6., 7., and 10., are examples of capturing light with long exposures to reveal the movements of fabric through the water.

My work as a lighting designer is much tied into my work as a photographer. My desire to control ephemeral nature of light, to paint with it was triggered along with my shutter.

Figure 6. “Reverie” Triptyc 2005, c-print.

Figure 7. “Dieselrea” Triptyc 2005, c-print.
Figure 8. Example Of Commercial Photography. Justin Vivian Bond And Anna Matronic 2007, NYC.

Figure 9. Example Of Personal Work Capturing Natural Light. Shadows Of Jubilee, 2015.

Figure 11. Controlling The Lighting For An Event At Webster Hall, NYC 2015.


Figure 10. Example Of Personal Work Capturing Light. “Ranz DesVaches” Tryptic, 2005, c-print.
In Figure 11., I am operating a whole hog 4 and full motorized rig and video system. Figure 12., was shot at the venue Music Is Love in NYC, and is the first example of using high and low technologies. Prisms arrays strategically placed to refract laser light and create geometry in the room. Intelligent lighting and a laser with basic optics. “Playing” the lasers off the prisms as a visual instrument, to coincide with music.

Chapter 2.4: The Electromagnetogram

The Electromagnetogram is a camera-less method for creating photographic prints, which combine aspects of photography, lighting, and painting. The name is derived using a traditional photographic naming convention, i.e. photograms, or a Luminogram, in this case, the use of the LASER (Light Amplification of Stimulated Electromagnetic Radiation) to expose photographic paper. This process was developed for the Mountain Lake Workshop in collaboration with artist Jessie Mann. The Electromagnetogram is an effort at isolating light, surface, saturation, and rhythm, in the manner of abstract expressionism. (J. Mann, personal communication, August, 2011.) In this case, photo chemicals and the purified light of lasers as a means to paint on the light and exposure instead of paint. In Figure 13., prism shadows can be discerned in the top left corner of the image. The black lines and gradients are a record of the laser across the photosensitive surface.

Figure 13. Example Of An Electromagnetogram. Stasis 16 x 20 inches, Liz Liguori And Jessie Mann, 2015.
PROCESS

The unexposed photographic paper is laid out under the safe light of the darkroom. The laser acts as a tool to “paint” light and expose the photosensitive paper. By combining the use of prisms, refraction and diffraction techniques and filters allows for overall control of the tones and saturation. The final print becomes a record of both chance operations and the movement of the light’s path across the surface. It is a rediscovery of the elements of photography as they can be employed toward an abstract expressionist end. (J. Mann, personal communication, August, 2011.)

Chapter 3.1: Old and Low Technologies

Building the Holographic Hive allowed for a type of visual problem solving to take place that was inspiring. The process of utilizing common materials was challenging and ultimately led to discoveries about the materials I was working with. The repetition required for many of the processes created head-space for further introspection. My need to have a better grasp on what Creative Technologies meant to me to literature on the history and philosophies of science and technology, like the writings of Cyril Stanley Smith.
Another influence that altered my path in the graduate program was a certification program offered through the graduate school called “Preparing the Future Professoriate”, the classes I took in this program had a huge impact on my experience as a student and covered a breadth of knowledge on higher education, philosophies on contemporary pedagogy and many other areas which provided me with a sense of agency as a student. I focused my research on the ways that technological advancements in the arts might affect arts education, in particular how the technological evolution of arts education will affect traditional arts programs. In my research, I learned that fundamental art programs are being defunded and cut from schools worldwide which are resulting in a loss of traditional and indigenous methods for art making. This knowledge inspired me to reconsider what I was considering a technology.

In keeping with the ethos of wanting to work with my hands, exercise my visual problem-solving skills and learn about a new process, I decided to work as low-tech as possible. Right down to clay. This decision felt to defy my candidacy as a master of Creative Technologies, but learning about such a fundamental technology seemed important. After all, ceramics is one of the most ancient technologies and industries on the planet that also allowed a way for us to express ourselves as conscious beings.

Chapter 3.2: Works in Clay

I was concerned at first that “playing in the mud” wasn’t high tech enough, but on a core level I knew there was something important behind the drive and my obsession with this process. There was an inherent guilt for exploring such a polarizing, lo-technology. I was really interested in finding a way to connect or elevate the status of this low and old technology and used it as a challenge to ask questions. How does one approach this from a visual problem-solving standpoint? Can simply embedding or installing some sensors and technology in or on something like clay elevate its status so it could be perceived differently… As hi-tech, or will it simply provide a harsh contrast to emphasize it natural earthly properties? How will this relationship alter the way the low or high technology is perceived? Is there a way of blending the two disparate ideas together seamlessly?

THE MUD HIVES

The Mud Hives is a series of hand-built, ceramic sculptures that are an interpretation of how the Organ Pipe Mud Dauber Wasp builds its hive.

Figure 15. Standing Mud Hives
in nature. The Organ Pipe Mud Dauber builds a distinctive tube-like hive on surfaces that resemble a pipe organ, hence its name. The Mud Hives are an effort at reconnecting low or old technologies with hi or new technologies. They are made with red stoneware clay by systematically rolling out clay in lumps and methodically building up layers. They have been fired and rubbed with iron oxide.

The wall mounted Mud Hive has a microcontroller, microphone, small speaker and MP3 shield with two audio tracks, one of a muffled buzzing noise of a wasp, and the other a four-second pipe organ chord played in C Major. The microphone provides a constant feedback of the ambient decibel level in the room. When there is a sound that exceeds a set threshold that has been programmed into the microcontroller, the C Major chord is played and followed with a four-second delay of silence, after which the subtle sound of insects ensues.

FINAL OUTCOME

The Mud Hive sculpture is a symbolic first step in my re-examination of technology. This project presented questions on the nature of what is typically perceived as a technology and is an attempt to elevate how the technology is considered. Clay seems to contrast the idea of what
is commonly considered a technology. Yet on a base level, it is a defining technology.

I do not believe the technology used in the Mud Hive helped to elevate clay as a technology, but I do believe it helped add a dimension. It was my modest attempt to bridge the disparity between human and the machine through the creation of art.

**TILES**

These are tiles made by hand. 150 were made in total. The technology, in this case, was used to make an impression, as a way of processing the material.

**RESEARCH**

The geometric patterns of Islamic tile work and the arabesque style of interwoven, linear patterns has always been a source of my inspiration as well as “Sacred Geometry”. Using this as a starting point, part of my research focused on learning how these geometric patterns are designed, and part became about the process. Many of the geometric patterns I was drawn to were based off an isometric grid—60° triangles arranged in a grid—and coincidentally the base structure of the hexagonal lattice I used to tightly nest the convex mirrors together of the Holographic Hive. For me to better understand the geometry used in some of the patterns I needed to hand draw and replicate it myself as seen in Figure 20.

The other areas of research were all part of the making process and the hands-on, problem-based learning. I worked out the details of how to create a template for my design on the laser cutter by trial and error.
PROCESS

The processes were guided by what I was learning in the “Molded Ceramics” course I was taking with Martha Sullivan through the School of Architecture + Design. Figure 21 shows one of several designs created for this class. Once I settled on a design, it was exported from Adobe Illustrator as an eps, a format compatible with the hi-tech laser cutting machines. A template was first cut from a piece of matte board to build a test from, and then finally from wood. I made a negative cutout of the design, and then cut out the same design from a thicker material and glued them together. An example of this is shown in Figure 22.

A frame was made to fit around the perimeter of this tile template. From there clay rolled into slabs ¾ of an inch thick and cut to fit the width and height of my frame. Tissue paper was then cut to size and placed over the side of the clay slab that was to be pressed into the mold. The square slab of clay was then placed into the frame (tissue side down) and equally pressed into the template. Spacers were then placed on the underside to help pop the tile out of the frame. A 60 second video of this process can be viewed here.

After the tiles were formed, each one had to be dried between layers of sheetrock. This allowed for the tile to dry evenly as the plaster in the sheetrock wicks away the moisture in the clay. The even distribution of weight across the surface of the tile under the weight of the sheetrock also aids in the tile drying flat. In order to prevent the tiles from molding over and speed up the drying process, the tiles were systematically repositioned.

After an initial bisque firing, each tile was rinsed and dried to allow for a proper application of glaze. The backside and half of the lower side of the outside of each tile were then coated with a layer of wax. A glaze was then mixed and put through a sieve repeatedly throughout the process to promote consistency in the appearance of the end result. The bottom of each tile was then wiped with a sponge. Finally, each tile is left to dry and then put into the kiln for a final firing.
FINAL OUTCOME

The process of hand-making 150 tiles was extremely time-consuming and took hundreds of hours of repetitive tasks. While the use of the laser cutter made it possible to replicate my design with consistency, ceramic firing is very old and low-tech. It got me thinking about how technology is supposed to make processes more efficient, sometimes through the automation of repetitive tasks such as this one. However, I found a great value in the repetition of working with the materials. It provides a deeper and true understanding that would be hard to learn from a book.

THE JULIA FRACTAL

Working with geometry was an accessible way for me to better understand certain mathematical functions do to its visual nature. As a visual learner these visual representations of mathematics are crucial to my understanding. The Julia Fractal is a complex mathematical function defined by iterations. Technological advancements have made it possible to visualize this dynamic mathematical equation through computing in two-dimensions, and now with 3-D printing. However, even with these visualizations I still find it difficult to fully understand the complex dynamics behind this particular fractal. I found a website by Karl Sims that help provide me with the best understanding through transformation videos. Technology has allowed us to visualize abstract mathematics. Figure 25. is a 2-dimentional open-source rendering of a Julia Fractal. (Hskim000, 2011, online)

The artist Joseph Beuys wrote “But [as an artist] one is forced to translate thought into action and action into object. The physicist can think about the theory of atoms or about physical theory in general. But to advance his theories he has to build models, tangible systems. He too has to transfer his thought into action, and the action
into an object.” (Beuys, 1990, p.92)

The 3D print of the Julia Vase (Figure 26.) is an open-source file by Virtox called “Julia Vase #004 - Bloom, posted to thingiverse that for me, “transfers thought into action and action into an object.” And, as discussed above, object and action are themselves, conversely, translated into thought, or pure information. Technology and art have this in common, and the 3-dimensional rendering of the Julia fractal represents that. I furthered this action to bridge the disparities created from human to machine. In this instance, my goal was to lower its technological status and bring it back to the earth.

RESEARCH

I spent some time trying to understand the mathematical principles of the Julia Fractal, also know as the Julia (set). The Julia (set) is defined as “a set of complex numbers that do not converge to any limit when a given mapping is repeatedly applied to them. (Google Knowledge Graph, n.d., online) In some cases, the result is a connected fractal set.” This project, however, was not about understanding complex dynamics in mathematics.

PROCESS

This project was another a final assignment for the Mold Making course with Martha Sullivan, and again my research was conducted through the process of making. I wanted to convert the 3D print of the Julia Fractal into a porcelain vessel. In order to do this a four-part plaster mold of the print would have to be made. I had to identify all areas on the form that would create an undercut that would leave an
overhanging section on the negative of the mold inhibiting the release of the casted form. This was done with an oil-based clay.

The next steps involved making the 3D print rigid so it would not collapse under the weight of the plaster. I used expanding foam spray used for insulating houses. After this had cured the Julia form was divided into four equal parts and marked accordingly. Each section would become one part of the four-part mold.

To create the plaster mold each section is defined by clay walls that are built up. Plaster is then mixed and poured over the section until it dries. The underlying clay is removed; the next section is built off the first and so on. Figures 27.-29. illustrate this process.

Once the plaster cast is made it must dry thoroughly. The porous characteristics of the plaster help to wick away any excess moisture from the liquid slip, which is a suspension of ceramic particles in water. The plaster mold is then bound together by rubber tubing and the porcelain slip is poured into the negative plaster mold. A shell begins to form around the perimeter of the mold, which will increase in thickness with time. After the desired thickness is achieved the remaining slip is poured out, leaving behind a casted positive as in Figure 30.

The clay body will begin to separate from the plaster cast when it is firm enough to remove from the mold. The slip-casted form is then refined by hand to remove any trace of the mold or the process and then bisque fired. The resulting form can be seen in Figure 31.

THE FINAL OUTCOME

16 pieces were made and 13 were bisque fired many of which were used for glaze testing. I felt that the final outcome was putting me closer to connecting the low and old tech with the high and new.
Figure 30. Plaster Mold With Porcelain Slip Positive.

Figure 31. Porcelain Slip Casted Fractal After A Bisque Firing.

Figure 32. Porcelain Cast Of Julia Vase #004 - Bloom.
Chapter 4: (Not) Drawing The Line: Making Connections

To “draw a line” often implies one of two things. You can “draw a line” between two points to form a connection, or a line can be drawn to define a separation. I found both to be a challenge as I’ve tried to connect with my exploration of creative technologies. The repetitive and intensive explorations of materials and process helped me feel connected to my work, but I often found it difficult to “draw the line” and separate myself from the process. I’ve often reflected on the idea that the time I invested in each of these projects was one way to “elevate” what I was doing, to give it value even if it’s worth was mine alone.

Cyril Stanley Smith says in his book *Art, Technology and Science: Notes on their Historical Interaction*, that for some reason the technical side of art has been downgraded as “mere” technique. Yet the
handling of matter will always be necessary to give reality to the artist’s all-important vision." (Smith, 1970, p. 501) As an artist, the “handling of matter” has helped me connected to connect with technology on a more human level.

My re-examination of technologies perhaps is the product of my generation’s specific place in history. As a Generation Xer, (born between 1965 and 1979) I have lived on the cusp of two worlds, the world before the Internet and the world after. I have tried to comprehend what it would be like to have never known the world without an Internet. Michael Harris writes about this in his book titled “The End Of Absence” that, “we have in this brief historical moment, this moment in between two modes of being, a very rare opportunity.” “For those of us who have lived both with and without the vast, crowded connectivity the Internet provides, these are the few days when we can still notice the difference between before and After.” (Harris, 2014) The difference was a prominent experience as a graduate student, and I believe this has helped push my introspection on the matter, to not draw the line in my explorations or my processes.

The #2 Pencil

Creativity applied to technologies “seems to provoke questions that may not usually be asked of technology.” (Candy & Edmonds, 2002, p. 53)

The #2 pencil is an exploration of the pencil as a technology. I used the #2 pencil as a challenge. It was another antiquated technology so mundane and common—like clay—most people would not bother to consider it as such. Stripped down it’s just graphite housed in wood or a conductive conduit wrapped in insulation. I chose the Dixon Ticonderoga #2 pencil for some specific reasons. I have no evidence to back this statement, but to me, this brand of pencil seems to be the most well and one of the oldest pencil companies in the United States. It was always the brand of pencil handed out before the scantron tests given from elementary school to high school. For me, it symbolic of being tested and the fear of failure, and the smell of its sharpening can still trigger a remembrance of that anxiety.
RESEARCH

I read a surprising amount of the history on the #2 pencil online, how the pencil is produced and the impact it has had on society. I compared the information I read in the various articles online and kept track what seemed to be the truest historic representation in my notebook I found this article in Popular Mechanics to be one of the most comprehensive.

My main method of research, as expected was conducted in the processing and exploration of its materiality. In figure “Pointless #2” one sharpening yielded 9,505 lines. In Figure 35. “Really Pointless” 19 sharpenings produced 204,528 lines. In both of these pieces, the lines produced have been drawn directly onto their encasement. Figure 36. is the remaining #2 pencil in 19 sharpenings.

PROCESS

Michael Harris states in his book “The End Of Absence” that “The brightest moments of human discovery are those unplanned and random instants when you thumb through a strange book in a foreign library or talk auto maintenance with a neuroanatomist. We need our searches to include cross-wiring and dumb accidents, too, not just algorithmic surety.” (Harris, 2014) For this section, I will let the documentation of the process itself get the point across.
Chapter 5: The Primitive Touchscreen

The *Primitive Touchscreen* is an interactive sculpture that uses the conductivity of graphite as an interface to activate a corresponding LED. My shrine to low and high technology and to process and materials.

**RESEARCH PART 1**

Before my work with the pencil, I had read an article in *The New Yorker* about a physicist at the University of Manchester called Andre Geim. He encouraged “curiosity-driven” research with his students. Through this ethos, Geim achieved something extraordinary which earned him the Nobel Prize in Physics. “Geim had isolated the first two-dimensional material ever discovered: an atom-thick layer of carbon, which appeared, under an atomic microscope, as a flat lattice of hexagons linked in a honeycomb pattern.” (Geim, 2014, online) His initial discovery of Graphene was achieved this with scotch tape. There were a few takeaways that stayed with me long after I read this article; the fact that graphite is conductive, (almost 250 times more so than silicon as a single level of graphene) and that playful experimentation was a good thing that more scientists should employ.

One serendipitous piece of information that I forgot I did not remember in this article is that molecular structure of Graphene is a lattice of hexagons.

**PROCESS PART 1**

During my research of the #2 pencil and exploring the various ways I could reframe and elevate its commonness as a material, I had coincidentally glued the pencils into this lattice of hexagons. I had
remembered that graphite was conductive from reading the article on Graphene and Geim’s discovery in the New Yorker. After I had used a miter saw to create this form, it occurred to me that this could be, in essence, a sort of primitive touchscreen.

I took my hexagonal form and drilled a tiny hole directly into one of the points of graphite (on both sides) and pushed the positive anode post of a LED into the hole on one of the sides. I connected the negative end to a ground cable running to a 9-volt battery. I then pushed a wire into the hole I drilled on the opposing side and connected that to the positive terminal of the 9-volt battery. The LED instantly lit up.

RESEARCH PART 2

I researched various sensors that might transform the conductive points from the grid of graphite into something responsive. I found a “capacitive touch-sensor” that would work with a microcontroller and ordered one to test out.

My initial testing was successful, however, I could only find capacitive touch sensors that could control up to 12 electrodes (or outputs). Upon further investigation, I discovered that the sensor was driven by an I2C interface which allowed up to four sensors to be addressed to work in unison. I scoured the Internet for any examples for using more than one of these sensors in together. The only clue I had to go on were these two lines in the datasheet. “An address jumper ties the ADD pin to ground, meaning the default I2C address of the chip will be 0x5A. If you need to change the address of the chip (by shorting ADD to a different pin), make sure you open the jumper first. I had only just begun to experiment with microcontrollers and sensors, and at the time this made entirely no sense to me.

I dedicated my research and thesis hours to teaching myself about microcontrollers, sensors, I2C drivers, soldering, and coding over the next
several months. It took me some time to figure out what they meant by “shorting ADD to a different pin” after I reread the 27-page document of jargon for electrical engineers called the “MPR121 Proximity Capacitive Touch Sensor Controller Datasheet” Freescale Semiconductor company back to back four times. I had to physically sever a micro-sized circuit on one side of the sensor.

PROCESS PART 2

The goal of the Primitive Touchscreen function was for each point of graphite to trigger a corresponding LED (arranged in the same formation) to light up with the touch of a finger. This was my visual problem to solve, how could I present this in an interesting and aesthetically pleasing way?

In the end, I wound up building two versions. Figure 45. shows the initial prototype for the LEDs. It was impossible to drill through the length of a #2 pencil, so in the first version, I sawed off the pencil near the ferrules that house the erasers. There were countless physical and visual challenges to solve for in the creation of the LED array embedded into the eraser end of the pencils. At every step, there was a new visual or physical problem to solve for. Here is a partial list:

- Drilling through the small stubs
- Drilling through the small stubs consistently and centrally
- Drilling through the erasers consistently and centrally
- Figuring out a system for wiring that was visually pleasing and easy to troubleshoot
- Gluing or adhering all the tiny stubs into a hexagon formation
- Running the wires to the capacitive touch sensors with aesthetic grace
- Embedding the LEDs so they will stay put in the center of the pencil stub
- Displaying the interface and the LED array in a pleasing manner
- Housing the electronics
- Wire colors

Figure 46. shows Primitive Touch Screen v.1.0

After the countless hours of putting together the Primitive Touch Screen v.1.0 I found some aesthetic flaws I was not happy with; The length, color and treatment of the wires, the fact
that not all the LEDs were perfectly centered—though this is relevant to my beliefs—I also longed for the length of the full pencil, but when I tried to drill through the length the drill bit would overheat halfway through and melt the painted surface. The biggest visual and aesthetic problem to solve was how the wires from the LEDs got down the sculpture.

I began production on v. 2.0. I built a jig to drill perfectly centered holes of the erasers (Figure 47.) and instead of drilling through the length of the pencil I built a jig (Figure 48.) to carefully run it through the table saw and allowed for a channel to run the wires for the LEDs.

All of these visual problems and countless hours of repetitive and tedious tasks had me thinking about technology again. I wondered why more consideration was not paid to the aesthetics of technology. Often things are hidden “under the hood” or thrown into a black box. For this purpose I wanted to display the wires and make them important to the form. Additionally, I always found beauty in circuitry. The beautiful copper traces the run along, making connections. Why weren’t circuit boards made beautiful and incorporated into designs? In that question, I created my next problem to solve for.

THE CIRCUIT BOARD

My answer for connecting the LEDs to the sensors was to create a circuit board. Figures 52. - 54. show some of the sketches drawn for the design. I used the isometric grid again and created a set of rules in which to layout the design. I divided the hexagonal lattice of points into 8 quadrants. The lines draw from the points in each quadrant follow a set of rules. I used this as a system for creating visual consistency.
Figure 55. CAD Design For Circuit Board.
After sketches were drawn I brought them into Adobe Illustrator. I recreated an isometric grid with guidelines and then laid out the vias (circuit holes) and lines and finished the design. I used the design layout to visual problem solve the circuitry and think through where I would place resistors.

RESEARCH 3

I began researching how to make my own PCB or “printed circuit board”. I thought about inlaying graphite or using conductive paint for the circuitry, but copper traces seems like the most suiting and visually pleasing option.

I found many DIY tutorials on how to make your own PCB with traditional methods much like the ones used in printmaking. An acid bath used to etch away the unwanted copper. I found one person who had developed a technique to create a circuit board on glass. This was very appealing, but I needed to be able to cut through the board to mount the touch screen and LEDs, which is two complex holes with a total of 86 sides. I was hitting up against a wall. I tried using consumer brand DIY cut machine which is essentially a printer with a razor instead of ink, but the lines I needed were too delicate. Because of the intricate design, I also could not create a mask and spray paint the circuits on.

PROCESS 3

I knew the laser cutter would be able to etch or cut the design with no problem, but the substrate of a PCB is carbon fiber plated with copper. I finally thought about painting the surfaces and using the laser cutter to etch away the excess. I found a black acrylic spray paint that would be safe to use with the laser and coated two PCBs with two layers of paint each.

I inverted the design so the laser cutter would
etch away everything but the circuits I wanted to be left behind and ran my first board through. It worked well but there was still paint residue left behind which would resist the ferric chloride acid. I ran it through a second time that cleaned things up nicely. I tried a third but the laser removed too much paint leaving traces that seemed too fine as seen in Figure 56. I processed another board, stopping after the second pass.

I hand drilled all the tiny holes for the vias. This was very challenging as there were almost 150 holes. Not all of the ground vias survived this process so I had to find a workaround. If I were to do this over I would print a two-sided board and make the traces for the ground circuits larger.

After hand drilling the holes I cut out the center holes by hand with a rotary tool, and finally etched them board in ferric chloride. The final board is shown in Figure 59. Process video for the Primitive Touch Screen can be viewed here.

Finally, everything was to be soldered put together, this task alone took over a week of work. Once this was complete I still needed to solve for a few more items, mainly how this would be displayed. I built a tiered pedestal and made the top removable with a stand for an easy way to troubleshoot the technology. I mounted the microcontroller (Arduino Mega) but I still had a mess of wires connecting the capacitive touch sensors to the microcontroller by way of a breadboard. Aside from the physical mess and potential for loose connections, this supposed-to-be-temporary setup was a nightmare to troubleshoot.

By the time I reached this stage I was awarded a $500 Student SEAD (Science, Engineering, Art, and Design) Grant through the Institute for Creativity, Arts, and Technology for transdisciplinary research.

I invited Javier Tibau, a computer science Ph.D.
to help me to develop the code my final project. Tibau was inspired by the *Primitive Touch Screen* and offered to help me improve my code, and “debounce” the touch sensors. Tibau also helped to reduce the wires and suggested we make a protoboard for the connections. I was reluctant to do to time restrictions and how much time had already been invested into the *Primitive Touch Screen*, but we did it anyway.

**FINAL OUTCOME**

The *Primitive Touch Screen* taught me a lot about technology, visual problem solving and myself. It is by far the most complex thing I have ever created on every level. Artists are typically concerned with visual problem solving, and technologist solves for the technology. In the case of the Primitive Touchscreen, I was solving for both.

Technology has historically been an extension of Figure 62. Capacitive Touch Sensors And Microcontroller Before Proto Board Built Improvement.

Figure 63. Capacitive Touch Sensors And Microcontroller After Proto Board Improvement.

Figure 64. Primitive Touch Screen Code.

Figure 65. Mapping Circuits and Diagrams.
Figure 66. The Primitive Touchscreen.

Figure 67. Primitive Touchscreen Detail.

Figure 68. Primitive Touchscreen Being Used.
our will, whether it be to move mountains or reconfigure nature, it is a function and a drive with intent, where art is more purely about making and doing, it seeks to extend our experience as humans.

Chapter 6: Return To The Ephemeral; Drawing the Line

Having successfully brought together the low and high (old and new) technologies with the *Primitive Touch Screen*, I finally felt more capable of trying to tackle a complex interactive laser sculpture. I have spent the last three years trying to envision what this would look like, and I have come up with many possibilities during that time. The one major detail I didn’t account for was how knowledge and experience affect our sensibilities. They provide a gift for knowing what is possible.

**DRAWING THE LINE**

*Drawing The Line* is an interactive laser sculpture that uses the consistency of vision to draw patterns and geometry onto an within an icosahedron.

The installation consists of two forms in space, a 20-sided icosahedron of equilateral triangles made from two-way mirror that hangs from the ceiling on transparent line (monofilament), and a hexagonal
pedestal placed six feet away from its pendant. The pedestal is embedded with three touchless (IR) infrared ZX sensors that each control a corresponding motor upon which a mirror is mounted, each slightly offset from one another.

**RESEARCH**

There were three distinct areas of research involved in the creation of *Drawing The Line*. The electrical engineering component required to properly power the laser. Developing the code for the IR sensors and calibrating their response to the environment, and finally, the two-way mirrored acrylic material used to make the icosahedron and how that would be put together.

As I mentioned in the last chapter I was awarded a SEAD grant to develop the technology for this project with Computer Science Ph.D. candidate Javier Tibau. Tibau wrote the syntax for the code based on my instructions. I would also like to credit Electrical Engineering Ph.D. candidate Mingyi Liu who showed me how to safely configure my power supply.

I started by disassembling a high end, custom-built laser system. I studied the hand machined components, optics, and layout to garner a better understanding its functionality. I salvaged several beam splitters made from dichroic glass and other various optics and electronics including the high-speed mirrored galvanometers that controlled the laser movement. I tried to find an electronic schematic for the device online but had no luck. My original concept was to create geometry around a room with two laser sources and beam splitters.

Next, I searched online to purchase more beam splitters like the ones I found inside of the laser housing. Optics of this quality are costly, so I purchase a small 12 x 12-inch piece of acrylic mirror to run some tests. The two-way mirror was 1mm thick, and after I tried to reflected a laser more than ones I found the quality of the optics degraded and cut down the intensity of the laser light to almost zero visibility.
I thought about reducing the geometry, and instead of trying to direct the beam over long distances in a room I could do so in a more defined area. Also, it would require a custom install every time I had to display it and that turned out to be an exhaustive process with the *Holographic Hive* and the setup involved. The sacred geometric patterns I had learned about came to mind and I researched 3-dimensional forms related to a hexagon. I settled on the icosahedron because of the potential geometry of lines that could be connected from the inner planes. I found this template online and laser cut a test out from chipboard to get a better sense of how it would assemble. I used a lower power setting on all of the vertices that were not part of the perimeter that allowed the triangles to be flexible and stay in one piece.

I then used the 1mm, 12 x 12 piece of two-way mirror to make a small prototype. Working with the individual triangles was difficult so I taped them in the formation I originally used Figure 72. Video of the prototype can be found [here](#). After the prototype was created, I researched places to buy two-way mirror in a larger and thicker dimension. I used the $500 student SEAD grant money to purchase this and was enough for me to build an icosahedron that had twenty, nine-inch equilateral triangles.

After the mirror was processed and laser cut, I figure out the angles each side needed to bevel, and how to build a jig to do so.

The laser and motors were salvaged parts, and after the electrical system was configured, I had to decide on what sensor to use. I wanted to interface to have a lightness that reflected the semi-transparent and reflective qualities of the icosahedron. There are a variety of touchless sensors available, but the one that best fit my needs was The *ZX Distance and Gesture Sensor*, which is capable of a simple detection of hand gestures on the Z and X axis.

**PROCESS**

Video of the process to build and assemble the icosahedron can be found [here](#).

Through the trial and error process, it was determined that three ZX sensors would be needed, one for each motor. This decision would allow each mirror to have the following functionalities when a hand is
held above the sensor:

• Swiping left to right (up to six inches) controls the speed of the motor; far left is a full stop, and far right is full speed rotation.

• Raising the hand up and down over the sensor (up to 10 inches) controls the “wobble” function which moves the mirror clockwise then counterclockwise in succession; from small to large increments and from full stop to full speed “wobble”.

Due to the limited I2C capabilities for addressing, two microcontrollers were needed. Two ZX sensors on one, and one ZX sensor on another.

Once the icosahedron was build and the sensors figured out the user interface was determined. To maintain the lightness in the feel of the icosahedron and the touchless sensors, the icosahedron was hung as a pendant. The pedestal was designed as the interface and housing unit for the sensors, microcontrollers, laser, mirrors, motors and power supply. The pedestal was to resemble a hexagonal prism to reflect the geometry that is within the icosahedron structure, to optimize the functions of the ZX sensors, as well as consideration of the form. The “pendant-facing” side of the pedestal has an oculus and vertical slit to allow a path for the laser (located on the interior) which is mounted on adjustable ball bearing hardware. The three ZX sensors were mounted into a removable top surface.

**FINAL OUTCOME**

*Drawing The Line* symbolically brought my journey as an artist and a student full circle. Its research, development, and process were by far the most efficient of all my work in the realm of creative technologies. Having the opportunity to collaborate with Javier Tibau to develop the coding for the interaction freed up time and space that allowed this efficiency. Overall I felt the project was a success and it emphasized the value of interdisciplinary collaboration.
Figure 78. Creative Technology.

Figure 79. Long Exposure Photo Of Drawing The Line.

Figure 80. End Of The Line.
Chapter 7: Future Plans

The protective and supportive academic environment has been the most rewarding and enriching experience of my life. It is my plan to be a lifelong learner and to continue my personal and professional development as an artist. My graduate experience helped me understand the value of collaboration and realize the greater potential that is possible when more than one mind is working on a common vision.

Over the next year, I would like to continue my interdisciplinary research exploring the nature of materiality and process in my art making as a way to further explore how technology is perceived and represented. I plan on applying for artist residencies and grants to help aid in this process.

It is my long-term goal to find an academic position as a way to keep me connected to a community of learners, and most importantly to share my knowledge and passion.
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